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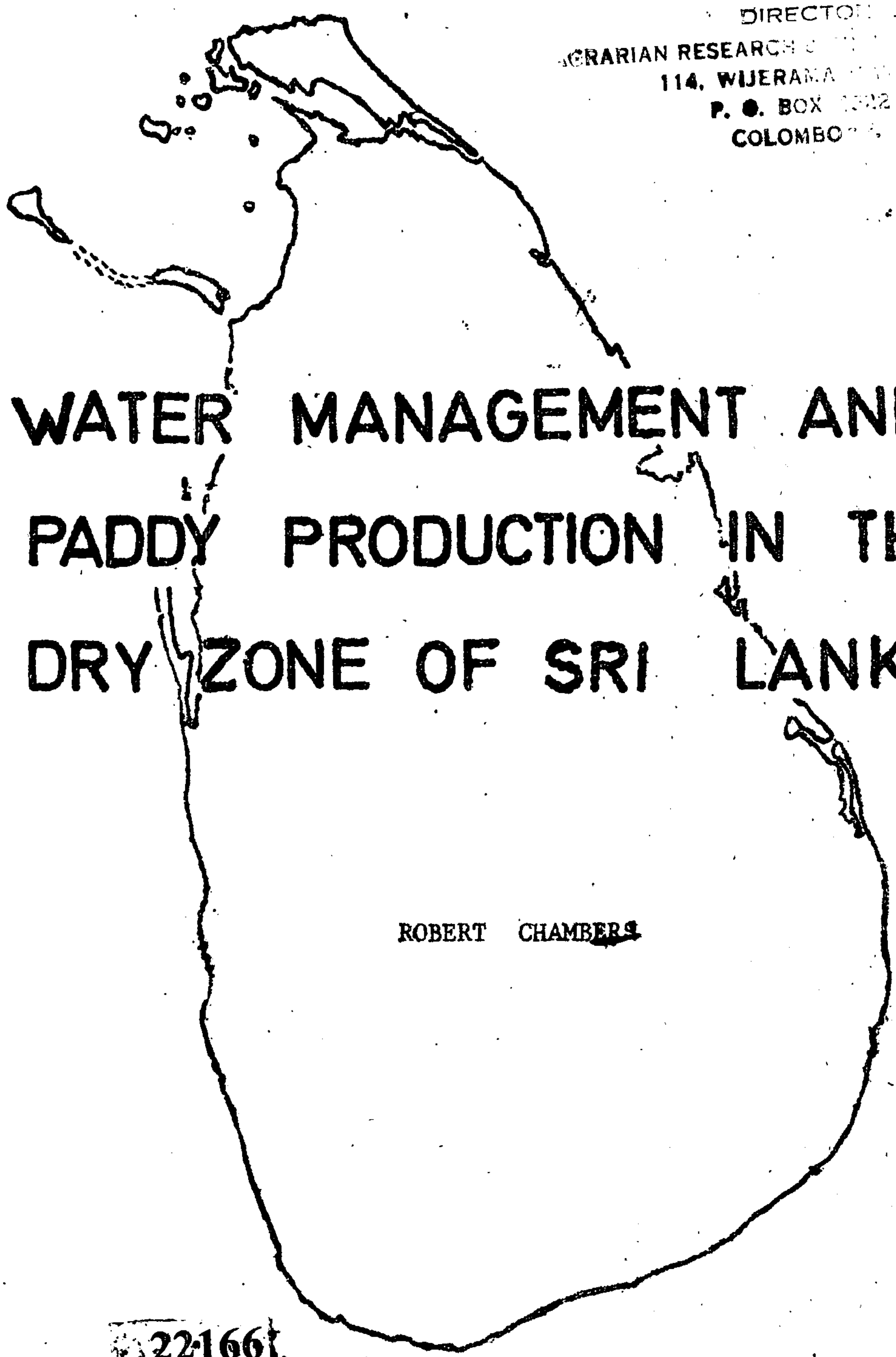

WATER MANAGEMENT AND PADDY PRODUCTION IN THE DRY ZONE OF SRI LANKA

ROBERT CHAMBERS

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AGRARIAN RESEARCH AND TRAINING INSTITUTE
114, Wijerama Mawatha,
Colombo 7,
Sri Lanka

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PREFACE

Agricultural Productivity and growth in Sri Lanka are intimately connected with the availability and use of water. Never before in the history of Sri Lanka has Water Management been given the highest priority as is being done now. In this situation we are happy to be able to publish under the Occasional Publication Series a paper written by Dr. Robert Chambers who served as a member of a team of researchers who worked on the UC-ARTI Project on Agrarian Change in South Asia.

Dr. Chambers' original paper was discussed at a seminar organised by the ARTI in August, 1974. In the light of the discussions that took place at this seminar Dr. Chambers has made useful modifications to the paper. It is our view that this paper focuses attention on some of the more important issues connected with Water Management in this country. It is not easy to find solutions to all the problems of Water Management nor is it claimed that this paper deals fully with all aspects relating to the efficient use of water which is no doubt a scarce commodity in this country as claimed by the author. We are, however, hopeful that this paper will provide a basis for further discussion and in-depth studies on this subject in the future.

The ARTI gratefully acknowledges the contribution made by Dr. Robert Chambers on a vital problem that this country faces today.

C. Narayanasamy
Director
Agrarian Research and Training Institute

ACKNOWLEDGEMENTS

In an earlier version of this paper I tried to acknowledge the help I had received from different people. Since then the volume of assistance and comment has reached a level at which this becomes very difficult. I am very grateful indeed to all those farmers, government servants, colleagues on the University of Cambridge and Agrarian Research and Training Institute Project on Agrarian Change, and other colleagues in ARTI, who have contributed to this paper, through their patience, knowledge and constructive criticism. I have been fortunate indeed in the number of experienced people who have been prepared to read the paper and react to it. Responsibility for whatever errors remain, and for the views expressed, is, of course, entirely mine and they should not be attributed to any other person or to any organisation.

The true test of a paper like this is whether the evidence and argument which it tries to marshal contribute to improvements in policy and practice, either indirectly through encouraging further research and analysis, or directly through changes in perception, prescription, and action. I hope that in these respects it will not be found entirely wanting.

WATER MANAGEMENT AND PADDY PRODUCTION IN THE DRY ZONE OF SRI LANKA

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SUMMARY

The Neglect of Water Management

Water management in the Dry Zone is a neglected subject. It is not a serious major focus of attention in any of the books and reports which have been consulted. The UNDP/FAO Final Report on Mahaweli Ganga is remarkable for the attention paid to other agricultural inputs and their management to the neglect of water. The papers of the 1973 FAO/Sri Lanka seminar on water management at the farm level have begun to open up the subject but also expose gaps in knowledge and concern around the crucial organisational and operating aspects of water management. The general neglect of these aspects is partly explained by the common preoccupation with new capital works, partly by cramped vision from within disciplinary boundaries and partly by the awkward nature of water itself compared with land.

Scope, Purpose and Values

The neglect and the gaps are associated with the different meaning which water management has for different specialists. This paper sets out to begin to explore some of the main gaps. In doing that, water management is defined as the control and operation of the distribution, allocation, application and drainage of water from the source of supply (anicuts or tanks) to the end of the drains.

The paper seeks to explore some relationships between technical imperatives and the potential for paddy production on the one hand, and their organisational implications on the other. It is confined to the Dry Zone and to irrigated paddy. The approach is somewhat like that of an economist-cum-political scientist. The values underlying the paper are (i) increasing paddy production, (ii) saving foreign exchange, and (iii) equitable distribution of water and access to it.

The Context: The Dry Zone and Paddy Production

Rainfall in the Dry Zone is taken as averaging 3.1 feet in Maha and 0.9 feet in Yala. The irrigation systems can be classified according to scale and type of organisation as (i) major project (Gal Oya, Uda Walawe, Mahaweli Ganga), (ii) major, and (iii) minor. In major project and major irrigation, water is controlled by a bureaucracy; in minor irrigation by a community. In analysis a key boundary in major irrigation is the handover point at which water passes from the control of the bureaucracy to the control of the community in a yaya. The term yaya is used to describe a paddy tract typically supplied by one handover point in major irrigation.

In the 12 districts which are taken to represent the Dry Zone, the acreages targetted for paddy for 1973/74 Maha were 900,000, of which 390,000 are under major project and major irrigation, and 230,000 under minor irrigation, the remainder (with which the paper is not concerned) being rainfed. Mean unweighted yields reported for these districts over a five year period were 48.9 bushels an acre for Maha and 49.4 bushels per acre for Yala, a negligible difference between the seasons. The increases in national paddy production in the past decade can be attributed more to increases in yields than to increases in acreages. The gap to be filled in order to achieve self-sufficiency in paddy is of the order of 25 million bushels of paddy. The Dry Zone at present produces rather more than three fifths of the national production total, and major irrigation produces rather more than one third of the national total. The paper is addressed to the contribution better water management might make towards increasing Dry Zone paddy production either through raising yields or through increasing acreage or both.

A Change in Thinking: The Productivity of Water

A change in thinking is required. Water is a scarcer resource in the Dry Zone than is land. In unirrigated conditions, land is a proxy for water from rainfall: yields per acre also express yields per unit of water. In irrigated conditions this no longer holds. To the contrary, water is land-augmenting: that is to say, the acreage cultivated depends on the water supplied. More water, or more sparing use of water, can increase that acreage, either through bringing new land under cultivation or through increasing the frequency of cropping on land already asweddumized. Farmers may continue to think in terms of productivity and yields per acre, but agricultural planners and others considering the national interest should make the difficult transition to thinking about productivity and yields per unit of water.

This change of thinking implies use of yield: water and calorie: water ratios as criteria of efficiency. When this is done, Maha paddy emerges as much more efficient in its use of irrigation water than Yala paddy, and soya beans in Yala emerge as much more efficient than paddy in either season. This shift also implies the design of agricultural research to measure returns to water both in research station and field conditions. The concept of water use efficiency also provides a criterion for judging between alternative agricultural and water management practices.

Practices and Choices

Water Duties and Productivity

Current water use is very wasteful. Water issues of over 16 acre feet for Maha have been reported for part of Uda

Walawe, and field use of 18 acre feet in Yala has been reported in Gal Oya. These compare with ex-sluice requirements in major irrigation, based on research (after allowing 25 per cent for conveyance losses and 15 per cent overflow from fields) of roughly 1 to 3 acre feet in Maha and 5 to 8 acre feet in Yala. When these are compared with the common conventions in the field that Maha requires ex-sluice duties of 3 to 5 acre feet and Yala requires 6 - 8 acre feet, it appears that water use in Maha is very wasteful compared with Yala. In Maha roughly twice as much water is issued as is needed according to these calculations. More sparing applications would reduce losses from flooding and could sharply increase the productivity of stored water.

Excessive water issues are associated with physical factors including irrigating unsuitable soils and failure to maintain structures. They are also associated with farmers' rational preferences. They can be reduced through organisation and management and through choices between alternative irrigation and cultivation practices.

Alternative Uses of Water Saved: Maha Versus Yala

A basic issue is the alternative uses of water saved. The dominant Dry Zone philosophy is that water should be saved in Maha and stored for Yala. For an imaginary but perhaps partly representative major irrigation tank (somewhat like Wirawila tank in Hambantota District), given a number of assumptions, it appears that the Yala acreage that can be cultivated with water stored from Maha is of the order of only one quarter of the acreage that same water could irrigate in Maha. This means that using such water for additional acreages in Maha is much more efficient. This reinforces the strategy which may now be necessary of increasing production more through extending acreages especially in Maha rather than through increasing yields.

In many cases and in many areas it remains sound **also** to store water for Yala, particularly under major project irrigation. But where the choice exists it appears much more productive to use water for additional Maha cultivation. The need is for water control in Maha to be tight to induce an apparent water scarcity to cultivators; in short, to make Maha appear to them more like Yala.

Staggered Cultivation: Benefits, Costs and Complications

Timeliness and staggered cultivation are complex questions. Research by Okamoto should help to gauge the costs of untimely cultivation, which may be high. Staggering occurs both intra-yaya and, on major project and major irrigation, inter-yaya. The causes of staggering and untimeliness include natural disasters, the sequence of water supply, effects of drainage, problems of input supply including labour, the growing of longer-duration varieties of paddy, the requirements of irrigation work maintenance, and competing demands for farmers' labour.

Staggering is commonly regarded as undesirable, but it has substantial benefits in reducing risks, maintaining a steady food supply, spreading demands for scarce inputs, moderating the demand on channels and drains, stabilising the flow of drainage water to those who re-use it, permitting replanting when a crop is lost in the early stages of growth, (perhaps) providing more steady employment for landless labourers, and giving administrators and politicians a quieter life than with a stricter system. It also often benefits the poorer cultivators.

Staggering, untimeliness, and extensions of water issues beyond agreed dates are not new but have a long history. In the past as today they have been irrigating to the tidy minds of officials, especially irrigation engineers. This may have obscured preception of these benefits.

The costs of staggering and untimeliness are, however, high. Per acre yields are affected by climatic factors, by difficulties in crop protection, by problems of water control, by flooding, by conflicts of interest between neighbouring cultivators, and by loss of seasons. Water use efficiency is affected by failure to make use of rain and by higher evapo-transpiration, percolation and conveyance losses. Staggering also makes maintenance and extension work more difficult and complicates the collection of statistics.

On balance, the productivity of both land and water would be enhanced through reducing staggering, but care is needed not to penalise unduly the weaker cultivators.

Choices of Crop and Paddy Variety

Choices of crop and paddy variety can also increase the productivity of water. Shorter-duration paddy, especially BG34/6 and BG34/8, should use less water than H4 and under good water management and supply, should outyield it per unit of water and probably per unit of land even under negligible fertiliser applications.

Substitutions Between Foreign Exchange, Water and Labour

Various substitutions are possible between foreign exchange, water and labour. Labour can substitute for water through transplanting and weeding. Farmers are unlikely to make such substitutions on any scale as long as water is available. As with other measures, what is desirable nationally conflicts with farmers' individual and narrowly conceived communal interests, and requires the more sparing issue of water to farmers who will want more.

Again and again, with water management, we find ourselves concerned with situations in which people have to be induced to do, in the national interest, what they feel is against their personal interests.

Organisational Implications

Intra-yaya allocations tend to benefit the better-off and more powerful people who may also tend to be those nearer the heads of channels, to the detriment of the tailenders. Various techniques for tackling this micro-political problem are :

- educating the farmer. But a farmer cannot be persuaded freely to do what he perceives to be against his interests.
- introducing water charges, but this is not practicable, the more so with the current and anticipated load of work and responsibilities for Agricultural Productivity Committees.
- careful design of physical structures. The potential of this approach is not known.
- political engineering, securing representation for irrigation area interest groups on Cultivation Committees through a system of intra-yaya irrigation "constituencies", using election, or failing that, appointment, with special care to secure representation for the tailenders and encroachers.
- selecting a person with authority to make and enforce water allocations.

Govimandala Sevakayas have worked to the extent that they have not because of an adequate incentive system as much as because they, or someone like them, are needed to make water allocations, to settle disputes, and to take action against infringements. The findings of the UCARTI survey in the Southeast Dry Zone suggest that a majority of cultivators would prefer a stricter system of water control. Such a system might best be administered by a person who combines local knowledge of the irrigation system with independence of judgement, and who is held in respect. In a situation of induced scarcities of water in Maha, such a headman would have more to do, and tailenders generally might become a more active pressure group to ensure their rights.

Inter-yaya allocations are mediated through the bureaucracy of the Territorial Civil Engineering Organisation. The framework of timings is set by water meetings chaired by Government Agents. The water meeting system is effective and requires an impartial chairman, as at present. These meetings do not, however, regularly consider inter-yaya water allocations. In the absence of strong direction or incentive, civil servants responsible for water issues, especially in Maha, tend to issue water permissively, most notably on major project irrigation.

The "induced" shortages which are necessary in order to spare water for larger acreages in Maha and in order to save more water for Yala can only be achieved if it is made rational for those controlling water to issue less water than cultivators and groups of cultivators demand. This requires two complementary measures, neither of which would be likely to work on its own: first a rigorous tightening of scheduling and levels of issues by the TCEO, working out with the Government Agent, the District Agricultural Extension Officer and representatives of cultivators, issue schedules and water duties for all major irrigation works; and second, sustained and visible support for tighter systems of control from the very highest political level.

The Opportunity

This paper leaves some questions unanswered. But it does suggest that there is an opportunity through better water management to increase acreages cropped and yields. It is an opportunity, in economic terms, to substitute political will for foreign exchange. The opportunity has not been as clear before because of the earlier relative ease of importing food and fertiliser. In the deepening world and national economic crisis, the opportunity seems, at the very least, to deserve early and serious investigation, perhaps through pilot projects with representative major irrigation tanks.

WATER MANAGEMENT AND PADDY PRODUCTION IN THE DRY ZONE

Robert Chambers

"What is there that cannot be done in this world by men of perseverance? "

King Parakramabahu the Great in the Mahavansa quoted in Brohier 1934:8

THE NEGLECT OF WATER MANAGEMENT

Water managment in irrigated agriculture has been receiving increasing international attention. In March 1973, for example, the Director-General of FAO said that as countries were compelled to turn towards increasing the productivity of land already under cultivation, more intensive agricultural techniques had to be adopted, and " probably the most important of these is the more effective use of water resources, since water is often the main factor limiting the potential for increasing productivity " (SID 1973). In Asia and the Far East this priority has been explored by FAO through a series of seminars on water use and management at the farm level held in Thailand, Korea, Japan, and, in June 1973, in Sri Lanka. In opening the latter, the Minister of Irrigation, Power and Highways mentioned the ancient irrigation works of Sri Lanka and the very stringent laws for distribution of water and cultivation practices which once prevailed. He gave as his opinion that the disaster of the previous Dry Zone Maha (Northeast monsoon) season, when there had been a severe shortage of water towards the end, could have been overcome with careful and efficient use of water. And he made the frank admission that

> " Over the past few decades the government has been spending increasing amounts of money for new works as well as for the restoration of ancient works. I am afraid, however, that while we have been devoting a great deal of care and attention on the major engineering works, we have not paid sufficient attention to the use of water at the farm or farm water management, which should form an integral part of the design and operation of an irrigation project. "

(Ceylon Daily News, 20 June 1973)

This paper, in trying to explore the potential of water management in the Dry Zone of Sri Lanka has, however, a slightly wider set of concerns, including the systems of distribution and drainage of water from the sources of supply as well the use of water at the farm and farm water management. The purpose of the paper is to try to see what potential there may be for increasing food and particularly paddy production through improved water management, and what organisational implications there would be in trying to realise that potential.

It is useful and salutary to begin with a review of some of the publications in fields related to water management. As observed by the Minister, the subject has been neglected. In the two valuable publications of the Ceylon Association for the Advancement of Science - the proceedings of symposia on, respectively, Research and Production of Rice in Ceylon (Abeygunawardena, ed., n.d. (1966)) and Development of the Dry Zone (Pieris ed., n.d. (1967)) there is no article among the 44 presented which directly tackles water management in Dry Zone conditions as its explicit central theme, although some of the papers, notably those by Murakami and Vignarajah and by Wyatt in the first volume and that by Alles in the second are useful and relevant contributions to the subject. In the Report of the Gal Oya Project Evaluation Committee (Republic of Sri Lanka 1970) the focus is on an ex post cost benefit analysis although the concluding recommendation, that it would be more rational to give priority to schemes for improving existing irrigation rather than undertaking major new investments, implies a movement towards water management (ibid:57). The same cannot be said of a report on Organisational and Management Requirements for Agricultural Development in Ceylon (FAO 1970) which, whatever its other merits, does not even mention the word water let alone consider water management. A government case study of staggered cultivation of paddy (MOAL 1972 c) moves closer to the subject but still does not discuss details of organisation and procedure at the lower levels of government organisation and with the farmer at the field level. Nor is M.W.J.G. Mendis' book, The Planning Implications of the Mahaweli Development Project concerned with the operation of the irrigation side of project, but rather with physical and regional planning, with, in the author's own words "An overall perspective for integrating .... development activities" (1973-1-29); it is then not surprising to find that Mendis' recommendations do not touch on water management. If other papers and reports are similar, the conclusion will stand that until recently water management has not been perceived as an area of priority attention and that it has been approached usually as an aspect or extension of a study of something else.

This may be understandable and proper in works with limited objectives or constrained by their terms of reference. It is much less justifiable in the final and finished work of a multi-disciplinary team considering the feasibility of a large and expensive irrigation project. The Final Report of the UNDP/FAO on the Mahaweli Ganga Irrigation and Hydro-power Project (UNDP/FAO 1969) is remarkable for its failure to see and grapple with the problems and opportunities of water management. The Report observes that water is more limiting than land in the project area: 900,000 acres, it estimates, can be irrigated out of a total of 1,500,000 suitable for irrigation but for which the water will be inadequate (ibid. Vol.1:55-6). It might be thought that this fact combined with the stipulation in the terms of reference that the survey should, among other things "Examine past and present land settlement policy in Ceylon, and the organizational and management problems in irrigation and settlement schemes arising from those policies" would have required detailed recommendations for the organisation of water management at the lower levels. In fact, however, there is little in the three volumes of the Report that can be considered even a preliminary approach to that subject. The emphasis of the volume on "Organisational and Management Requirements" (ibid. Vol.3) is on infrastructural development, human settlement and organisational structure, to the neglect of operational requirements and procedures. Moreover, it is odd that a major survey of a project, a central feature of which is the supply of water for agriculture, should treat improved seed, fertilizer, other agro-chemicals, tractors and equipment as inputs, but not water. 8 pages are devoted to the supply of these inputs, 7½ to marketing, a further 7½ to agricultural credit and co-operatives and 8½ to agricultural research, extension and education. Apart from tangential references to the need for optimal water use and to staff who would be responsible for it, the main presentation on water management is less than one page dealing with administration at the lower levels, mentioning structural, but not operating, arrangements, (ibid. 72-3). The neglect of this subject as a focus can, however, most easily be illustrated from the table of contents. The volume on "Organisational and Management Requirements" has 5 chapters and 39 headings, of which only one can be construed as related to Water Management, and that refers to three sentences on water charges, without any mention of administrative arrangements. It may be quoted as an example of the persistent failure to recognise the complexities of water management and of the organisational requirements for it. The section reads:-

" 6. Water charges

There is no tradition in Ceylon of payment for irrigation water supplied by the Government.

In the first five years the settler should be asked to make a nominal payment to the Government, but thereafter he should be required to pay the annual maintenance and operating costs of supplying irrigation water. The basis for making these charges should be on the amount of water used, in order to prevent water wastage and promote crop diversification"

How the water is to be measured, the charges assessed and the dues collected is left to the imagination of the reader.

More recently, the papers of the FAO seminar on water management at the field level have begun to open up the subject. Recent research on water application was reported by Lewis (1973) and Sivanayagam (1973) among others. Organisational aspects were described and commented on by Senthilnathan (1973) and Houghton and Rajanayagam (1973) presented a clear, convincing and distressing outline of the current practices of water management on the Gal Oya scheme. In spite of these and other papers, there appears to have been a constellation of overlapping gaps, corresponding no doubt with gaps in perception and research. Buddhadasa, for example, in taking an engineer's view of "Design and Operation of Irrigation Canal Systems" (1973) only mentions the human side of water management in the sentence. "The cropping patterns are selected by the farmers' organisations with the advice of the project personnel" (ibid. 12). He deals with what is required in terms of duties and flows; but not in terms of who does what. "Operation" of an irrigation system in this engineer's sense is limited to the movement of water and does not extend to the behaviour of people. This is but one example perhaps unfairly singled out. But in general, the gaps in perception and research revealed by the papers correspond with the gaps between the engineer and the agriculturalist, between the research station and the field, between the senior civil servant based in the capital city and the junior civil servant at the periphery. And in the middle of these gaps lie the day to day problems and practices of handling and distributing water and using it under field conditions, that is, the operating and human aspects of water management.

One reason for the neglect of the crucial operating aspects of irrigation projects may be the common human preoccupation, sometimes almost obsession, with the capital investment, construction and settlement processes to the neglect of the vital routines of operation which follow. Capital investment, construction and settlement are immediate, exciting and once-for-all, and attract special energies. Further, just as the ancient kings gained fame for the tanks they built, so too may the leaders and engineers of today wish to leave behind them great and enduring works which bear their names down to posterity. But all too easily the construction of more and more works can become the political and psychological equivalent of chena[1] cultivation: an effort is made, something is done, but then nature is left to take over - the jungle of vegetation in the one case; the jungle of inter-organisational and inter-personal confusion and discord in the other.

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[1] The form of shifting or semi-permanent non-irrigated cultivation practised in the Dry Zone.

Chena cultivation may be rational for a cultivator with short time-horizons and with low investment; but with major irrigation works time horizons should be long in view of the high investment costs incurred, and returns to the investment depend critically on the levels of management which are maintained. It may be far easier to sustain an impetus for new capital works on a grand scale, as Parakramabahu the Great did, than to sustain high levels of efficient and disciplined management of the water which they make available. Psychologically and politically it is far more palatable and far easier to build a new project than it is to make an old one work well. But it is in operation, not construction that the greater challenge lies; and also the greater opportunity.

A second reason is cramped vision from within narrow disciplinary boundaries, themselves further restricted by the blinkers of what is considered respectable research methodology. One may thus feel sympathy for the sociologist with the UNDP/FAO team engaged on preparing the Mahaweli Ganga Final Report. As might be expected, he conducted surveys: one of people in colonisation schemes; and one of colonisation officers. As so commonly with surveys, it may then have been impossible, for lack of time or resources, to follow up on the leads thrown out. Yet at least three of his survey findings pointed straight at lower level water management as a concern. First, when people were asked "What more do you want the administration to do for you? ", a majority mentioned better irrigation facilities; and in reporting this, he comments "It seems that the functions of the Irrigation Department need to be looked into in the colonies". (Barnabas 1967:56). Second, when Colonisation Officers were asked what their allotted functions were, by far the highest response (85 per cent) was "issues of irrigation water" (*ibid:* 79). Third, again in the survey of Colonisation Officers, he reported "As for facilities it was surprising to know that almost one fourth asked for better irrigation facilities" (*ibid:* 83). Yet the implications of these findings were not followed through. Arrangements for distributing water were dealt with in two vague sentences

> "It will be up to these organisations (It is not clear from the text which organisations) to get the cooperation of the people in the economic use of water, to pay the due water rates and other dues. The administrative staff particularly the Colonisation Officer and the Co-operative department should help them in this activity" (ibid:116).

Finally, a summary at the end of the report lists 23 recommendati ns, none of which mentions water.

This example illustrates this second reason - the confining nature of disciplinary boundaries - for the neglect of water management. For it is a no man's land between disciplines. Some other no man's lands, such as colonisation schemes or land reform, can fairly safely be explored and occupied by social scientists who can feel themselves, as it were, on fairly solid ground. But the issues in water management for irrigated agriculture are so closely tied in with the insights and techniques of engineering, hydrology, climatology, soil science and agronomy, that the prudent social scientist may perhaps be excused for backing away. What has happened, it seems, is that everyone has held off: the engineers, hydrologists, climatologists, soil scientists and agronomists have as much hesitated to follow their noses into the realms of sociology, management, economics and political science as the social scientists and others have discretely avoided trespassing in the mine-fields of engineering and the physical and biological sciences. As I have found to my cost, starting with water management as the centre of concern is bewildering; for one is faced with branching paths leading off in many directions, each of which has to be explored and plotted before returning again to the centre. In the case of the Dry Zone in Sri Lanka, I have been fortunate in the depth and extent of the work that has been done and written up intelligibly for the layman. But the degree to which I have failed to come to grips with and place in order the many relevant aspects will, I fear, become painfully obvious to any reader who is persevering enough to follow through this paper to its conclusion.

A third and most intriguing reason for the neglect of water management may be the awkward nature of water itself. Land stays still (usually) and can easily be measured. Water in contrast cannot be relied on to stay in one place and is much harder to measure. It flows, evaporates, condenses, transpires, percolates, seeps, scours banks, and deposits slit. It is brought into and removed from the field enviornment by the weather in a singularly unpredictable fashion. As a result, those who study water and who try to handle it have their research capacity heavily taxed with quite limited tasks such as measuring flows, or evaporation, or percolation. It is small wonder that they do not have time or energy to spread their work into the domains of other disciplines.

SCOPE, PURPOSE AND VALUES

Lack of exploration outside disciplinary boundaries is justified and reinforced by implicit definitions of water management. It means very different things to different people. For engineers it describes the processes of control which are exercised over the collection, storage, distribution and drainage of water. Their interest in water management is largely concerned with surveying, design, construction, structures, volumes, and flows. What happens beyond when the water comes into contact with cultivators, is a realm they do not wish to know about: it does not conform to their precise laws and its annoying and unpredictable behaviour is described and dismissed as "peoples' problems" and (as in some engineer-dominated feasibility studies) as "social constraints" (see for example Huntings on Uda Walawe c. 1968). For agriculturalists it describes the supply and control of water required for a growing crop. Whereas spatially the engineer's concern is mainly with those areas where there are larger structures, the agriculturalists' concerns focus inside the fields. (It may be noted in passing that there is commonly a physical gap between the end of the engineer's responsibility where water enters a field channel and the begining of the agriculturalists' concern - the point at which water enters the cultivators' fields. Not surprisingly this corresponds with a yawning research gap.) For economists water management is related to the benefits and costs of alternative water uses, and the efficiencies of water use measured as a cost against benefits in terms of various outputs. For hydrologists-geographers, water management primarily concerns the relationships between water in different environments - groundwater, surface water, rain water and interchanges between them. For sociologists, water management may be seen in terms of the social processes and relationships associated with the distribution of water. To the political scientist, water management may be seen primarily in terms of processes in which resources are authoritatively allocated between people. To the management consultant, water management might been seen in terms of functions requiring the design and introduction of forms of organisation and procedures. To geographers ...... but notwithstanding possible reservations (see for example Lipton 1970:15), it may well be that geographers are the best equipped of all to handle this subject, able as they are to move with a fair degree of ease and fluency through the territories of both the social and the physical sciences.

It seems reasonable to conclude that no one person can combine in himself all the professional expertise adequately to analyse problems and opportunities in water management in irrigated agriculture. Also, any mono-disciplinary analysis is likely to stop so far short of the central issues and to leave out so much that it will be of doubtful use unless combined with other studies. One prescription from these rather intimidating and depressing assertions might be that a large-scale integrated multi-disciplinary research project should be mounted. Perhaps it should. But in the meantime, on the principle that the easiest inter-disciplinary collaboration takes place inside the same head, the rash approach of this paper is to start from the centre of the no man's land moving outwards as necessary but trying to avoid going off into remote, if fascinating, orbit. If this does no more than provoke others to point out the errors of my perceptions and conclusions and thereby draws them towards that same centre, it may prove justified.

The centre is defined as those aspects of water management in irrigation the inter-relationships between which have so far, to the best of my knowledge, been largely unexplored: these include the closer definition of the technical imperatives in the distribution and application of water; the human management and organisational aspects of water distribution, both in the government bureaucracy and at the community level;

the geographical area from the point at which water is issued from a sluice to the point at which it enters a cultivator's field; the micro-politics and decision processes of water management; and, throughout, a perspective firmly based upon the concept of water as a scarce resource complementary to other scarce resources.

Against this background, water management can be defined for the purposes of this paper as the control and operation of the distribution, allocation, application and drainage of water, from the source of supply to the end of the drains. In this definition " the source of supply" refers to anicuts wherever they exist (including anicuts which feed channels to tanks) and to sluices from tanks where there are no anicuts.

In seeking to examine this area this paper attempts to draw conclusions and make prescriptions. But its scope is limited in several respects. It is very largely confined to paddy production and to the Dry Zone of Sri Lanka. Much of the evidence on which it is based comes from Hambantota and Moneragala Districts and from the Gal Oya and Uda Walawe Projects; although some attempt has been taken to assess the validity and relevance of the conclusions for the rest of the Dry Zone and particularly for the Mahaweli Ganga Project. The paper is concerned only with water distribution systems and does not consider alternative sources and systems of water supply, although as Bandara (1973) and Fernando (1973) have persuasively argued there is considerable potential from groundwater in the hard rock areas, and there is obviously much room for increasing and improving the supply and storage side of irrigation. These however are longer term issues, modifications to the organisation of distribution as advocated below can be undertaken more quickly. A further limitation is that micro-level decisions and problems as they occur at field level are not discussed in any detail in this paper any more than they were in the papers of the 1973 seminar: they must await their own research. Nor are the engineering and water control aspects of different types of structures considered.

What the paper does seek to begin to investigate is the relationship between on the one hand the technical requirements, imperatives and potential of paddy irrigation in the Dry Zone and on the other social, administrative and political institutions and procedures based on those requirements and imperatives and which might realise some at least of that potential. The approach resembles that of an economist-cum-political scientist.

The values which underlie prescriptive writing about development should, as Myrdal has argued (1968:31-4) be made explicit. In the case of this paper they can be expressed in terms of three policy-objectives.

The first is food production for Sri Lanka. In 1974 this scarcely requires justification. About one-third of the country's rice requirements are imported when it is technically possible for them to be provided entirely from domestic agriculture. It is true that effective demand may be static or even declining as declining real incomes offset the demand effects of population growth, but a large gap between demand and domestic production is likely to persist. Despite the frequent prognostications of self-sufficiency in rice by certain (receding) target dates, the immediate prospect, with declining and small supplies of fertilizer and agro-chemicals for the paddy sector, and in the absence of some major countervailing tendency such as sharp price response by producers, is of greater difficulty than ever in moving towards this target. A central concern of this paper is then to see whether and to what extent improved organisation and operation of water management could increase food, and especially paddy, production.

The second objective is closely related, but partly distinct: the saving of foreign exchange. The extremity of the crisis that now faces Sri Lanka is difficult to grasp. According to newspaper reports of estimated foreign exchange earnings in 1974, half would be needed to maintain imports of oil at 1973 levels, and much more than half for food imports, let alone capital equipment, newsprint, drugs, raw materials for local industries, agro-chemicals, pesticides, and other items. As early as November 1973, before the magnitude of the crisis was evident, a new way of thinking was already envisaged in the Sri Lanka country statement to the Seventeenth Conference of FAO:

> "...we think that the correct perspective, at least as a transitional phase, is for us to organize our farming in such a way that we consciously limit and contain the quantities of imported inputs that we will use in our agriculture .... The adoption of these policies must necessarily mean a reordering of our research and extension services as well as introducing changes in the pattern of farming. We are conscious of the fact that very high levels of productivity per unit of land or labour can be obtained only by the managed application of very high levels of inputs. The acceptance of this scientific truth will not deter us from accepting the challenge of the present times that our agriculture must rest on the lowest possible levels of imported inputs." (Debates 1973: col.815)

The question arises to what extent water or water management can be substituted for imported inputs at present used in food, and especially paddy production.

The third objective concerns equity. Irrigation systems are notorious for the way in which their physical layout favours some and penalises others. Attempts to mitigate such inequalities often conflict with the criterion of production. Nevertheless, in line with national values and my own, some weight is given in this paper to fairness in the distribution of water and access to it.

The reader is asked to understand and tolerate the directness of the unsolicited recommendations with which the paper ends in the light of the current economic situation. I write with some reticence as a foreigner who has lived and worked in Sri Lanka for no more than a few months and who cannot speak Sinhalese. It would be safer to write a purely academic paper. But given the economic abyss which faces the country, the probable severe shortage of the inputs on which the green revolution strategy has been based, and the absence of any prior studies which have combined the economic, organisational and political aspects of water management with the technical imperatives, it would be irresponsible not to come out forthrightly with what I believe is a relevant and practicable set of prescriptions. In deriving these I have, drawn an experience with the organisation of paddy irrigation elsewhere, especially on the very successful Mwea Irrigation Settlement in Kenya (Chambers and Movis 1973) where cultivators have for a decade averaged over 110 bushels per acre. But the great bulk of the evidence is from Sri Lanka, and the recommendations are tailored to Sri Lanka conditions.

Perhaps I may also be forgiven for feeling inhibited by the immemorial experience with the problems of irrigation and paddy production in Sri Lanka. I have had the feeling in writing this paper that I am moving over ground which is well known and which has been moved over many times before. Again and again, in reading and discussions, I have been struck with the age and familiarity of problems. One reads, for example, in Senewiratne and Appadurai's work <u>Field Crops of Ceylon</u> (1966:8), that "Self sufficiency in rice has been the declared objective of Agricultural policy in this country for many decades and numerous measures have been adopted in an attempt to realise this goal with varying degrees of success".

The same might as well have been written today nearly ten years later. But what is different today is the acuteness of the impending & deepening economic crisis, the grave threats to the green revolution high-input strategy, and the new official emphasis on water management. These do at least suggest that this may be a good time for a fresh look.

* * *

THE CONTEXT: THE DRY ZONE AND PADDY PRODUCTION

The characteristics of the Dry Zone have been described by a number of authorities (e.g. Farmer 1957; various authors in Pieris ed. n.d. (1967); and Mendis 1973). We need not concern ourselves here with problems of definition of the Dry Zone except to note that the simplest is that area which lies below the 75 inch isohyet, very roughly two-thirds of the island. For the purposes of this paper it is necessary to deal with figures which are available on a district basis. We therefore rather crudely take 12 districts as comprising the zone for our statistical purposes. These districts are Puttalam, Kurunegala, Moneragala, Jaffna, Vavuniya, Mannar, Anuradhapure, Polonnaruwa, Trincomalee, Batticaloa, Amparai and Hambantota. In addition, Walawe appears in some tables as it is treated as a district for agricultural statistical purposes.

The rainfall in these districts for the two main seasons of paddy cultivation - Maha (Northeast Monsoon) and Yala (Southwest monsoon) are shown in the table:

TABLE 1. **DRY ZONE SEASONAL MEAN RAINFALLS**

District	Representative station	No. of years of records	Mean Rainfall Maha	Yala	Annual
1. Puttalam	Tabbowa (552)	59	31.61	14.13	50.99
2. Kurunegala(1)	Kurunegala (302)	88	37.23	33.46	81.69
3. Moneragala	Okkampitiya (436)	32	35.5[illegible]	12.69	69.15
4. Jaffna	Jaffna (215)	102	41.53	7.76	52.34
5. Vavuniya	Nedunkenie (420)	76	44.91	12.56	62.42
6. Mannar	Murunkan (402)	75	32.18	7.99	43.78
7. Anuradhapura	Marandankadawala (355)	84	32.42	11.03	58.32
8. Polonnaruwa	Polonn. Agr. (487)	33	39.1	10.2	n.a.
9. Trincomalee	Trincomalee (576)	103	42.64	13.08	67.98
10. Batticaloa	Batticaloa (n.a.)	104	49.50	7.76	67.12
11. Amparai	Amparai Tank (18)	87	50.58	11.47	73.97
12. Hambantota	Hambantota (168)	104	21.0	10.1	42.34
13. Walawe	Embilipitiya (tank) (128)	57	30.7	11.7	57.98
	Means of all stations:		37.61	10.87(2) 12.61(2)	60.67

(1) The southern part of Kurunegala is, however, in the Wet Zone.

(2) 10.87 is the mean without Kurunegala.
12.61 is the mean with Kurunegala.

Notes: For stations 1, 2, 4, 5 and 6 Maha is taken as October through February and Yala as April through August.

For stations 3 and 7 - 11, Maha is taken as November through March and Yala as May through September.

For stations 12 and 13 Maha is taken as November through March and Yala as May through September.

Figures in brackets are rainfall station serial numbers.

(I am much indebted to W.S. Alles for the information on which this table is based and for advice from him and A.S. Ranatunge about the appropriate seasonal intervals).

Somewhat arbitarily for the purposes of this paper the Kurunegala Yala rainfall has been excluded since it is so sharply different from other Yala rainfalls. Mean rainfalls are taken, in crude terms, as being 3.1 feet in Maha and (after the removal of Kurunegala) 0.9 feet in Yala. Median rainfalls would be slightly less than this, and would be more appropriate for most of the calculations which follow. But they would not upset the conclusions which are based on orders of magnitude.

The irrigation systems of the Dry Zone can be described and classified in various ways including by source of water, whether from a stream or river with an anicut or whether from a tank; according to reliability; and according to the normal division into "major" and "minor". Since the main concern here is with organisation, the classification is based upon organisational implications. Here the most important dimension appears to be physical size. There are, admittedly, substantial differences between perennial flow irrigation (such as Uda-Walawe Left and Right Bank Schemens)[1] where a continuous flow from an anicut is led into channels which are then, in theory at least, assured of water; and the more typical tank storage irrigation in which a fixed amount of water may have to be eked out throughout a cultivation season. But in practice the operation of these two systems is remarkably similar if their scale is similar: both suffer the same problems of channel maintenance, of excessive off-take high up the channels to the detriment of cultivation lower down, and of delays in water reaching the tailend where it is often late and too little. The classification adopted here is based upon scale and its associated type of organisation:

1. Not to be confused with the Uda Walawe Project, which is upstream.

(i) major project irrigation. This includes the Gal Oya, Uda Walawe, and Mahaweli Ganga Projects. These differ in that Uda Walawe and Gal Oya are both storage reservoir projects liable to water shortages while the Mahaweli Ganga Project relies to a greater extent on continuous flow and may not have the same problem of shortages. Nevertheless the scale of organisation and the dangers of overdemand resulting from excessive water use are common to them all.

(ii) major irrigation. These are irrigation works from which the release and distribution of water is controlled by the Territorial Civil Engineering Organisation. They are distinguished from Minor Irrigation normally by the presence of government staff with responsibilities for controlling flows down to a point in the channel system where control is handed over to the cultivators represented, at least in theory, by a Cultivation Committee.

(iii) minor irrigation. These are irrigation works from which the issue of water is controlled by members of the community which uses it.

In describing distribution systems, canals, branch canals, and distributaries are used to refer to the hierarchy of channels under major projects and major irrigation which are controlled by a government organisation, while field channels are those under major project and major irrigation which are controlled by the Cultivation Committee. Under minor irrigation all channels are field channels. The handover point is the point, typically a gate, at which water is issued from the government-administered part of the system to the part administered by the Cultivation Committee. In describing paddy tracts, the term yaya is used to refer to a continuous tract of paddy land served by one handover point.

In the twelve Dry Zone Districts the asweddumized acreage in 1971 was reported to be about 990,000 acres (MOAL 1972 a-sum of district figures). This was a 7 per cent increase on the figure for 1968 suggesting an annual growth rate of about 2 to 3 per cent. However only about two thirds were under major or minor irrigation, the remainder being rainfed and thus beyond the scope of this paper. More recent estimates can be inferred from the targets for 1974 (MOAL 1973b) which are broken down into major, minor and rainfed by district. The Dry Zone districts sum to :

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	Maha 1973/74 target acres	Yala 1973/74 target acres	
	000		000
Major Irrigation	392	258	650
Minor Irrigation	227	82	309
Rainfed	285	43	328
	904	382	1,287

(not all figures sum because of rounding)

Perhaps these lower figures giving a total of 904,000 acres are to be preferred to the earlier higher ones.

Reported yields (MOAL 1973a) taken as an unweighted average for the 12 Dry Zone Districts, omitting Mannar for which data are incomplete, over the 5 year period from Maha 1967/8 to Yala 1972 are:

Maha 48.9 bushels per acre

Yala 49.4 bushels per acre

This contrasts with the higher yield potential of Yala than Maha. The most obvious explanation (apart from possible unreliability of the statistics) is that although yields in Yala may be higher in a good year, risks are also higher and the average is dragged down by years in which there is damage from water shortages.

Nationally, reported yields rose during the 1960s from between 30 to 40 bushels per acre to between 40 to 50 and occasionally over 50 bushels per acre. As the table reveals, insofar as the figures are reliable, more of the increase in production reported can be attributed to an increase in yields than to an increase in acreage asweddumized. This was in accordance with the strategy of introducing higher-yielding varities and improving the supply of inputs to farmers, though improving the water supply through water management does not appear to have been a significant part of this approach.

Table 2. NATIONAL PADDY PRODUCTION STATISTICS 1963 - 1973

Year	Season	Asweddumized area acres 000	Sown area acres	Gross Harvested area acres	Yield per acre bushels	Production in 000 bushels	
1963-4	Maha	1,249	1,014	980	38.60	32,149	50,506
1964	Yala		572	555	38.92	18,357	
1964-5	Maha	1,273	985	796	34.11	23,070	36,252
1965	Yala		471	447	34.70	13,182	
1965-6	Maha	1,323	1,050	1,007	35.91	30,739	45,787
1966	Yala		567	505	35.04	15,048	
1966-7	Maha	1,331	1,054	1,006	40.84	34,900	54,917
1967	Yala		583	561	42.01	20,017	
1967-8	Maha	1,349	1,147	1,078	47.49	43,509	64,593
1968	Yala		596	556	44.59	21,084	
1968-9	Maha	1,385	1,182	1,079	51.23	46,962	65,860
1969	Yala		527	461	48.24	18,898	
1969-70	Maha	1,408	1,191	1,115	52.21	49,492	76,447
1970	Yala		684	661	49.78	27,955	
1970-1	Maha	1,419	1,147	1,089	44.90	41,560	66,895
1971	Yala		646	625	47.66	25,335	
1971-2	Maha	1,448	1,186	880	48.09	42,327	62,720
1972	Yala		608	551	43.54	20,393	
1972-3	Maha	1,440	1,179	1,085	45.54	42,004	62,900
1973	Yala		613	575	42.78	20,896	
1973-4	Maha	1,498	1,318	1,288	47.72	52,629	

Sources: DCS 1972: 61, MOAL 1973a, and communications from MOAL.

Note: Production is calculated by multiplying nett extent harvested by yield. The nett extent harvested in Maha 1973/4 was 15 per cent less than the gross extent harvested.

There are reasons for treating the yield figures with care. The Statistical Abstract of Ceylon - 1969 warns us of the crop-cutting survey on which the figures are based: "Due to certain operational difficulties in the conduct of the survey for estimating the yield of paddy, it is likely that a certain amount of bias of a non-sampling nature may have entered into the results of this survey. It is therefore suggested that the trends indicated in these figures be treated with a measure of caution" (DCS 1970: 113, 114, 115). Nevertheless there are many reasons (declining food imports, increased fertiliser use, the spread of higher-yielding varieties, higher agro-chemical use) for supposing that yields did substantially increase and gross national production of paddy with them. It is important, however, to bear in mind that the production figures are vulnerable to distortion either from reported nett harvested areas or from reported yields, or from both, since these are the figures from which they are calculated.

With these reservations, the paddy production figures can be set against imports of rice to obtain an impression of the gap between production and self-sufficiency.

Table 3. RICE IMPORTS AND DOMESTIC RICE PRODUCTION.

	Rice Imports 000 tons	Domestic Rice Production 000 tons	Total 000 tons
1964	549	721	1,270
1965	575	518	1,093
1966	547	654	1,203
1967	372	786	1,158
1968	388	923	1,310
1969	249	941	1,189
1970	526	1,092	1,618
1971	334	956	1,290
1972	262	896	1,158
1973	377	881	1,258

Sources: Karunatilleke 1971: 311 for 1964 - 1970: Central Bank of Ceylon 1973: 218 for imports 1970 - 2; and own calculations for domestic production for 1970 - 2 based on Karunatilleke's assumption of 32 lbs. of rice from a bushel of paddy; personal communication - W.P.T. Silva for 1973.

A number of different estimates converge on 90 million bushels of paddy as the current annual level of consumption. To achieve self-sufficiency in rice, however, it would probably be necessary to exceed 90 million bushels because consumption would increase as self-suffiency approached (because of probable increases in the rice ration, if for no other reason and because of increased demand from the growing population). At the same time, until Maha 1973/4, production had been on a plateau of between 63 and 67 million bushels for six years, with the exception of 1969/70 when 76 million bushels were reported to have been produced. As a rough order of magnitude it is perhaps reasonable to guess on the basis of these figures that self-sufficiency in rice requires the production of an additional 25 million bushels of paddy.

We can now appraise the position of the Dry Zone in paddy production. Taking the two most recent seasons for which figures are available - Yala 1973 and Maha 1973/4, Table 4 shows the contribution of the Dry Zone districts to the national totals. Taking these

Table 4. Dry Zone Paddy Production in Yala 1973 and Maha 1973/4

,000 bushels

	Yala 1973	Maha 1973/4	Total
Puttalam	215	804	1,019
Kurunegala	2,789	4,670	7,459
Moneragala	168	1,070	1,238
Jaffna	315	2,860	3,175
Vavuniya	58	1,840	1,898
Mannar	94	2,270	2,364
Anuradhapura	849	5,710	6,559
Polonnaruwa	2,161	4,830	6,991
Trincomalee	272	2,080	2,352
Batticaloa	694	3,070	3,764
Amparai	1,946	3,740	5,686
Hambantota	1,010	3,390	4,400
Dry Zone Total	10,571	36,334	46,905
National Total	20,896	52,630	73,526
Dry Zone as a percentage of national total	51	69	64

Source: Communications from MOAL

Note: Hambantota for Maha 1973/4 includes Walawe. No separate figures were given for Walawe for Yala 1973, for which season Walawe production is assumed to be included in other districts' totals.

two seasons together, the Dry Zone was reported to have produced 64 per cent of the national total. Figures for the breakdown of reported production for the Dry Zone Districts are available only for Maha 1973/4. These are given in Table 5.

Table 5. DRY ZONE PADDY PRODUCTION MAHA 1973/4 BY TYPE OF WATER SOURCE

PRODUCTION IN ,000 BUSHELS

District	Major Irrigation	Minor Irrigation	Rainfed	Other	Total
Kurunegala	840	1,500	2,330	–	4,670
Puttalam	200	390	120	130	840
Moneragala	420	340	140	170	1,070
Jaffna	1,380	60	1,380	40	2,860
Vavuniya	450	740	500	150	1,840
Mannar	1,250	330	180	510	2,270
Anuradhapura	2,260	2,900	350	200	5,710
Polonnaruwa	3,790	460	400	180	4,830
Trincomalee	1,070	190	620	200	2,080
Batticaloa	1,040	20	1,770	240	3,070
Amparai	2,680	160	710	190	3,740
Hambantota	1,810	420	140	–	2,370
Walawe	1,020	–	–	–	1,020
Total	18,210	7,510	8,640	2,010	36,370
Percentage of Dry Zone Total	50	21	24	6	101
Percentage of National Total	35	14	16	4	69

Source: Communication from MOAL.

They show that for that season major irrigation was responsible for 50 percent of the Dry Zone total, 35 percent of the national total, while major and minor together were responsible for 49 per cent of the national total. This was, however, an exceptional season. But in general, in order to have an idea of orders of magnitude, it may be reasonable to conclude that the Dry Zone normally produces rather more than three-fifths of the national total, and that major irrigation in the Dry Zone produces rather more than one third of the national total.

The question which we have to consider, and to which we will return at the end of this paper, is to what extent improved water management in the Dry Zone might provide a means for reducing the production gap and moving towards the goal of self-sufficiency.

A CHANGE IN THINKING : THE PRODUCTIVITY OF WATER

In order to answer this question we must adopt a slightly unconventional way of thinking.

The historical record over the years reveals intermittent references to water as a scarce resource. There is the much-quoted statement by King Parakramabahu the Great that:

> "In a country like unto this not even the least quantity of water that is obtained by rain should be allowed to flow into the ocean without profiting man."

More recently Farmer observed that "one of the most urgent tasks if Ceylon's water resources are to be used to the best advantage is to arrive at more economical use of irrigation water." (1957:184). A further example can be taken from the ILO Mission which identified as the next main task in agricultural production "to intensify land use ..... and to economise water"(1971a: 102). Perhaps the fullest statement is Wyatt's axiom (Abeygunawardena ed. n.d. (1967) 163-166), the core of which is contained in the words

> "The ultimate development of agriculture in Ceylon depends on the development of agriculture in the Dry Zone.
>
> The ultimate development of agriculture in the Dry Zone depends on the water available for irrigation. There is more irrigable land in the Dry Zone than there is water to irrigate it. Therefore the ultimate development of agriculture in the country is limited to the optimum use of the irrigation water available."
>
> (ibid., 165)

The UNDP/FAO Final Report on the Mahaweli Ganga Project supports this axiom in the case of the largest irrigation project with the largest volume of water.

It says:

> "The surveys of the Scheme have revealed that soils suitable for irrigation extend over an area of about 1.5 million acres. The water resources available after full development (about 5.6 million acre feet per year) would however only be enough for year-round irrigation for about 0.9 million acres. In other words, the limiting factor is the availability of water and not of land."
>
> (UNDP/FAO 1969 : 55-56)

Finally, Alles in his seminal article written seven years ago on "Soil and Water Conservation in the Dry Zone" anticipated much of the reasoning which follows, arguing that water should be treated as an input with economic value. (Pieris ed.n.d. (1967) : 52-3).

It is, however, oddly difficult to pursue this line of thinking through to its logical conclusion, and then having reached it, to remain there. The issue may be stated simply. We are concerned with the relative scarcities of two resources necessary for agricultural production - land and water. Wherever irrigation is not practised, land is a proxy for water, which comes from rainfall: the more land, the more rainwater. In thinking about yields per unit of land we are then also thinking about yields per unit of water, since the first subsumes the second. But with irrigated agriculture, the position is different. Where water limits production more than land, then productivity should be thought of and expressed primarily as yields per unit of water. In the first situation, without irrigation, land is water-augmenting: that is, the water available for agriculture can be increased automatically by increasing the area of land cultivated. In the second case, with irrigation, the position is reversed: water augments land. The land available for agriculture can be effectively increased (i) by increasing the water available or (ii) by more sparing applications of water, either of which provides a surplus for use on additional land or for taking additional crops off the same land.

This is so simple and so obvious that it is at first sight extraordinary how rare it is for economists, engineers or agricultural scientists to think in terms of yield per unit of water. When the word "yield" is used, it is almost always assumed to refer to yield per acre of per hectare. Two recent examples from many illustrate this point. First, Gunadasa (1973) in a paper which breaks out of conventional per unit area concepts in paddy intensification, and considers returns to captial and returns to labour, nevertheless never mentions returns to water. Second, Ladejunsky, in a recent article summarises his point of view as "In brief, the green revolution stands for producing more food and other agricultural products from less land" (1973:A-133). The attitudes of both writers are valid for many environments, including, for example, the Wet Zone of Sri Lanka where water is often too abundant, and for all rainfed conditions. They are misleading for those irrigation conditions where it is not land but water that is more limiting.

These are, however, the conditions prevailing in most of the Dry Zone in all three types of irrigation - major project, major and minor.

Under major project irrigation, not only will water be more limiting than land under the Mahaweli Ganga project, but it has already proved so under current levels of management on the Gal Oya and Uda Walawe Projects. At Gal Oya some 20,000 acres which it was originally intended to irrigate have not been brought under cultivation[1] and there are shortages of water at some of the lower edges of the scheme (Houghton and Rajanayagam 1973:4 (MOAL 1972c: 8-9 and 39). Moreover, of the paddy acreage under command at Gal Oya about one third to one half remains uncultivated each Yala[2]. The situation at Uda Walawe is if anything a more marked example of water, rather than land, shortages. In each of Maha 1972/73 and Yala 1973 only some 11,000 acres of paddy were cultivated[3], as against the longer-term plan for 25,000 acres of paddy but even with this small acreage a shortage of water in the reservoir held up releases for Maha 1973/74 some six weeks from 1st October to 5th November, delaying cultivation beyond its optimal date.

On neither project need water be so limiting. Much of the present difficulties and failures to approach the potential irrigable acreage stem from permissive water issues at the request or instance of cultivators. For much of the time the water duties are restrained not by considerations of water management but quite simply by the capacities of the canals and channels. In the event water issues on Gal Oya are held down by the diminished capacity of the main channel, designed for 1,145 cusecs but after 20 years or so without maintenance only able to issue 700 to 750 cusecs; while on Uda Walawe the right bank canal is continually operating at 30 per cent above its designed capacity. Considering that it is water, not land that limits or will limit Yala acreages on these projects it is mystifying to note the manner in which the capability to provide water for that acreage is dissipated by capitulation to cultivators' demands.

With major and minor irrigation in the Dry Zone, water is probably if anything even more limiting than under the major projects, although each tank is a case on its own, and exceptions can doubtless be found. The official figures for percentages of asweddumized extents actually sown in Hambantota district may give some indication of the general tendency. The acreages reported sown as percentages of the acreages reported asweddumized, expressed as means of five years' figures for Maha 1967/8 through Yala 1972 were

	Maha	Yala	
Major irrigation	78	66	
Minor irrigation	76	33	(ARTI 1974:58)

1. Faulty survey and/or design may also be partly responsible for this.

2. Reported figures could easily be exaggerated because of double-counting under staggered cultivation.

3. These were, however, reported to be climatically poor seasons on Uda Walawe.

Ofcourse, many factors may influence a failure to cultivate, and the low percentage for Maha under major irrigation is associated with a loss of seasons under staggered cultivation. All the same, a subjective impression is that shortages of water contribute seriously to these shortfalls in Maha, and that they are the main factors in Yala. A counter argument is that the low percentages reflect over-extension of asweddumized acreages for the tanks in question, and that 100 per cent cultivation in Maha is now only possible in years of exceptional water supply. This may certainly be true, as a result of encroachments, under current levels of water management. Under better management, the percentages should rise, and the degree of apparent over-extension diminish and perhaps often appear as under-extension. Water would remain generally limiting rather than land, since under most tanks there appears to be additional land suitable for cultivation but not yet asweddumized Were there more water, or if it were used more sparingly, larger acreages could be cropped. Once again, water and sparing water management, are land-augmenting.

These considerations imply that the preoccupation with land as against water is misleading. It is, however, tenaciously persistent. We must ask why in order to be able to guard against it. Several influences can be suggested:

- the bias of conventional economics which regards land, labour and capital as three main factors of production, omitting specific mention of water.
- the origin of agricultural economics as a discipline in countries with temperate climates where land is a proxy for water.
- the gulf between the disciplines of irrigation engineering dealing with water and agronomy dealing more with land and crops.
- the ease of measuring land and yields per unit of land compared with the difficulty of measuring water applications (including percolation, evaporation, transpiration and outflows).
- the lure of the new project and the greater attraction of opening up and settling new land under a new supply of water compared with improving the efficiency of use of water under an existing supply
- perhaps some deep human propensity to value and think in terms of land. (see for example Ardrey 1967).

When these factors are taken into account, it is easier to appreciate the difficulties in changing our ways of thought.

Once it is accepted that water is scarcer than land in the Dry Zone, we find we need to revise our concepts of productivity and that there are implications for research methods and priorities.

(i) Concepts of productivity: Referring to the problems of obtaining fertiliser and agro-chemicals in the new world situation, the Sri Lanka country statement to FAO in November 1973 said that "... the world food crisis should provide an excellent opportunity for generating a new value system for agricultural productivity" (Debates: cols 815-6). This may particularly apply to water, especially if other inputs become very scarce. Already agricultural research is increasingly using new criteria of efficiency, notably returns per unit of time and returns per unit of water (Kanwar 1973:4). Returns per unit of time may be more appropriate in conditions of lift irrigation where water is not limiting, and they do not appear to have much application in Sri Lanka, except perhaps in the Jaffna area. But returns per unit of water are directly and vitally applicable. Experimental work conducted at Siripuppa in India, reported by Kanwar, presents "water use efficiency" expressed as kilogrammes of grain yield per centimetre of water per hectare. For Sri Lanka units, the equivalent (but not equal) ratio would be bushels per acre inch or acre foot of water.

We may distinguish here between a farmer's point of view and that of an agricultural planner or economist. For the farmer, his land is usually his datum. For him it is often rational to think in terms of productivity per unit of land[1] only when his irrigation water supply is constraining does it become sensible for him to think in terms of the productivity of water, and then only to the extent that the constraints are predictable. For the agricultural planner or economist, in contrast, national resources are the datum, and for them it is particularly logical and necessary in situations like that of the Dry Zone for analysis to be in terms of the productivity of water.

The argument can be carried further. There are, of course, many rigidities which limit the choice of crops, and rice is likely with flour to remain a principle staple for many years. But in a situation of national and international food shortage it may be more important to consider productivity not only in terms of yield: water ratios but also of calorie water coefficients. Taking figures in use on Uda Walawe we get the following results.

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1. Although his first concern may often be the marginal productivity of labour.

Table 6. Calorie Litre Ratios for Paddy and Soyabean by Seasons

Crops	Water duty acre feet	M^3	Per Acre Yield	Kg.	Cals/100 gm for the crop	Cals/ litre
Paddy (Maha)	3	3700	70 bu	1016	345	95
Paddy (Yala)	5	6167	80 bu	1161	345	65
Soyabean (Yala)	1.5	1850	1,120 lbs.	508	432	119

Notes: 1. The water duties must be regarded as rather speculative. Elsewhere in this paper it is argued that ex-sluice water duties in Maha are usually less than half those of Yala. The advantage of Maha paddy over Yala is therefore probably underestimated.

2. The yields assumed for paddy are high compared with Dry Zone averages of about 50 bushels per acre. In practice Yala yields do not appear to be significantly higher than Maha.

3. No adjustments for moisture have been made. The cals/100 gm figures are based on 13.7 moisture of paddy and 8.1 moisture with whole soyabean.

(For calorie/weight ratio figures and for other advice I am grateful to W.B. Wijeratne.)

Insofar as these figures are valid paddy cultivation in Maha is much more efficient than paddy cultivation in Yala, and soyabean cultivation is more efficient than both (quite apart from its high fat and protein content, and its potential for fixing nitrogen in the soil). In particular the greater efficiency of soyabean over paddy in Yala is striking.

The point here is not that these figures are necessarily completely valid; but that there are the sorts of calculation which should be made.

(ii) Implications of Research

The implications of this concept of the productivity of water for research can be examined at two levels.

At the level of agricultural research stations, a careful appraisal of the costs of water measurement and of the opportunity costs of research capacity should indicate the extent to which yield: water and calorie: water co-efficients should be measured in work related to the Dry Zone. Perhaps it could be a rule that even when it is not possible to measure directly the consumptive use of a crop, at least an estimate should be made; and if yields must continue to be expressed in terms of productivity per unit area, then tables should always also include estimated productivity per unit of water. The land fixation is so strong that even when the amount of water required to achieve a certain yield is stated, the final step of expressing this as yield: water or calorie: water ratios is left out. Yet these are essential for effective comparisons of water use efficiency.

At a second level, there may be much to be gained from conducting agricultural research in the cultivators' fields (as for example by Sivanayagam at Maha Illuppallama and by Houghton and Rajanayagam at Ampari). The differences in water duties under the controlled conditions at research stations and those used by cultivators are sometimes spectacular; and it is only by becoming aware of the practical conditions of water management in the field that the correct priorities for research can be assessed. It cannot be enough for agricultural scientists to work on controlled experiments under optimal conditions and then to stand back from the difficulties of field implementation, dismissing them as "people's problems". Good research is implementable or assists policy choices; and that must be based, as much of the work in Sri Lanka has been, on an understanding and realistic appraisal of field conditions, which are almost always less optimal than those on the research station. It is at this point that sociologists and agricultural economists have a contribution to make. They are trained to look at rural situations from different points of view which complement and correct those of agricultural scientists. Their contribution may be especially important in water management in assessing what can be achieved, and in applying the criterion of water productivity as opposed to that of land, in assisting decisions about research priorities, and in working out the applications of research results.

(iii) Choice of Practices

The concept of productivity in terms of returns of water also provides a criterion for judging between alternative practices. The green revolution approach appears to have gone ahead largely indifferent to its water consumption requirements, except in insisting that a reliable and adequate water supply must be provided. Water has been treated as a free good, a part of the environment that can be taken for granted. But if the argument up to this point is correct, a prime criterion in devising and choosing between cultivation practices should be the returns to water used. It is this approach which underlies the sections which follow, in which the costs and benefits of some alternative practices in Dry Zone paddy cultivation are assessed.

PRACTICES AND CHOICES

Armed with the criterion of the productivity of water, and taking food production, foreign exchange saving and equity as benefits, we can now examine some of the irrigation and cultivation practices in the Dry Zone. Most of the factors contributing to low productivity of water have an organisational or management dimension, and it is with these that we are finally concerned. But a first step is to try to identify what ought to be done. Only then can we look at how to try to do it.

The practices and choices in irrigation and paddy cultivation interlock and overlap. We will try to separate out and analyse the main manipulable clusters of activities and choices, which seem to be:

- water duties and productivity
- alternative uses of water: Maha versus Yala
- timeliness and staggered cultivation
- choices of crop variety
- substitutions between foreign exchange, water and labour.

Water Duties and Productivity

A water duty is the amount of water passing an issue point expressed as a ratio of water volume to area irrigated. Here we shall follow the convention used in Sri Lanka of expressing this in terms of acre-inches and acre-feet per acre. Much confusion can arise and vagueness persist if the point at which the duty is measured is not specified. We shall refer to water duties "ex-sluice", which means the duties passing over the sluice of a tank or anicut; and on-field water duties, meaning the duties received by the cultivator's field. Further confusion is common when it is not clear whether a duty includes or excludes rainfall. Here we shall follow the convention that ex-sluice water duties include only the water which passes over the sluice, whereas on-field water duties include rainfall.

Observed water duties in practice in the Dry Zone vary considerably and are particularly sensitive to the permeability of the soil and associated percolation losses. They also tend to be higher during Yala and Maha. Some water duties are listed in Table 7.

The theoretical water requirements of paddy cultivation derived from research are much lower than these figures based on actual practice. Senewiratne and Appadurai state that the benefits from standing water during growth can also be obtained by more soil saturation and that "Standing water is a luxury and confers only marginal benefits such as temperature regulation which is hardly of any use in Ceylon, and weed control which can be achieved by other means (1966: 49-50).

Research-based estimates of on-field water requirements have been made by Murakami and Vignarajah (n.d. (1966):158) and by Alles (n.d. (1967):55). Both estimates apply to a four-month variety. The best interpretation of Murakami and Vignarajah's findings in the form in which they have been

Table 7. Some water duties in practice

(acre-feet per acre)

Source of data	Meaning of figures	Maha	Yala
1. Arumugam 1957:	Observed water duties ex-sluice excluding evaporation, other storage losses and rainfall	0.5 - 7	4 - 19
2. Field interviews (1973/74)	Common conventions about storage required for ex-sluice issues for Maha and Yala	3 - 5	6 - 8
3. Uda Walawe Project memorandum	Water issues, probably from main into branch channels, October 1972 through January 1973 (an incomplete Maha not including rainfall)		
	Tracts 2-4	16	
	Tracts 5-7	9	
	Chandrikawewa	9	
	Tract 12	7	
4. Personal communication, C.W. Houghton (1974)	Gal Oya experiment with a 3 month variety - water supplied to field, not including rainfall which was however negligible		
	Farmer's control plot		18

misreported (see the appendix for an analysis of this issue), is that including water for land preparation and with continuous flooding throughout the life of the crop, an on-field duty of 4.9 feet is required for Maha and of 6.3 feet for Yala. Alles' estimate is that excluding water for land preparation, 3 feet are required in Maha and 3½ feet in Yala. If to these latter we add Murakami's estimate of 170 mm (0.6 feet) of water for land preparation, we have 3.6 feet for Maha and 4.1 feet for Yala. These two estimates can then be placed against two sets of rainfall figures:

a) mean seasonal rainfall for the Dry Zone

b) Alles ' 75 per cent probability figures for Maha Illuppallama (ibid:46).

to obtain on-field water issue requirements:

Table 8. On-field water duties and issues with mean rainfall

Source	On-field water duty		Rainfall		Issues required to the field		
	Maha	Yala	Maha	Yala	Maha	Yala	
Murakami and Vignarajah	4.9	6.3	3.1	0.9	1.8	5.4	Mean Rainfall
Alles ..	3.6	4.1	3.1	0.9	0.5	3.2	
Murakami and Vignarajah	4.9	6.3	2	0.5	2.9	5.8	75% probability
Alles ..	3.6	4.1	2	0.5	1.6	3.6	

If these figures are adjusted by assuming 15 per cent wastage of the water received on the field through overflows and a 25 percent loss in conveyance (assuming major irrigation) the ex-sluice water duties become

Table 9. Ex-sluice water duties in acre-feet

Source	Maha	Yala	Maha:Yala ratio	
Murakami and Vignarajah	3.2	7.9	2.5	Mean rainfall years
Alles	1.3	4.8	3.7	
Murakami and Vignarajah	4.5	8.4	1.9	Low rainfall 75% probability
Alles	2.7	5.3	2.0	

It is quite possible that the assumptions of conveyance losses and of wastage are excessive for many Dry Zone conditions because they take no account of the re-use of drainage water and of inflows to fields through seepage from other fields. But even if we accept these ex-sluice water duties as they stand, they differ sharply from the earlier actual duties. For our generalising purposes the mean rainfall years may be taken. They give us (ex-sluice):

	As calculated above	Observed duties (Arumugam)	Field conventions
Maha range	1.3 – 3.2	0.5 – 7	3-5
Yala range	4.8 – 7.9	4 – 19	6-8

These calculations suggest that in both seasons there is a heavy wastage of water. In very rough terms about twice as much water is issued in Maha as is necessary under the fairly liberal assumptions listed above. Water is also wasted in Yala, but to a lesser degree. The implications of this will be taken up later. For the moment we can note that it appears that with more sparing issues of water in Maha the productivity of ex-sluice water could be sharply increased.

This conclusion is further supported by losses from excessive water applications and from flooding. This applies particularly under permissive water management regimes, such as Gal Oya, and when there is heavy rainfall, typically in Maha. At the tail end of many major and some minor irrigation systems there are asweddumized areas which are especially vulnerable to crop loss or delayed planting as a result of flooding. On Gal Oya alone there are reported to be several thousand acres which in a dry year produced an unusually heavy crop because they were, exceptionally free from excess water.

Research in India and Sri Lanka further strengthens the conclusion that more sparing applications can decisively improve the productivity of water. Work on black soils at Siripuppa in India reported by Kanwar (1973:4) has shown (Table 10) that water use efficiency is lower with continuous submergence than with saturation to hair cracking, which in turn is lower than with saturation to field capacity, and that under experimental conditions these treatments involve negligible declines in yields per unit area of land.

Table 10. Effect of different moisture levels on water use efficiency in rice

(Black Soil at Siripuppa)

Moisture level	Mean Grain Yield of Rice Quintals/Ha	Mean amount of water used Cm	Water use efficiency Kg/cm/ha
Continuous submergence (5 cm)	49.9	139.9	35.6
Saturation to hair cracking	49.6	89.2	55.6
Saturation to field capacity	49.1	79.2	62.1

Source: Kanawar 1973/7

Work on Gal Oya conducted by Houghton and Rajanayagam has shown that in field conditions the contrasts in water use efficiency between controlled and permissive applications can be extreme. While a control farmer cultivated a 3-month variety using his normal water use practices, three trials with the same varieties were carried out nearby using more sparing applications. These were categorised as "wet", "medium" and "dry" applications. The results are shown in Table 11.

Table 11. Relative efficiencies of water use under four treatments on the Gal Oya Scheme

Number of plots	Type of plot	Water supplied to field	Yields in bushels / acre	Mean	Efficiency in bushels per acre inch
2	Wet	30"	109 92	100.5	3.35
2	Medium	17"	100 109	104.5	6.15
2	Dry	14"	93 95	94	6.71
1	Control (cultivator)	18 feet	62	62	0.29

Notes: 1. Source: Personal communication, C.W. Houghton 1974

2. Standard fertiliser applications were given to the trial plots. Although the control farmer claimed he made these applications, this was not confirmed. Low or inappropriate applications may therefore have contributed to his lower per acre yields.

3. Negligible rainfall fell during the period (Yala 1973).

According to these figures, the wet, medium and dry plots were respectively 12 (wet), 21 (medium) and 24 (dry) times more efficient than the control plot in their use of water.

An attempt to improve the productivity of water can start from the factors which contribute to waste. Some of these are physical. Excessively permeable soils are asweddumized, as on Uda Walawe. Badly laid out liyaddes contribute to waste. Percolation losses in channels under major irrigation are high, commonly estimated at 25 per cent; lining channels is an obvious means of reducing these losses, but is rarely practicable because of its cost and foreign exchange requirements. Other losses result from damaged and faulty structures. Padlocks on gates are broken and not replaced, making controlled water allocations difficult or impossible, sometimes with a huge cost in loss of timeliness of planting and adequacy of water supply lower down a channel as a result of excessive and continuous extractions higher up. Other structures leak and are not repaired. One of the supply gates through the Kataragama bund is said to have been leaking for five years, sometimes augmenting flooding and at most times wasting water required at the margin of cultivation. Any attempt to improve the productivity of water must include an efficient and effective system of maintenance of such structures as a complement to the organisational changes which are needed.

But many of the factors contributing to low productivity of water are associated with farmers' practices and preferences. Farmers have good reasons for preferring flooding and a continuous flow of water through their fields. It reduces risk by maintaining and continually replenishing a stock of water as a buffer against possible shortages later or drying out. It also reduced the labour requirement and makes supervision easier since sparing applications are liable to be more time-consuming and laborious. Farmers may also prefer longer-duration varieties of paddy which require more water than shorter-duration varieties. Most farmers in the Dry Zone have also shown a readiness to adopt new varieties and practices, and the green revolution approach (high fertiliser, high agro-chemicals, high yields) is water-intensive and also involves higher risks from water shortages than traditional cultivation. In general, farmers can be expected to prefer more liberal water applications than are considered desirable either technically or nationally. A basic problem is that farmers quite rationally do not want to save water.

Before tackling that problem it will be as well to go further in trying to identify other aspects of how beneficial more stringent water management might be. And to do that we must look at alternative uses of water saved.

Alternative Uses of Water Saved: Maha versus Yala

Using the criterion of productivity of water, we can try to compare the marginal efficiencies of Maha and Yala cultivation. This is a complex subject, many of the subtleties and twists of which are probably either not perceived here or if perceived not mentioned. Some of the assumptions used are very arbitrary; and the validity of the conclusions may be confined to certain types of irrigation situation.

The common philosophy of Dry Zone major irrigation is that water should be conserved in Maha so that Yala cultivation is possible, enabling cultivators to take two crops of paddy (or more recently sometimes a crop of paddy in Maha and a different subsidiary crop in Yala) off the same land. It is sometimes observed that the asweddumized acreages are over-extended by what are pejoratively known as "encroachments". Leaving that question open, let us begin by asking what are the relative efficiencies at the margin of using the same water for additional cultivation in Maha or storing it for Yala.

For an imaginary major irrigation tank (the resemblance of which to Wirawila tank in Hambantota District is not entirely a coincidence), with a capacity of 10,000 acre feet, a Yaya of 2,000 acres, receiving 12,000 acre feet in Maha, losing 20 per cent of storage through evaporation and percolation between Maha and Yala, and similarly losing all its Yala rainfall, the relative water use efficiency of Yala under four sets of water duty and rainfall assumptions is startling as Table 12 shows.

Table 12. The relative marginal efficiency of using the same storage water available in Maha for Maha or for Yala for a hypothetical Dry Zone Tank.

	(1) Maha Water Duty required ex-sluice acre/feet	(2) Total Water over sluice acre feet	(3) Remaining for Yala at end of Maha acreage	(4) Equivalent Maha acreage	(5) Remaining for Yala acre/feet	(6) Yala Water duty ex-sluice	(7) Yala acreage	(8) Yala/Maha acreage ratio
A	3.2	6,400	5,600	1,750	4,475	7.9	566	0.32
B	1.3	2,600	9,400	7,231	7,520	4.8	1,567	0.22
C	4.5	9,000	3,000	667	2,400	8.4	286	0.12
D	2.7	5.400	6,600	2,444	5,225	5.3	986	0.4

Notes

A Murakami and Vignarajah's corrected figures and mean rainfall

B Alles' figures and mean rainfall

C Murakami and Vignarajah's corrected figures and 75 per cent probability rainfall at Maha Illuppallama.

D Alles' figures and 75 percent probability rainfall at Maha Illuppallama.

(1) The water duty ex-sluice. For calculations see pages 27 and 28.
(2) The total water flowing over the sluice at that duty to irrigate the 2,000 acres of the Yaya in Maha.
(3) The volume of water remaining for Yala assuming that 12,000 acre feet enter the tank in Maha, and that the tank was empty at the start of Maha.
(4) The additional marginal acreage which could be cultivated in Maha with the water remaining for Yala, assuming the same ex-sluice water duty and land available.
(5) The volume of water remaining for Yala after 20 per cent storage losses from evaporation and percolation between Maha and Yala.
(6) The water duties required ex-sluice for Yala cultivation.
(7) The acreage that could be cultivated in Yala with that water.
(8) The ratio of Yala to Maha acreage using the same water.

The table suggests that the efficiency of use of the Maha water for Yala varies between 0.1 and 0.4 times that of using is in Maha. For purposes of generalising a figure of 0.25 may be reasonable. That is to say, if the water is used for additional Maha cultivation, it will supply 4 times the acreage it could supply if stored for Yala.

These figures must be interpreted carefully and also qualified. First, channel losses for marginal Maha acreages are likely to be high since the additional land cultivated will probably be at the tail end. Second, the yields from that marginal land may be lower than average because of difficulties over water supply at that distance from the tank. This qualification is, however, also an argument for tighter control of water issues higher up the channel. A third qualification is that if the water supply is good, then per acre yields in Yala are likely to be greater than in Maha.

In terms of orders of magnitude, however, these and other qualifications seem unlikely to upset the conclusion that where there is additional land available for Maha paddy irrigation, and where the alternative use of the water is to save it for Yala paddy irrigation, production per unit of water will be well over twice as high if that water can be used for Maha. Whether it can be so used depends, of course, on several factors, not least the extent to which labour, draught power and various inputs are constraining. Some indication of lack of a labour constraint may be given by the amount of "encroachment" which has taken place. And one advantage of further extension of Maha acreages is that those who encroach may tend to be the poorer people.

Any extrapolation from these figures is bound to be very hazardous. It is however, instructive to explore possible implications. The target for Dry Zone major irrigation sown in Maha 1973/74 was, at one stage, of the order of 400,000 acres. If all these areas were similar to the imaginary example in that the Maha acreage could be doubled by more sparing use of water, and if yields to that acreage were 50 bushels per acre, then an additional 20 million bushels of paddy would be produced. In some cases the water used would have no opportunity cost from Yala since it would otherwise have spilled; in other cases the alternative use for the water would have been storage for Yala. If we assume that these quantities are equal, if we take the Yala; Maha acreage ratio for the same water as 0.25 and if Yala yields are the same - 50 bushels per acre, as Maha; then the Yala production foregone is 400,000 x 1/2 x 0.25 x 50 = 2.5 million bushels. The net gain in production from this exercise would then be 17.5 million bushels.

The point of this calculation is not to show that this is a way in which such a large addition to production could be achieved, but rather to suggest that this is a direction in which it may be worth trying to move since the benefits at the margin are so considerable. On production grounds there does seem to be a strong case, where feasible, for encouraging a larger Maha acreage. This might coincide with a revised production strategy of shifting emphasis from high inputs and high yields to maintaining yields and extending acreages. This is obviously a major policy issue and depends partly or largely on the fertiliser and agro-chemical import position. But if this is poor and likely to remain poor, the case for concentrating on improving returns to water by extending acreages is strengthened.

In many areas and in many cases, saving water for yala remains a vital and land augmenting strategy. Yala cultivation is also very important for cultivator families, since it gives them two paddy crops a year instead of only one. From a production point of view, the case for this strategy is clearest where maha rainfall is heavy, as with the Gal Oya and Uda Walawe Projects, the Yala acreages of which are liable to be constrained by shortages of water resulting from permissive and wasteful issues in Maha. An honourable exception to this statement is the tenacity with which those resposible for water issued on Gal Oya managed in 1973/4 to withhold Maha issues until 15th January, compelling cultivators to make use of rainfall for their Maha cultivation up to that date. The water saved could then be used to extend the Yala acreage, which is said to be usually limited by shortages of stored water to only one third to one half of the area under command. Moreover, wherever there is no additional asweddumizable land that can be cultivated in Maha, the issue is simple: if water saved can be stored for Yala, it should be used sparingly and stored.

The practical imperative which follows from this discussion is scarcely revolutionary. It is that in circumstances of major project and major irrigation except during the period when a tank is spilling, water issues in Maha should be restrained. This is not exactly a new insight. But the fact is that in Hambantota District, under Gal Oya and Uda Walawe, and probably under major irrigation elsewhere, the attitudes of officials and farmers to water issues in Maha are relaxed. In order to increase the productivity of water, and except when a tank is spilling, water issues in Maha should usually be more sparing and its distribution more rigorously allocated. Maha, in fact, has to be made more like Yala, perceived by cultivators as a period when water is scarce.

Staggered Cultivation: Benefits, Costs and Complications

Staggered cultivation means different cultivation activities occuring simultaneously. For ease of analysis we can distinguish two types: intra-yaya staggering, in which cultivators in the same paddy tract have fields at different stages of cultivation; and inter-yaya staggering, in which whole irrigation units which are part of the same major project or major irrigation system are at different stages of cultivation.

The incidence of both types is widespread in the Dry Zone. They are perhaps most pronounced under the Gal Oya Scheme. Houghton and Rajanayagam state that "the fact is that planting and harvesting are going on in every month of the year with the possible exception of December" (1973:5). A report by the Ministry of Agriculture and Lands (MOAL 1972c) presents the findings of an investigation into staggered cultivation in four areas under the Scheme. Elsewhere in the Dry Zone it may be commonly observed: inter-yaya staggering may be more common under minor than major irrigation, while by definition inter-yaya staggering can only take place on a major irrigation system.

The most prevalent causes of staggered cultivation and untimely cultivation appear to be:

(i) natural disaster. Delays in the onset of the monsoon, droughts, excessive rain leading to floods, and losses of crops for other climatic or biological reasons are recurrent causes of delay.

(ii) water supply sequence. Both inter-yaya and intra-yaya staggering result from the sequence in which water reaches fields, this in turn depending on the volume of water released, the conditions of the channels, and the amounts abstracted in their upper reaches. Inter-yaya staggering based on the water supply sequence is a pronounced feature of major irrigation projects with long supply channels.

(iii) drainage staggering. Intra-yaya staggering may result from the way in which one field drains into another. For those lower down, planting is impossible until those higher up have drained their fields for planting. Badly drained parts of a yaya may habitually have to be cultivated weeks later than the rest.

(iv) input supply problems. Difficulties in obtaining labour, buffaloes, tractors, seeds, credit and basal fertiliser may all hold up cultivation. Farmers questioned on Gal Oya in 1972 gave shortages of labour and shortages of mammoties and tractors as common reasons for delay. The ILO Report went as far as to suggest that "In Ceylonese conditions.. tractor ploughing is (on balance and in most areas) likely to disrupt the timing of sowing in the main Maha season, because the short period required encourages delay, while the uncertain availability of machines spoils plans" (1971b:102). Cultivators in Hambantota District often do not know much in advance when they will be able to obtain tractors, and this may contribute to delay. But earlier in 1908-1911, Leonard Woolf's diaries show that shortages of draught power had the same effect (Woolf, 1962)

(v) crop duration staggering. The most favoured explanation of staggering, at least in Hambantota District, is the introduction of H4, a 4 1/2 month variety with a much higher yield than its predecessors (ARTI: 1974:53-4). After this was released for general cultivation in 1959/60 it was rapidly adopted not only for Maha, but also for Yala where it replaced the traditional shorter-aged, usually 3-month, varieties. By 1964/65 65 per cent of the paddy acreage in Hambantota was reported to be under H4 (DAEO's Annual Report for the Financial Year 1964/65, Hambantota District). In consequence, Yala was prolonged, running over into Maha and intermittently, as a result of this and other factors, seasons were completely lost.

(vi) irrigation maintenance staggering. The former system of fixed dead seasons for maintenance of irrigation works has lapsed in Hambantota District and elsewhere. As a result maintenance tends to be a series of unpredictable crisis measures. In the words of one civil servant engaged on maintenance work "everything is urgent now - whenever it breaks, put in the whole gang - do a slipshod job" (Interview 1974). Maintenance programmes exist on paper but are not implemented in practice.

As a result there are unpredictable interruptions to water supplies which contribute to the loss of seasons (as with Yala 1973 under Walawe Right Bank, and also under Wirawila, though the questions were complex in the latter case).

(vii) competing labour demands. Opinions differ about the degree to which there is competition between chena and paddy cultivation, and if there is, whether this might sometimes lead to a delay, especially in Maha paddy cultivation (Tennakoon 1972:27 ff; Percy Silva, personal communication) However, it is at least plausible that some cultivators, relying on the rice ration for much of their subsistence and wishing to exploit high prices for chena crops might give priority to chena over paddy, leading to delays in paddy cultivation.

Since delays and staggering are usually condemned out of hand, let us start by considering their benefits before their costs. The benefits are surprisingly numerous and substantial. They include:

(i) reducing risk: With cultivation at different stages, the dangers of a natural disaster eliminating an entire crop are reduced. For example, a flood which drowns young paddy may not harm an older taller crop.

(ii) maintaining a steady regional food supply. With crops being harvested throughout the year seasonal shortages and price rises are less likely to be serious.

(iii) Spreading demands for scarce inputs. The effects of shortages of draught power and labour in particular are mitigated if cultivation can be spread out over time. Moreover, the capital stock of tractors and buffaloes and the labour pool required can be less for a given acreage if it can be used more continuously.

(iv) moderating demand on channels and drains. A tighter system of synchronisation on some systems would require larger flows than desirable on engineering grounds, and might lead to flooding through excessive simultaneous draining, for example at harvest.

(v) stabilising the flow of drainage water to those who rely on it at the tail-end. If there were full synchronisation, the flow might be more uneven and flooding would be more likely to ruin crops. Moreover, the double or treble use of water through basnawa (drainage) systems enhances the efficiency of its use.

(vi) permitting replanting where a crop has been lost. This may be possible even under a tighter system, by planting a shorter-duration variety which will catch up with the rest; but this is not always so, especially where flooding ruins a young crop more than once. Under a system of permissive staggering a farmer can replant any number of times without having to wait for a new season.

(vii) providing more steady employment for landless labourers. This is speculation, but might be a significant social benefit in some places.

(viii) giving administrators and politicians a quiet life. In a laissez-faire system, cultivators are more likely to blame fate or the weather than politicians or administrators for their problems.

(ix) helping the poorer cultivators. Perhaps the most powerful benefit, related to several of this points, is that a permissive system may help the poorer cultivators. As Wimaladharma and Clifford have pointed out a tight schedule under purana conditions penalises the small man: "... small landowners", they say, "find it difficult to operate as tenants or labourers whilst cultivating their own plots. Some staggering of the cultivation table might permit the small farmer to be engaged during a longer period in the year" (1973:13). In a tightly enforced programme, those who are already better off will be able to obtain the tractors or buffaloes, and the poorer and less powerful will be those who fail, and perhaps even lose their opportunity to cultivate. Even if they succeed however, they will be at the end of the queue and in their desperation may be forced into the adverse terms of a distress contract for procuring draught power. It might further penalise those tailenders who often do not manage to achieve a Yala crop, and for whom a successful Maha is therefore critical, especially if the arrival of water to their plots is delayed by heavy synchronized abstractions higher up the main or field channels. One common loss in such situations has been (at least until the introduction of BG34/6 and BG34/8), that the tailenders have had a smaller yield because they have been constrained to grow a shorter-duration and lower-yielding variety than those who are nearer the head of the channel. There may, indeed, be a general principle underlying these observations, that authoritarian systems tend to penalise the poor where they are competing for a scarce resource; and we shall return to this later.

Given all these benefits one may wonder for a moment why there has been such sustained official opposition to staggering and to untimely cultivation. One possible explanation is that it is a relatively new phenomenon. Certainly its incidence may have increased since the decline and abolition of the Vel Vidane system, and since the introduction of H4. Under former village irrigation there was a venerable tradition of synchronised activities under village tanks (Leach 1961). On major irrigation projects there was a system of fixed dates for activities and fixed dead seasons during which maintenance was to be carried out. But it is as well to recognise that there was considerable staggering and untimeliness in the past as well as in the present. The diaries of the Assistant Government Agents in Hambantota in the 1920s show that extensions and variations of timings were common. Seasons were even lost. The AGA wrote in his diary for 19 October 1927:

> "To Tissa... held a meeting of proprietors under the Kirinde Oya Right Bank Scheme. In view of the fact that reaping is not over in the fields here and as in consequence the cultivators would be unable to complete the cultivations for the next Maha before 13th December, it was decided to have a combined Maha and Yala cultivation beginning on the 15th January".
>
> (Diaries...)

The impression from these diaries is, however, that whereas delays in cultivation and harvest, and extensions of water issue to whole yayas, were quite common, they were usually contained within the framework of the continuing programme without loss of seasons, and intra yaya staggering was much less frequent. In the absence of quantified time-series data, it seems reasonable to conclude that insofar as Hambantota District is typical of the Dry Zone, it is likely that over the past two decades or so there has been an increase in the incidence of intra-yaya and inter-yaya staggering, in the loss of timeliness and in the loss of seasons.

Another possible explanation of the official opposition to staggering and untimeliness might be that administrators and engineers like tidiness and discipline. The diligent Government Agent or District Revenue Officer, having presided over a cultivation meeting at which decisions are taken about dates to begin and end water issues and at which to carry out and complete various cultivation activities, is naturally inclined to take an interest in their implementation and enforcement. Perhaps even more, the irrigation engineer, conditioned as he is to the arts of precise measurement and calculation, is inclined to prefer and demand the regular and predictable performance of activities on set dates. The Director of Irrigation, writing in 1922 about the loss of much of a Yala crop under the Kirinde Oya Right Bank Scheme, was speaking for irrigation engineers in general when he said :

> "The dates prescribed in the proprietors' rules are that the Yala cultivation is to commence on March 13th. The sowing is to be completed on May 8th and the final date of the irrigating period is to be August 6th. These dates ...... are never adhered to by the proprietors with the consequence that scarcity of water during the last stage of the Yala is of periodical occurrence and had the Yala crop started at its proper time this year the loss of crops would not have been so great. The reason for the delay in the Yala cultivation is that the dates for the Maha cultivation are frequently extended. This department has no jurisdiction over such extensions and it has for many years strongly advised against such extensions being allowed. Despite the advice the extensions continue ..."

(Letter, Director of Irrigation to the Honourable the Colonial Secretary, 31, August 1922, Hambantota Kachcheri file E 85)

One may perhaps also detect something of the same attitudes underlying the more or less automatic assumption today that staggered cultivation is a bad thing and should be reduced.

Bearing in mind the benefits of staggering, and being careful to avoid any predisposition necessarily to condemn it, let us now look at its costs. These are not easy to categorise because of the manner in which many of them interlock. The central issue is whether untimeliness and staggered cultivation are associated with lower yields per unit of irrigation water than the alternatives of more timely and more synchronised activities.

We may first note that cultivators themselves, thinking in terms of yields per unit of area, consider that, for whatever reasons, delays in operations affect their yields. This has been mentioned in interviews in Hambantota District and in the 1972 survey in Gal Oya 81 per cent of the farmers who replied to the questionnaire believed delay in cultivation had affected their yields in one or both of the two previous seasons (MOAL 1972c:36 read with pages 4 and 51). Moreover, survey findings support this belief. The ARTI survey of Hambantota District found the following variations :

Table 13. Distribution of Farmers under Major Schemes According to Time of Sowing and Yields – Hambantota District, Maha 1971/72

Month	No. of Farmers who cultivated up to 5.00 acres	Bushels per acre for all varieties cultivated	No. of Farmers who cultivated only NHYVs	Bushels per acre reported for NHYVs
August	4	25	–	–
September	2	19	–	–
October	11	44	5	69
November	19	57	8	64
December	19	49	4	87
January	6	30	1	24

Source: ARTI 1974:66 Bushels per acre have been rounded in this version.

Further data on a much more extensive scale could be found in the crop-cutting surveys conducted since 1952 by the Department of Census and Statistics; but this data has not been analysed. These farmers' responses and survey findings refer, however, to the outcomes of complex and variable processes. Moreover, they are related to production per unit of land and not of water. In looking deeper into the costs of untimely and staggered cultivation, we can perhaps best organise the discussion into three sections:

- factors affecting yields
- factors affecting water use
- administrative factors

(a) Factors affecting yields

(i) climatic factors. Unfortunately the work of Okamoto has not yet been published or released. Based on the Central Agricultural Research Station at Gannoruwa he has been conducting trials to measure yields per unit area of land against time of planting at three locations, one of which is Maha Illupallama in the Dry Zone. Six varieties of paddy – H4, BG34-6, BG34-8, IR 262, BG11-11 and IR8 have been planted at monthly intervals and given what are considered optimal water treatments and the recommended fertiliser and agro-chemical dosages. The variations in yield per unit area of land presumably attributable to photoperiodism, temperature, solar radiation and perhaps other factors such as humidity and wind, are believed even in the case of H4 to vary by a factor of about 2 between the highest and lowest yield per unit of land. If this is so, and to the extent that such variations are regular, there will be a very strong case for timely operations.

(ii) crop protection. It is a commonplace of the rationale for intra-yaya synchronisation that it helps crop protection. The reasons are :

- protection from birds at sowing (when they pick up the seeds) and near and at harvest (when they eat the ripe grain) is easier if all cultivators are in step. The bird damage is spread throughout the Yaya instead of being concentrated on one or a few fields.

- protection from cattle. The tradition of fencing the whole Yaya during the growth of the crop and then of de-fencing on a set date and allowing the cattle in was evolved to protect the crops against animal damage. Unless there is individual fencing (as on parts of Uda Walawe, at high foreign exchange costs for the barbed wire), damage is liable to be extensive; and individual fencing involves sharp diseconomies of small scale compared with communal fencing.

- reducing pest and disease build-ups.

(iii) water control. Water control is more difficult with intra-yaya staggering than when activities are synchronised or arranged in co-ordinated sequences. Farmers may not be able to drain their fields for sowing, for fertilizer applications or for harvest because of seepage from their neighbours' flooded fields or from feeders or drains. Conversely, in haphazard intra-yaya cultivation they may be unable to ensure that they receive water when they need it, since it may be abstracted higher up.

(iv) flooding. Permissive water issues at the top and middle of an irrigation system as at Gal Oya, may lead to chronic flooding lower down. It was estimated in 1970 that some 3,000 acres under Gal Oya and near the lagoons had been permanently waterlogged (Thamotheram 1970:3) and it is significant that when water became scarce on Gal Oya, the lower levels had a bumper crop because they did not suffer their normal excessive supply of water (Sivasubramaniam 1973:3). Since the permissiveness is associated with staggering, these effects may be evaluated as costs of staggering.

(v) incompatibility of inputs. Yields may be reduced through incompatibility of inputs. Examples are:

- damage to neighbours fields, bunds and crops by tractors.
- damage to neighbours' crops through the draining of water.
- damage to young crops which use drainage water caused by weedicides applied higher up the irrigation system.

(vi) loss of seasons. Loss of seasons is associated with intra-yaya and especially inter-yaya staggering. It would be useful to know whether Hambantota District has an exceptionally high incidence. The ARTI survey report, incorporating the experience of an Agricultural Officer with long knowledge of the district, states that :

> "... due to overlapping of seasons, particularly under the Walawe Scheme, the farmers invariably miss one cultivation season, generally once in two or three years. Although water is not a major problem under the Walawe Scheme, most farmers miss one season of cultivation in every two or three years. As a direct consequence of overlapping of seasons there was no Yala cultivation in 1972 in Walawe left bank covering an area of 6,000 acres (approx.). *As some of the most productive paddy lands in Sri Lanka are located under Walawe, it is unfortunate to allow highly productive lands to miss cultivation seasons, particularly when Walawe Ganga brings in adequate supplies of water during most parts of the year.*"
>
> (1974:66 The report's italics)

There is an interesting heresay that in terms of production per unit of time (i.e. production over the years), the loss of seasons may not lead to a reduction in output, since it tends to be associated with growing longer (4 to 4 1/2 month) varieties instead of shorter-duration (3 to 3 1/2 month) varieties. This cannot be proved or disproved without field studies. But considering the issue first in terms of per acre yields we can compare four assumed conditions :

Table 14. Four Combinations of Loss of Season and Age classes of Paddy.

Seasonal intensity of cultivation	Age Class of Variety Grown in		Number of Seasons Age Class of Paddy	
	Maha	Yala	4 - 4 1/2	3 - 3 1/2
A. One season lost in 5	4-4½	4-4½	5	-
B. One season lost in 5	4-4½	3-3½	3	2
C. No seasons lost	4-4½	3-3½	3	3
D. No seasons lost	3-3½	3-3½	-	6

Comparing A and B, which involve loss of seasons, and C and D which do not and assuming yields for the same age class cancel out in the comparisons, we get the following requirements for breakeven production :

1. For A's production to equal C's the 4-4½ month variety under staggering must yield 1.5 times that of the 3-3½ month variety with no seasons lost.

2. For A's production to equal D's, the 4-4 1/2 month variety under staggering must yield 1.2 times that of the 3-3 1/2 month variety with no seasons lost.

3. For B's production to equal C's, there would have to be higher yields under loss of seasons, which seems improbable.

4. For B's production to equal D's, the cultivation of 4-4½ month varieties under staggering would have to yield 1.33 times the 3-3 1/2 month variety with no seasons lost.

A possible factor increasing production under loss of seasons might be the larger acreages cropped. On the other hand, yields might very well be lower, not higher, as a result of untimeliness. These estimates are by no means conclusive, but it seems a little unlikely that loss of seasons could in these circumstances often be more productive per acre. Given the waste of water with staggering, it seems even less likely that loss of seasons would be more productive per unit of water. It does not seem at this time profitable to pursue further the almost endless ramifications of this issue.

(b) Water Use Factors

(i) making use of rain. Timely planting can make use of rain, thus saving irrigation water. This has been clearly put by Alles :

> ".. One obvious way to minimize the use of irrigation water and maximise the returns from the limited quantum of water in the irrigation system is to organise the time of planting so that the best use is made of natural rainfall. This principle is particularly applicable in the Dry Zone of Ceylon. A four-month paddy will receive the maximum benefit from the Maha rainfall of October to January if it is sown at the beginning of October... An October-sown crop of paddy could expect a contribution of at least two acre feet of water towards On-Field Duty in 75 per cent of years at Maha Ulluppallama. In other parts of the Dry Zone this lower quartile will vary".
>
> (n.d. (1967)46)

A Yala crop, he goes on, will receive maximum benefit from rainfall if it is sown as soon as possible after the Maha harvest.

(ii) timeliness and losses from evapotranspiration and percolation. Although it is difficult to quantify, a major cost of staggered cultivation must be higher percolation and evaporation losses as with inter-yaya, and also intra-yaya, staggering, water is run through channels for longer, sometimes almost permanently, sometimes for the benefit of only a few people.

(iii) intra-yaya and inter-yaya interrelationships. Intra-yaya staggering on the yayas near the top end of a channel may extend the period during which water is extracted at the top end. This may then increase inter-yaya staggering by delaying the time at which water is received by yayas lower down the channel.

(c) Administrative factors

(i) maintenance. Regular maintenance of channels depends on a regular dead season when no water flows through them. With staggering these dead seasons are either erratic or non-existent. One consequence is that less water flows through the channels as they silt and fill with weeds. This in turn delays water reaching to the ends of the channels, which in turn reinforce staggering. On the Gal Oya project, there is said to have been no desilting of the main canal since it was built and it now carries only 700-750 cusecs against its design capacity of 1145.

(ii) with staggering, it is difficult to organise campaigns for extension and input supply. Conversely, with synchronised cultivation, extension can be fitted to the crop cycle, operation by operation. (For the benefits of such a system see Chambers and Moris 1973).

(iii) unreliable statistics. As Houghton and Rajanayagam point out (1973:5) continuous cropping with staggering makes seasonal crop statistics vulnerable to exaggeration through double-counting, and this may be particularly serious when benefit: cost evaluations of projects are made.

From all these considerations, the conclusion seems on balance fairly secure that yields to water (and to land) would be higher with some lesser degree of staggering. But it also emerges that there is a conflict here between production - increased by greater synchronisation - and equity for the weaker cultivators - liable to be penalised by greater synchronisation and tighter discipline. On balance, however, it seems reasonable to conclude that within limits, both intra-yaya and inter-yaya staggering should be reduced. It is hard to see how this can fail to mean penalities for those who fall out of line, the most obvious being refusal of water, and a tightening of water issues both in duration and quantity, at the handover point from the canal system to the field channels. All these measures are likely to be unpopular with some cultivators.

Choices of Crop and Paddy Variety

Choices of crop variety can be related to the criterion of the productivity of water. This can be applied either through yield: water coefficients (where dealing with one fairly uniform crop like paddy) or through calorie: water coefficients when comparing crops with differing weight: calorie ratios. As already shown, using these yardsticks, paddy in Maha is much more productive than in Yala, and soyabeans in Yala are much more productive than paddy in Yala. The implications of the latter have for some years been explored and one obvious prescription is that the current policy of crop diversification on paddy lands, where possible, should be pursued especially in Yala. In doing this, soil factors (Pannabokke n.d. (1967) are critical and will substantially modify practices in particular environments.

The choice of paddy variety is closer to our concern. It is also easy to influence, at least in Hambantota District, through the government supply system, through the advice given at cultivation meetings and the decisions taken at them, and through the Gambarayas who sometimes supply seeds to their tenants.

In circumstances of nil or low fertilisers of a drive to increase calorie: water efficiencies, and of new high-yielding 3 and 3 1/2 month varieties bred for local conditions (BG34/8 and BG34/6 respectively), there may well be a case for prefering these short duration varieties for Yala and perhaps also often for Maha, for the following reasons:

(i) Murakami and Vignarajah found, before the advent of those higher yielding short duration varieties, that :

- transpiration loss and transpiration ratio (quantity of water expended to produce a unit quantity of dry matter) of the shorter-duration varieties were less than of the longer-duration varieties.

- the grain: straw weight ratio decreased with the age of variety.

- 3-month varieties used water most efficiently, i.e. the return in terms of grain weight per unit of water was greatest with short-term varieties.

(n.d. (1966):155-6)

Providing this is still true of short-duration NHYVs under conditions of low fertiliser, the implication is that other things being equal they should be preferred to longer duration varieties.

(ii) the balance of professional opinion that I have been able to canvass, in the absence of experimental data, is that with good water application but without fertiliser and agro-chemicals the short-duration NHYVs would outyield H4 per acre. In terms of yield per unit of water their advantage will be greater, since they are in the ground for a shorter time and consequently use less water. Indeed, this advantage might mean that even if yields per acre were lower with the NHYVs, yields to water might still be higher and therefore gross production for any given irrigation system might be higher.

(iii) with H4 and other 4-4 1/2 month varieties, staggered cultivation is liable to be aggravated, as it has been in the past, with all the costs in production foregone that that implies.

(iv) a further advantage of the short-duration BG varieties over H4 is that they are less liable to lodging.

The BGs may, however, be more sensitive to moisture stress; so that the argument here converges on a need for a reliable and adequate water supply if the higher-yielding varieties are to be grown. In the absence of reliable water, farmers themselves might well prefer H4. The concluding imperative is that in the conditions anticipated, more reliable and adequate water will be needed in order to provide conditions in which farmers will wish to grow NHYVs and in order to benefit from the NHYVs' higher genetic yield potential.

<u>Substitutions between foreign exchange, water and labour</u>

The case for developing and popularising water-sparing technologies and practices are strong. Some of these, including time of planting, dry tillage and dry sowing, maintaining ponded water only when necessary, using varieties adapted to restricted moisture conditions, minimising channel losses, and properly regulated field delivery, have been clearly described and discussed by Alles (n.d. (1967): 46-52). Following these, we can try to identify some of the main points at which substitutions in paddy cultivation practices can take place between the main resources which are both scarce and manipulable - foreign exchange, water and labour. Any cost benefit appraisal of these practices is beyond the competence and scope of this paper, and would anyway be highly sensitive to many variables including soils, aspects of climate, time of planting, reliability and quantity of supply of water, labour, draught power, fertiliser, agro-chemicals, credit, and the variety of paddy grown. It would also be sensitive to the fact that paddy grown domestically is virtually foreign exchange saved. All we can do here is identify some of the points at which substitutions <u>might</u> be desirable.

Some of the main relationships are shown in Table 15.

The technologies of the green revolution have tended to be water-intensive. The most obvious point is that the NHYVs' benefit from fertilisers is highly sensitive to adequate and timely water applications; this may have accentuated their demand for water.

Table 15. Substitution Matrix for Practices in Paddy Cultivation

Operation	Alternative methods		Intensity of resources use per unit of land		
			Foreign Exchange	Water	Labour
Land Preparation	Tractor, wet		+	+	-
	Buffalo, wet		-	(+)	+
	Tractor, dry		+	-	-
	Buffalo, dry		-	-	+
Planting Fertiliser Weeding	Broadcast	F W	+	+	=
		F -	+	-	+
		- W	-	+	-
		- -	-	-	=
	Trans-plant	F W	+	+	=
		F -	+	-	+
		- W	-	+	-
		- -	-	-	=
Weedicides	Weedicides (instead of water)		+	-	(-)
	No weedicides (using water)		-	+	+
Pesticides	Pesticides		+	?	(+)
	No Pesticides		-	-	-

Notes : The relative amounts of resources used per unit area is crudely indicated for each group of operations in the scale (high) + (+) =(-) - (low) for each of the three resources.

F = using fertilizer

W = using water to reduce weeding

Tractors often use more water in land preparation than buffaloes: this was a finding of experiments at Maha Illuppallama, to which may be added the need of tractors for additional water to avoid their paddle wheels clogging, and water losses from damage to liyadde bunds in transit to and from fields. Fertilizer also appears to require more water since fields have to be drained and then refilled for its application. Until BG 34/6 and BG 34/8 were introduced, the HYVs which had been bred were longer-duration varieties which by virtue of requiring water over a longer period also used more water. Against these points must be set water-saving through the use of weedicides in place of flood water. But on balance the new technology has required more water. This does not imply that it is less efficient in terms of productivity per unit of water; yields per unit of water may not have risen as much as yields per unit area, but it seems likely that under most conditions they have nonetheless risen.

For the moment ignoring productivity, the main possible substitution between labour, foreign exchange, and water appear to be :

Labour can save foreign exchange through :

- substituting buffaloes and mammoties for tractors
- substituting hand weeding for weedicides
- substituting organic manure for chemical fertilisers
- substituting transplanting for broadcasting to facilitate weeding (saving weedicides)
- (perhaps extreme) substituting handpicking of pests for pesticides.

Water can save foreign exchange through :

- water management for increased production of paddy substituting for imported rice
- flooding fields for weed control to save weedicides
- flooding to substitute for pesticides in killing a pest (e.g. Army worm)

Labour can save water through :

- hand-weeding instead of flooding
- better field-level water management
- transplanting instead of broadcasting, reducing the length of time during which a field has to be flooded. (But opinions differ on the extent to which transplanting saves water, if at all)

In the situation prevailing, there appears to be a strong case for measures to encourage the substitution of labour for water, water for foreign exchange, and labour for foreign exchange.

From a discussion as loose as this **it** would be dangerous to try to derive firm imperatives. Whatever is considered desirable on national and economic grounds may, as so often, conflict with farmers' preferences. Farmers' leisure preferences will tend to make substituting or resubstituting labour for water or foreign exchange difficult unless there are either powerful economic incentives or resource supply constraints or both. Economic incentives are largely outside the scope of this paper but are often crucial. Resource supply constraints, in relation to water, are however central to the paper. For example, farmers are unlikely to substitute hand-weeding of broadcast paddy for flooding if the water for flooding is available. They are similarly unlikely to transplant instead of broadcast to save water if the extra water required for broadcasting can be obtained. If there is an imperative deriving from these points, it is that water issue constraints could be one factor in inducing the substitutions of labour for water considered desirable not by the individual farmer, but by the government in terms of the national interest. This implies either an absolute shortage of water, or a strong social or bureaucratic organisation controlling its issue.

ORGANISATIONAL IMPLICATIONS

The arguments and evidence put forward so far converge on a number of imperatives for water management for increasing production of paddy in the Dry Zone. Expressed without the many qualifications and ceteris paribus assumptions being made explicit, the more important of these are :

1. issuing and using less storage water especially in Maha in order :

    (a) to reduce losses from flooding
    (b) to enable a larger acreage to be cultivated
    (c) to save storage water for Yala
    (d) to reduce risks of crop failure

2. securing greater timeliness and synchronisation of cultivation in order :

    (a) to benefit from the higher per acre yields of timely cultivation

(b) to reduce pest and disease losses

(c) to reduce water use

3. choosing paddy varieties which have higher yield: water ratios.

4. substituting labour for water and foreign exchange, particularly through transplanting and weeding practices, through the use of buffalo and mammoty instead of tractors for land preparation, and through applying organic in place of chemical fertilizers.

5. ensuring a technically adequate, timely, predictable and reliable supply of water to all cultivators.

These constitute a top-down technical view of the opportunities. Let us now set this against the bottom-up view of cultivators. For it is only in matching and meshing these two that increased production can be achieved.

In many, perhaps most, Dry Zone irrigation environments, individual cultivators have negligible incentives to be sparing in their use of water. If the water is available for them to take, they rationally perceive that within liberal limits, they benefit, by abstracting more rather than less, since this reduces risks of subsequent shortages by maintaining a buffer supply in their fields and reduces the labour demands of weeding. Cultivators' fixed resources are land areas and they are concerned with productivity per unit of land. They have little or no incentive to try to achieve greater productivity per unit of water, socially desirable though that may be, as long as they can obtain all the water they want. Not surprisingly, then, one finds cultivators who are nearer the heads of field channels in yayas, and groups of cultivators in yayas which are nearer the heads of canals in major irrigation, appropriating quantities of water which are technically (quite apart from socially) excessive, to the prejudices of their neighbours further down. Methods have to be devised for reducing the amounts of water they abstract. But, and this is a fundamental point underlying the discussion which follows, they will not like this. We are concerned with engineering (in the widest sense) situations in which people have to be induced to do, in the common interests, what they feel is against their personal interests.

The problem can be considered at two levels: intra-yaya, and inter-yaya. A yaya here is defined as a paddy tract served by one irrigation source (a sluice, an outlet from channel, etc.), the water from which is managed by the community of irrigators and/or their leadership. Intra-yaya therefore refers to most minor irrigation and under major project and major irrigation to matters internal to yayas. Inter-yaya refers mainly to major project and major irrigation and to water management from the sluice or anicut to the point of handover to the yaya. Intra-yaya matters are thus typically handled by the community; inter-yaya typically by the water control bureaucracy.

Intra-Yaya

Within a yaya there may be a general tendency for those who are more powerful and wealthy to have their fields nearer the tope of the field channels and conversely for the less influential and poorer people to have their fields further away. If this proposition, based as it is on slight and unsystematic observation and a priori reasoning, holds true in the face of more evidence, then it will be particularly difficult to reduce the water abstracted by those near the top. Water allocations are in any case a major micro-political question, and if an objective of policy is to reduce the resources available to those who are better off and to redistribute them to others, and if those who are better off have direct physical prior access to those resources, as they do in this case with irrigation water, then the political issues become acute. Sometimes, it is true, there are long-established systems of allocation and rationing. The karahankota system described by Leach (1961: 160-165) whereby a grooved wooden weir divided water in fixed proportions between channels according to immemorial custom, is an example, but in that case the system was in 1954 no longer operated in its original form although the proportions of water were maintained. Today, in Hambantota District, a rationing system in Yala in which cultivators are given tickets indicating the hours at which they can extract water, has a similar effect. And there are various systems of rotational issues of water within yayas. These may effect more equitable allocations than in a free-for-all situation, although it would be surprising if those near the head of the channels did not remain in a privileged position, receiving more water and receiving it earlier than those lower down. The rotational cultivation system of kattimaru and thattumaru and the fragmented holding system of bethma (Farmer 1957:45; Leach 1961:169-71) also serve to even out inequalities in access of water. While these traditional or recent arrangements mitigate the advantage of those who are better placed, it is still common, at least in Hambantota District, to find a free-for-all in Maha. That this should occur in areas of recent settlement under Uda Walawe is perhaps to be expected, since conventions have not had time to develop. But it also appears to exist under minor irrigation, for example Kataragama, where (notwithstanding a myth to the contrary) those nearer the tank probably always take water first.

Various techniques for tackling this problem have been proposed. To be realistic, none can be expected to succeed unless it takes account of the power and factional structure in the local community.

The first approach is to "educate the farmer". Thus Abeyratne, has written (n.d. (1967):128) "It may be possible to cultivate 3 times more land with the same amount of water that is now available, it water is used carefully, and the farmer is educated to conserve water". More recently, Senthilnathan (1973:1) has said that "The present Sri Lanka farmer does not have adequate knowledge of economical use of water". Both these statements are carefully qualified by the authors. There is, however, a danger in official thinking that when farmers do not do what is expected of them an explanation is sought in ignorance. Often it is not in the interests of the farmer, as he sensibly perceives them, to do what is recommended. The problem in extension is often to find recommendations and practices which he does perceive to be in his interests and which he can adopt. But in the case of the sparing use of water, as I have argued, it is often not in his interest to follow recommendations. An extension campaign to explain to farmers the dangers to yields from too much water might have some success. But an extension campaign to persuade farmers to save water by putting in more labour and at the same time increasing their risks without any commensurate return in yields, would be doomed to failure; and that is precisely what a major campaign for the sparing use of irrigation water would imply. There is indeed, some potential for educating the farmer, but it is rather limited.

A second approach which is frequently suggested (FAO/UNDP 1959: Houghton and Rajanayagam 1973: 12 qualified at page 8; Senthilnathan 1973:10), is charging a payment for irrigation water. The argument is that "As long as irrigation water is made available free of charge it is difficult to make the farmer realise the importance of water management" (<u>ibid</u>:6-7). In none of the cases cited, however, are the administrative arrangements for measuring water use and collecting the charges explored in any detail. Senthilnathan suggests that the installation of measuring devices may be necessary and that the Agricultural Productivity Committee should be sold the water in tanks which they would then in turn issue to the farmers "on recovery of a suitable irrigation rate". Some of the many practical objections to such a system are :

- the Agricultural Productivity Committees are new institutions already burdened with very heavy responsibilities which in most rural situations elsewhere are shouldered by a mixture of government and the private sector. Moreover, the APC members are expected to discharge these duties without (at the time of writing) the incentive of remuneration.

- political infeasibility. The proposal would involve appropriation by government of what people regard as communal resources - the water in tanks, and then resale to the people. It would be surprising if there were not widespread opposition.

- lack of specification of the means of collection.

- the improbability, given the endemic foreign exchange crisis and the difficulty of local manufacture, of being able to provide measuring devices.

Without much more detailed working out and without a strong and consistent political will to impose an unpopular system, charging fees for normal irrigation issues of water cannot be considered practicable.

A third approach might be through the design of physical structures. It is their physical position in relation to the water supply which gives those near the head of field channels their advantages. There may be methods of irrigation layout which are more equitable than others. The work of the Ceylon-Japanese team at Dewahuwa may be important in this respect. Certainly this aspect deserves to be explored.

A fourth approach is political engineering to increase the relative power and control over allocations of those who are further down the field channels. They would then exercise pressure for lower applications by those higher up so that more water could be supplied to them and in a more timely fashion. The most obvious recommendation would be a democratic system with regular elections. It is arguable that one of the reasons for the failure of the nominally democratic Cultivation Committees is that they did not have frequent enough elections and that the elections were not conducted as intended (for an example, see Gooneratne, Gunewardene and Ronner 1973:21). Whatever the causes, they were captured as might be expected by those who were more influential at the local level. The Administrative Secretary (<u>Govimandala Sevaka</u>) appointed by the Committee and who had responsibility for irrigation allocations is usually himself one of the more influential people. Since elections have been few and far between, and then often not properly conducted; the Administrative Secretary has not been subject to effective sanctions from the body of cultivators if he does not do his work fairly. The cure for bad democracy is often more democracy. A system of enforced regular elections might not at once radically change the situation; but over time it could be expected to make the leaders more responsive to that majority of cultivators who were not close to the head of the channel and who were not traditionally influential. For this to be effective it would be advisable to relate representation to irrigation constituencies (physical areas of water supply with common interests) ensuring adequate representation to the tailenders. If, under current policy, this democratic path is not acceptable, appointment to the Cultivation Committee could similarly be based upon irrigation area interest groups.

A fifth and related approach is to select a person with authority to make and enforce water allocations. This brings us towards the centre of the discussion, which is the interlocking of the imperatives of irrigation with social and political organization. A brief historical excursion will help to isolate some of the issues. This theme has been dominated by the analysis and arguments of Wittfogel (1957) and his critics. Wittfogel's thesis defies short summary, but a central thread is that large-scale irrigation generates and requires a totalitarian organization in order to mobilise the human labour needed for construction and maintenance work. This has influenced explanations of the collapse of the Rajarata civilization in Ceylon, notably that of Rhoads Murphey who has argued that the collapse followed a failure to maintain the organization and will necessary for maintenance and repair of major works. Paranavitana, while partly accepting this, goes further and suggests that the persecution of the kulinas, the local chiefs who maintained the authority of the king in their respective geographical spheres, was a critical factor. He writes :

> "The peasants as a whole had been accustomed for centuries to obey the kulinas who had the specialised knowledge and experience that were required to run the public administration, including the maintenance of irrigation works. Deprived of their guidance, and the force that is always necessary to make the average man act for the common good, the peasants no doubt neglected their traditional obligations towards the state". (1960:715-6).

One may perhaps speculate further than this. It may be that historians, following the lead of Wittfogel and misled by the selective nature of the evidence, have been too pre-occupied with the physical works of irrigation to the neglect of the less obvious and less visible problems of operating irrigation systems. The humiliation and removal of the kulinas described by Paranavitana may indeed have weakened the capacity for maintaining irrigation works; but perhaps as critically it may have removed from the scene those who by tradition and experience were able to manage water allocations. This could have permitted a situation in which those best placed to abstract water took more, and those at the lower margin were no longer able to cultivate. If this were so, production would have declined and those at the tailends would have been forced into other occupations or migration.

This historical speculation may verge on the tenuous, but it may be noted that independently of Wittfogel's main argument about construction and maintenance there has been a tendency for water management at the level of the yaya to be controlled by one person. Whatever the role of the kulina, the Vel Vidane of the colonial and early post-colonial period and considerable responsibilities and power in matters of water allocation and descipline. The more recent Govimandala Sevaka, by contrast, has been much weaker. He has lacked the traditional authority of the Vel Vidane (whose office was often in practice hereditary within families) without any significant compensating authority derived from the modern state. He has lacked the incentive of the Vel Vidane who had an interest in successful cultivation by all cultivators since he took payment for his services in the form of a proportion of the crop, to the contrary, the Govimandala Sevaka's remuneration, being a proportion of an acreage tax, is related to his capacity to extract money from cultivators rather than to his effectiveness in providing them with a service. He has been partly beholden to a committee - the Cultivation Committee - which may have made him hesitate to act, instead of relying as the Vel Vidane did, on the authority of government through the Government Agent. He has also lacked recourse to swift sanctions against those who infringe regulations. With these low incentives and slight powers, what is remarkable is that the Govimandala Sevakaya have worked at all.

That they have done so reflects the need for their services. The extent of the need must await micro-political research. In the meantime, preliminary interviews in Hambantota District suggest that particularly in Yala when water is scarce, there is much work of allocation, arbitration and discipline which it is in the common interest of cultivators as a whole and often in their individual interests that someone should carry out. The system of three or six hourly rotational issues on the tundu (ration card) system, said to be practised quite widely under major irrigation in Hambantota district, may require someone to be up in the middle of the night seeing fair play. The allocations also have to be made judiciously and authoritatively if major conflicts are to be avoided. Many small disputes come up for settlement and a respected arbitrator is needed for settling them. Infringements such as illicit tapping of water require swift remedial and disciplinary action. At the local level of a yaya, these functions do not lend themselves to being split up among several individuals. They are most effectively vested in one person with adequate powers.

The early tentative indications from the UCARTI survey in Hambantota district suggest that this may be quite widely recognised by cultivators themselves. Cultivators have been asked:

"Which system do you consider the best to control the cultivation calendar and the distribution of water?"

The investigators have been instructed to read out this list -

"The old system with the vel vidane
the present system
direct government control with stringent regulations
any other system"

and then to ask respondents to choose one of those responses.[1] Unfortunately, of the 200 farmers in the sample, most did not cultivate in Yala 1973. Of the 50 Yala cultivators' questionnaires which have been analysed, 18 preferred the Vel Vidane, 10 preferred direct government control with stringent regulations, and 20 preferred the present system. Of that 20, however, 7 came from an area recently supplied with water from the Uda Walawe project, and their responses are thought to show satisfaction with the better supply of water they are now receiving: 6 more of the preferences for the present system came from a cultivation committee with an unusually active Govimandala Sevaka. The heaviest preference for the Vel Vidane came from Tenagama in the Intermediate Zone where there is endemic conflict between the cultivators of a sequence of small yayas which lie in series below small tanks along the bed of a valley, and where these conflicts have not been resolved, even by the Government Agent. A provisional conclusion from this evidence is that except where there has recently been a dramatic improvement in water supply or where there is an unusually active and influential Govimandala Sevaka, a majority of cultivators say that they prefer a more authoritative system than at present.

If we conclude that there is both a need and a readiness on the part of cultivators to accept a water headman of some sort at the level of the yaya and that he should be vested with stronger incentives and powers than the present Govimandala Sevaka, we are faced with the danger of creating a local dictator who will exploit his power to his own benefit and that of his friends. This is, indeed, a classic problem of political science, albeit oddly neglected by contemporary political scientists (though perhaps Watergate will change that). There are no perfect solutions. There will always be problems of enforcing rules and restrictions on influential people, particularly at the yaya level, a problem which lessens somewhat as the unit administered grows larger (see Ellman & Ratnaweera 1973 for an example). But is can be suggested; that at the time of election or selection of the headman an attempt should be made to pick a person who combines local knowledge of the irrigation system

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1 The questionnaire was devised jointly with C.M. Madduma Bandara and B.W.E. Wickremanayake, and analysed by the latter.

and independence of judgment and who is held in respect. This latter may be more important for effective functioning that independence of the main power groups in the area.

Another measure is to attempt to mobilise effective pressure groups within the yaya to agitate against abuse. In the longer term this may be most effective means, although subject to innumerable local qualifications and variations. This again is a subject for further investigation.

A difficult, complex, but important set of issues revolves around the scarcity of water. The technical imperatives include restricting the issues of water in Maha, making Maha as we have said, more like Yala. This means that the headman will have to be more active in Maha. The emergence of vocal groups of tailenders might be precipated by this measure: if they suffered only in Yala before, to suffer in both Maha and Yala might push them over the threshold of tolerance, so that they would insist on fairer allocations. A further intriguing and related speculation is that cooperation and organisation may be tighter the shorter water is. Wickham in her study of the sociology of irrigation in the Philippines found to her surprise that cooperation between farmers was greater in the area where water was scarcest (973:8). In a different context, Gray (1963) studying an irrigation-based society in East Africa, found that the power of a group of elders was linked with their authority to allocate scarce water. Taken together, these two findings perhaps indicate that the scarcer water is, so the more elaborate, specified and authoritative tend to be the institutions and conventions for its allocation. It is thus quite possible that in situations of scarcity - whether "natural" in Yala or "induced" in Maha - the headman will appear to exerciee more power but at the same time be constrained within more formally defined rules for allocation; and that these rules, because of their importance to the tailenders and the pressures which a situation of crisis forces them to bring to bear, may embody reasonably fair allocations, even fairer ones than under a permissive regime.

<u>Inter-yaya</u>

Inter-yaya water allocations concerned only major project and major irrigation. They are under the control of a bureaucracy - part of the project organisation on Uda Walawe, and elsewhere under the Territorial Civil Engineering Organisation (TCEO). The designations of staff have changed from time to time, and the terms used in the field are often not those which are now official. However, under the TCEO the hierarchy within a district is one of typically several Executive Engineers (with responsibilities for roads, various forms of construction, and irrigation apart from major construction which is the responsibility of the Irrigation Department). Technical Assistants (who in theory are competent in all spheres of activity but who in practice may specialise). Works Supervisors and Grade IV Labourers (which latter two groups have various responsibilities for regulating water flows). It is these staff who are critically involved in any attempt to improve inter-yaya water management, and whose work and problems deserve to be analysed as a priority part of any further investigation of water management.

Inter-yaya water allocations can be examined against the background of the system for deciding dates for water issues. These, for major irrigation, are determined in cultivation meetings held before each season under the chairmanship of the Government Agent or his representative, with representatives of various government departments present, and with attendance by all cultivators of the tract concerned who wish to come. Discussion is often long and involved. Many sectional interests come into play. The advice of the Executive Engineer about the volume of water available and of the District Agricultural Extension Officer about agricultural matters are put before the meeting. Decisions taken usually include dates of first and last issues of water from a tank or anicut and the age class of paddy variety to be grown. Discussion may however cover questions such as whether to skip a season, when cultivation has been delayed, or whether to cultivate only part of the area under command. The issues are complex and both technical and political. At their best such meetings lead to intelligent arbitration and mutual agreements between cultivators. An outstanding example is the agreement secured by the Government Agent Hambantota in 1973 from the cultivators under Kirindi Oya Left Bank (Tissa), which is usually short of water in Yala, who agreed to rotational cultivation of the paddy tract, sections taking their turn for going without water.

These meetings appear an admirable system. They require a high level of skill, patience and understanding on the part of the chairman. (The Tissa agreement mentioned above was only achieved after two very long meetings lasting into the night, and much explanation with a blackboard). The arbitration and leadership function of the chairman is difficult and can best be performed by someone who is known to have no personal interest at stake. It is difficult to imagine that this function could be performed nearly as effectively by a political leader from the area or by an Agricultural Productivity Committee, since either would be regarded as being partial. The case appears strong for continuing the present proven system unchanged.

But further than this, there are good reasons for suggesting that the functions of the civil service should be strengthened and extended in the control of irrigation.

It is notorious that water issues are frequently prolonged beyond the agreed dates as a result of pressures by small numbers of cultivators who have planted late, or who have deliberately planted longer-duration varieties. Cases like these have to be judged on their merits. They cannot fairly be judged on grounds of political influence. If abuse of cultivation practices are to be avoided, it seems essential that the decision should rest with an impartial civil servant. The obvious person is the Government Agent.

Pursuing this line of reasoning, we can now examine the problem of permissive water issues and inter-yaya competition for water under major project and minor irrigation. Permissive water issues occur for many reasons. Where communications between farmers and staff are poor or mediated through corruption, as they are said to be on Uda Walawe, farmers are liable to feel insecure about their water supply and therefore to demand continuous heavy applications. Where staggered cultivation is endemic, as it is on Gal Oya, restrained water issues are difficult to achieve because water is always flowing. Where structures and gates are damaged and padlocks missing, as on much major irrigation, controlled issues are difficult or impossible. Where civil servants are subjected to heavy political pressure or direction to issue water, they have no incentive to resist and they (sensibly from their point of view) let the water flow until it runs out; at which time they can take protesting cultivators and politicians to see the empty tank, and argument for stopping issues that no one can refute. Finally, pressures are very common for water issues beyond agreed terminal dates to benefit those who for various reasons have planted late crops.

The situation is, however, far from hopeless and must not be overdrawn. Permissiveness is partly a function of size - it is most marked on Gal Oya and Uda Walawe; and partly a function of abundance of supply - as on Walawe Right Bank where there is continuous run of the river supply throughout the year. Where there are serious problems of adequacy, as with Kirinde Oya Left Bank, much more stringent issues are practised and accepted by the cultivators.

The problem we are confronted with, however, is one of "induced" shortages: that is to say, handing over to yayas less water, and perhaps at longer intervals and over shorter seasons of issue than they demand. (For the rationale for this see above). One example of this is what are known as "rotational issues". An illustration of what is possible can be taken from Gal Oya. Thamothoram (1970:3) has written that:

> "In April '68 when a decision had to be taken with regard to the extent to be taken up for Yala - in the light of the depleted storage in Senanayake

Samudra and the then prevailing severe drought - any recommendation by the department that cultivation be confined to a limited extent would have been unrealistic. The writer, in consultation with the Irrigation Engineer, took the bold decision to recommend that the entire extent be taken up for Yala cultivation under a strict system of sporadic issues, to keep the people happy and the paddy plants alive. This has been the system of rotational issues which was practiced in 1969 as well, with immense success. This was an unique achievement in the history of the Irrigation Department and has been extended to other schemes in the District as well. It has also resulted in the reclamation of nearly 3,000 acres of low lying purana paddy lands on the fringes of the lagoon which used to get submerged by the excessive drainage water from the lands higher up. In 1969 the pattern was one of 3-4 days issues and 10 days break. With the present satisfactory storage in Senanayake Samudra, the gap has been reduced from 10 days to 6 days. This is considered optimum."[1]

Various systems of water issues are possible. Some of the main ones may be:

- permissive flooding: practised on Uda Walawe and Walawe Right Bank. Water is run at capacity or overcharge through the channel, and yayas are permitted maximum extraction.
- capacity rotation. Yayas receive water in rotation but in large quantities. Levine et al. have suggested that such a system may simplify intra-yaya cooperation "Relatively large deliveries, controlled at the lateral, alternating with zero flow, could reduce the requirements for cooperation among farmers while at the same time providing reasonable, if not optimum, satisfaction of farmers needs." (1972:11)
- sub-capacity rotation. Yayas receive less than delivering capacity, perhaps at more frequent intervals. This may require more intra-yaya rotation.

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1 In spite of this system, however, water management on Gal Oya is recognised as being very far from satisfactory.

- deliberate inter-yaya staggering, with dovetailing troughs and peaks of water demand according to the stages of growth of the crops. This may be too intricate for current levels of management, but should prove an economical method of distributing water, particularly where there are problems in getting water to the end of the channel.

All these systems except the first involve denying to groups of cultivators something which they want. All are therefore liable to political pressures. If they are to be operated, therefore, those responsible must in some way be insulated from those pressures, or must have some strong incentive to resist them, or both. The people subject to pressure are civil servants - overseers, technical assistants, executive engineers, government agents, and so on. They sense their careers to depend on their responsiveness to political wishes and influences. They have little incentive to deny water to anyone.

There are two complmentary ways in which issues can be tightened up. Either would be unlikely to succeed without the other. The first is a rigorous tightening of scheduling by the TCEO, working out with the Government Agent, the District Agricultural Extension Officer and representatives of cultivators schedules for water issues for all major irrigation works. What I mean here is systems of rotational issues specifying the duties to be issued to different yayas. The second is the public and sustained support for tighter systems from the very highest political level. It would be necessary for it to be very clear to civil servants that they were supported in their difficult task of denying water to those who demand it. If the morale and conviction of civil servants was to be sustained, it would be necessary for there to be public demonstrations of this high level political support, for example in publicly supporting the denial of water to maturing paddy which had been planted outside the cultivation calendar. To a minority of cultivators this would appear a betrayal by their representatives; to a majority, however, it would soon become clear that the restraint in water issues exercised by the civil servant with the highest political support was not only in the country's interest but also was part of a system which assured them of adequate water on a more reliable basis.

Without these measures it is doubtful whether more than a trivial proportion of the benefits of stricter water management could be realised. With them, if the evidence and arguments of this paper are correct, very substantial increases in paddy production might be achieved.

* * *

THE OPPORTUNITY

This paper makes many assumptions, some of them rather arbitrary; leaves some questions unanswered; and does not explore all the implications of its conclusions. It does, however, suggest that there is a major opportunity to increase paddy production in the Dry Zone through increasing the productivity of water. If we consider major irrigation alone, since that is the area in which government intervention is easiest, we can estimate additional production that might accrue under different assumptions. The two main sources of increased production from stricter water management on major irrigation would be increased yields on land at present cultivated (resulting from more timely and more appropriate supplies of water) and increased areas cultivated in both Maha and in Yala. Taking production from Dry Zone major irrigation per annum as lying in the range of 20 to 25 million bushels of paddy, then additional production under different assumptions can be presented as in Table 16.

Table 16. Increases in paddy production from Dry Zone major irrigation under different assumptions

Estimated base of Dry Zone production from major irrigation	Percentage increase in yields on currently cultivated area			Percentage increase in acres cultivated at current yields		
	10	20	30	10	20	30
20 million bushels	2.0m	4.0m	6.0m	2.0m	4.0m	6.0m
25 million bushels	2.5m	5.0m	7.5m	2.5m	5.0m	7.5m

To close the production gap of 25 million bushels and attain or approach self-sufficiency would require at least 50 per cent increases in yields on currently cultivated areas and in acres cultivated (assuming current yields only), and this might well be unattainable. But if the respective increases were only 20 per cent, then some 8 to 10 million additional bushels would be produced, as much or more than the additional paddy expected from the first two stages of the Mahaweli Ganga Project by 1980.

The basic point is that water is scarcer than land in the Dry Zone, and sparing use of water is land-augmenting. Constructing new irrigation works in order to increase the water available and the land irrigated takes much foreign exchange and much time. Improving the management of water which is already there takes little foreign exchange and can be quick; and the effects — more water available for irrigation, more land irrigated — are the same. In order to achieve this improved management, the prime requirement is political will exercised at the highest level. The opportunity, in economic terms, is to substitute political will for foreign exchange. The opportunity has not been as clear before as it is now because of the earlier relative ease of importing food and fertiliser. In the much more difficult world situation of the mid-1970s and the deepening economic crisis which faces Sri Lanka, this opportunity seems at the very least to deserve further early and serious investigation. This might perhaps be best be achieved through designating some representative major irrigation tanks as pilot projects and ensuring political support for the staff involved. It might then be possible to gauge more accurately the scale of potential benefits in terms of additional paddy produced that could be expected from this approach.

PADDY WATER REQUIREMENTS: **APPENDIX A**

Murakami's and Vignarajh's calculation

Research results reported by Murakami and Vignarajah (in Abeygunawardena, ed., n.d. (1967): 158), unfortunately contain misleading errors of calculation and typesetting, concluding with false figures. These are for the total quantity of water expended in the cultivation of a 4-month crop by providing standing water from sowing to harvest. The figures given are 5 feet approximately in each of Maha (November-February) and Yala (May-August). The figures should however, be 4.9 and 6.3 acre feet approximately, as the following analysis shows:

Postscript: Some topics for further investigation are:-

1. the extent of land below major irrigation tanks which is suitable for cultivation but not yet asweddumized.
2. the extent to which labour and other constraints would limit cultivation of that land
3. the frequency with which major irrigation tanks in the Dry Zone spill in Maha
4. micro-political research, both intra-yaya and inter-yaya
5. studies of the actual operation of water control bureaucracies.

The published Table records:

Table I. An Estimation of the Total Quantity of Water Expended in the Cultivation of a 4-month Crop, by Providing Standing Water from Sowing to Harvest.

Period	Item	Maha (November-February)	Yala (May-August)
Prior to sowing	Water requirement for puddling and levelling and maintaining field at saturated moisture condition for 2 days	170 mm	170 mm
From sowing to trans-planting	Evapotranspiration days (No. of days)	Em/(3.3 mm) (20) = 67 mm	(6.5 mm) (20) = 130 mm
From trans-planting to harvest	Transpiration	(340) (700 Kg/10a) = 240 mm	(450) (700 Kg/10a) = 315 mm
	Evaporation (Em/day) (No. of days), (E/Em)	(0.54)= 385 mm	(0.54)= 385 mm
For sowing to harvest	Percolation (Perc./day) (No. of days)	(7 mm) (120) = 890 mm	(7 mm) (130) = 910 mm
For sowing to harvest	Total	1545 mm = 5 ft (approx)	1910 mm = 5 ft (appr.)

Em - Evaporation - Meteo. Stn. reading (from free water surface)

E - Evaporation in Field

Corrections

Under Maha, evaporation should read 178 mm instead of 385 mm., which appears to be a typing or typesetting transposition from Yala. 178 mm. is the figure in Murakami's original mimeographed report to the Ministry of Agriculture.

Under Maha, percolation of 7 mm per day for 120 days gives a figure of 840 mm, not 890 mm.

The total for Maha thus becomes 1495 mm or approximately 4.9 feet.

Under Yala the total of 1910 mm appears to be correct, but this is not 5 feet but approximately 6.3 feet.

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