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Irrigation Research Possibilities in Sri Lanka: A Challenge to the Social Sciences*

by

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The importance of irrigation in the agricultural development of Sri Lanka can hardly be overemphasized. Dry Zone development in particular is characterized by a high degree of dependence on irrigation. The Mahaweli Ganga Multi-Purpose Project—the largest ever development project to be undertaken is again an indication of the crucial importance of irrigation in the development strategy of Sri Lanka.[1] However, it remains a curious fact that irrigation as a subject of research has received scant attention from social scientists. It is true enough that aspects either related or incidental to irrigation such as land use and settlement have been researched; but irrigation *per se* as a subject of research has not received the attention that it deserves. It should, however, be noted that this situation is not peculiar to Sri Lanka.[2]

Since the distribution, allocation and utilization of irrigation water have both social and economic implications it is necessary that the social scientists actively engage themselves in irrigation research with a view to filling the existing lacunae. It is only thus that a more pragmatic approach to irrigation development can be found. The object of this paper is to identify some research possibilities insofar as these relate to the social sciences with a view to stimulating research in irrigation development.

For convenience the discussion of research possibilities in irrigation is grouped as follows :

(1) Traditional Irrigation Institutions,
(2) Operation and Management of Irrigation,
(3) Irrigation Economics,
(4) Irrigation Perception and
(5) Comparative Irrigation Research.

Historical research on irrigation though important is not the focus of concern here, but undoubtedly (1) above involves an historical dimension.[3] The above categorisation is purely arbitrary and does not imply a sequential basis for research on irrigation development. However, what is important is that research should be sufficiently broad-based as to encompass the areas listed above. In passing, attention is drawn to the rather lengthy foot-notes and references supporting the arguments of the paper. The very paucity of social science research pertaining to irrigation in Sri Lanka has made this

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necessary as it enables attention to be drawn to work being done in other parts of South and South-east Asia. Where necessary the references contain elucidatory comments.

Traditional Irrigation Institutions

The term traditional irrigation institutions is used here in a very broad sense to cover both the institutional and organizational aspects. There exist in Sri Lanka traditional systems of irrigation which contrast with the primarily State-sponsored larger irrigation systems of more recent times. These systems are controlled and regulated by traditional institutions which are of course subject to evolutionary change and modification. There is a real need for a critical study of these institutions based on empirical research, particularly with a view to their selective transferability to new situations. Coward's study of the indigenous irrigation bureaucracy in Thailand points at possible lines of investigation.[4] Presumably, the study of traditional irrigation institutions will also provide the necessary data for evolving theoretical models for the comparison and evaluation of traditional irrigation systems, which in turn will be crucial in improving their levels of efficiency. Leach's classic study of Pul-Eliya illustrates the complex institutional arrangements relating to water rights in a *wewa* (tank) based irrigation system in the Northern Dry Zone of Sri Lanka.[5] However, there is a need for more information on traditional water rights and irrigation practices. Such information should not only relate to the *wewa* based systems, but also to the flow-irrigated systems based on both perennial and non-perennial river systems.[6] It is equally important to study the traditional institutional arrangements relating to lift irrigation. Ho Sung's study of customary rules of water management for small irrigation reservoirs in Korea provides useful guidelines for similar studies in Sri Lanka.[7] The work of Geertz and Birkelbach in Indonesia is equally suggestive.[8] Another possible area of research is to identify the stresses to which the traditional institutions are increasingly subjected. Thus, for example, with the increasing use of capital inputs in agriculture there is bound to be conflict between individual needs and community control of irrigation water; and it may well be that traditional institutions place constraints on desirable changes.[9] There is also the situation in which the traditional institutions operate in an organizational vacuum, largely because of the failure of village-level organizations to whom has been delegated the responsibility of managing irrigation.[10] Therefore, there is the danger of traditional irrigation institutions losing their viability in a rapidly changing social context. How could the process be contained or, more positively, be given re-direction? The answers to these problems may lie in a careful and discerning analysis of the traditional institutions of irrigation. Hence the need for research of the type suggested above.

Operation and Management of Irrigation

There is much scope for research on the operational and managerial aspects of irrigation. In Sri Lanka this is almost an untrodden field by social scientists, and the work of Chambers and Harriss may well be considered as pioneering efforts.[11] There is evidence to suggest that in canal based irrigation there are numerous constraints placed on efficient operation and management. A fundamental difficulty arises when a canal system is unable to provide a dependable supply of water to the irrigators. A dependable water supply should ensure the availability of irrigation water in the right quantities, at the

right time and at the right place. There may also be situations in which irrigation water, though available, is not equitably distributed through the entirety of the canal system, thereby creating problems of inequity between top-enders and tail-enders. Further, it is possible that among both top and tail-enders those located closer to the source of water supply (i.e. the main or the distributory canals) derive more advantages resulting in inequities both within and between groups. Irrigation water may be misappropriated and in general not efficiently used. The permissiveness in water use has been identified as a major constraint on improved management practices in irrigation.[12] Some of the above problems necessarily arise due to faulty designing and bad maintenance of irrigation systems; but there are others which are more directly related to the human factor, whether at the level of the bureaucracy or of the local community. In minor irrigation, typyfied by the *wewa* based communities of the Northern Dry Zone, elaborate institutional arrangements have been devised to eliminate inequity in access to water and for the maintenance of irrigation systems.[13] However, in recent times the functional viability of such systems have been threatened by the failure of village-level institutions such as the Cultivation Committees.[14] Hence the need for social science research on the operational and managerial aspects of irrigation. It should of course be emphasized that research should be concerned with more than the simple identification of problems listed above; in fact research should be concerned with possible approaches to the resolution of such problems. Research possibilities relating to operation and management of irrigation, for convenience may be grouped into four areas as follows :

(a) Irrigation bureaucracy,

(b) Water management,

(c) Irrigation communities and

(d) Irrigation politics.

These groupings, however are not mutually exclusive.

(a) Irrigation Bureaucracy

Simply stated there is the need to study the manner in which the irrigation bureaucracy operates. Thus it is useful to study the patterns of interaction between the irrigation bureaucracy and the irrigators; the relationship between the elitist and non-elistist groups within the bureaucracy may have direct implications for the way in which it performs. Wade, for example, refers to the "low-trust" quality of relationships in Indian canal administration.[15] It is interesting to determine the extent to which this situation is evident in irrigation administration in Sri Lanka. Not too infrequently there is the tendency on the part of the irrigation bureaucracy to ascribe the failure of irrigation systems to external factors; but it is worth examining the extent to which problems internal to the system account for such failures. There is also the need to investigate the efficiency of field-level operations of irrigation staff with a view to identifying the practical difficulties involved. It is further necessary to look into the motivation, sanctions and rewards for irrigation staff.[16]

(b) Water Management

This is a very crucial area in irrigation research. The extremely low level of water management obtained in Sri Lanka has received comment in many technical reports on irrigation.[17] The non-availability of a reliable water supply has been identified as a major problem in existing irrigation settlements.[18] Further, there is the need to discover non-zero sum (i.e. the means by which the supply of water to the tail-end can be improved without top-enders becoming worse off) solutions to the problems of water management.[19] The type of implication that better management of irrigation water is bound to have on paddy production in Sri Lanka has been examined by Chambers.[20] There is a need for similar studies to test the validity and practicality of the proposed strategies for management.[21] It is suggested here that in-depth studies of water management in relation to specific irrigation systems will prove to be important in policy formulation. There is also much potential for researching into specific aspects of water management, e.g. water rationing and water accounting as demonstrated by Reidinger and Wade with reference to canal irrigation in India.[22] It is equally important to study water management situations with special reference to levels of performance under traditional systems of irrigation. It is, for example, interesting to study the impact of the provisions of the Irrigation Ordinance on the level of performance of village irrigation systems.

(c) Irrigation Communities

There is much scope for research on irrigation communities. An area that needs immediate attention is the type of irrigation association necessary to organize the irrigators into cohesive groups. The absence of functional irrigation groups at the community-level is an observable weakness in the operation and management of irrigation systems in Sri Lanka. In regard to irrigation associations several basic problems should be carefully researched. The means of strengthening the participatory role of farmers in the decision-making process is obviously an area for investigation. How is it possible to strengthen the bargaining position of the local groups vis-a-vis the irrigation bureaucracy? How should the leadership roles be articulated within such groups? Where should the accountability of irrigation leaders lie—should it be to the bureaucracy or to the local community? In what manner and to what degree should new leadership roles relate to existing patterns of authority at the village-level? How relevant are the now defunct roles of irrigation headmen and irrigation agents as models for the formulation of a new type of institutional leadership?[23] It will, of course, be necessary to carefully research the constitution of irrigation associations. A vital need in this area is to strengthen tail-end representation in such organizations. Is the answer to be found in "political engineering" as suggested by Chambers?[24] An interesting experiment in farmers organizations is being attempted in the Mahaweli development area. It will be useful to monitor the performance of such organizations particularly with reference to the discharge of leadership responsibilities and the probability of membership participation and stability. The findings will prove useful not only for Mahaweli development but also for the existing irrigation development schemes as well.[25] The work of Gillespie and that of Parker and Bromley suggest the other possible approaches to the study of irrigation communities.[26]

(d) Irrigation Politics

Irrigation is very much the stuff of politics and it is important to research the impact of politics on the operation and management of irrigation. The fact that all too frequently politics exert a negative impact on irrigation management is well known. Moore refers to the "siege mentality" afflicting the irrigation bureaucracy due to frequent and unwarranted political intervention in irrigation administration.[27] Similar experiences have been observed elsewhere, particularly in India. [28] It is, therefore, necessary to examine the formal and informal patterns of political intervention in irrigation administration, In such studies there is the need to be conscious of the different levels at which politics interact with irrigation management, viz. State, village, institutional and organizational, etc. Research should also be concerned with the problem of developing a more positive relationship between politics and irrigation administration. This is especially important at a time when in Sri Lanka decentralization of administration results in a greater devolution of authority on Development Councils, thus necessitating closer interaction between politicians, the irrigation bureaucracies and the community of irrigators.

Irrigation Economics

This again is another major area with research possibilities. Cost-benefit studies of irrigation development should be vigorously pursued. It may well be that the only post-settlement cost-benefit evaluation of an irrigation project in Sri Lanka has been that of the Gal-Oya Project, which indicated a benefit-cost ratio of 0.5.[29] A fundamental point at issue is the extent to which this finding is true of other irrigation projects of Sri Lanka. Hence, there should be similar studies relating to other irrigation schemes. At the micro-level the returns versus costs for alternative water management/cropping systems may be analysed to ascertain economic efficiencies of irrigation. The short term versus long term-cost-benefit analysis of alternative supply systems, e.g. between flow irrigated and lift irrigated agriculture, indicates another possible line of investigation. Another area of importance is the study of the distribution of irrigation benefits.[30] Irrigation development should be concerned with the equitable distribution of benefits within the community. If inequities exist, how could equity be achieved? In such situations it is worth investigating whether market solutions are possible to reconcile differences. The relationship between improved irrigation practices and productivity is another potential area of research.[31] It would be especially interesting to study the impact of stability of production of irrigated crops on farm income. The labour absorptive function of improved water management practices is another aspect worth irvestigating.[32] There is also the need to arrive at objective criteria to determine water pricing policies.[33]

Irrigation Perception

It will be useful to undertake perception studies on irrigation. Such studies are bound to provide useful insights into ways and means of improving the efficiency of irrigation water use. The crucial point is to ascertain the ways in which irrigators perceive the opportunities available to them. Thus the way in which top-enders in a canal system perceive the benefits of water rationing may be radically different to that of tail-enders. Attempts at the introduction of more intensive systems of water management may clash with the

irrigators notions of work and leisure. It may well be that an authoritarian irrigation leadership may actually be perceived beneficial by the irrigators. How will the peasants, who are used to a system of tank based small scale irrigation in which water rights and rights to land coincide, perceive a system in which these do not coincide as in large scale canal based irrigation systems? How indeed do irrigation communities perceive the new environments in which they are settled, as, for example, in the Mahaweli settlement area; and how will those without previous irrigation experience or with a different type of experience respond to fresh challenges.[34] The above issues are of particular relevance in the "H" areas of the Mahaweli where there is both a process of settlement and re-settlement in operation. The present writer has demonstrated the way in which the risk perception of a tank based small peasant community in the Dry Zone compels the community to decide on alternative strategies of cultivation when threatened by the drought hazard.[35] This obviously has implications for irrigation efficiency. Ranaturiga and Abeysekera show that cereal crops such as maize and sorghum, considered as potential lowland *yala* crops in the tank modernization programme, had evoked no interest among farmers.[36] It would be worthwhile to study the way in which the irrigation bureaucracy perceives its role vis-a-vis the irrigation communities and vice-versa. Equally, how do the irrigation communities perceive the provisions of the Irrigation Ordinance? At this point reference may be made to Bailey's study of the world view of the Indian peasant to indicate the potential relating to perception studies.[37]

Comparative Irrigation Research

Comparative studies on irrigation is another possible area for research. Needless to say, comparative research provides a useful basis for evaluation, assessment and planning of irrigation systems. They may also prove useful in the formulation of irrigation policy. Useful comparative studies of irrigation have been made by several authorities. Thus Coward attempts a comparison of three traditional irrigation systems—including that of a *wewa* based small irrigation system of Sri Lanka—where the physical components for handling water are broadly similar, but in which significant institutional/organizational variation is found. The alternative approaches to organization and control of irrigated agriculture are compared, thus providing useful insights.[38] Similarly, a comparison of irrigation systems in Bali and Morocco is made by Geertz.[39] The comparative study by Bottrall of irrigation organization and management through a wide spectrum of world irrigation systems indicates other possibilities.[40] It may be suggested that the problems identified in the foregoing sections could be the basis for comparative research and analysis. Several areas for immediate comparative research may be noted. Thus, despite the differences in magnitude, a comparison of irrigation systems of Sri Lanka and India—within a comprehensive framework, is bound to yield important results. Another possibility is to compare traditional lift irrigation in Sri Lanka with similar systems in other parts of the world and more especially of South Asia. Comparative studies are also possible within the local context itself. The spatial variations in irrigation is a useful point of entry into such studies. Additionally comparisons are possible of both similar and dissimilar systems of irrigation. Such studies could either concentrate on specific aspects or on holistic appraisal.

Conclusion

This paper outlines several possible areas for irrigation research in Sri Lanka. The issues raised may perhaps indicate further directions in which research opportunities are available. The paucity of research of the type outlined above undeniably constrains the efforts to improve the efficiency of irrigation water use. It is in this sense that irrigation research offers a challenge to the social sciences. It is, however, worth noting that the research possibilities outlined above are not the exclusive domain of any particular field within the social sciences. Interdisciplinary approaches by researchers within the social sciences are bound to be highly productive in irrigation research; and indeed there lies much scope for social scientists to collaborate with researchers outside the field of social sciences. Thus collaboration with social psychologists will be useful in perception studies and engineers and agriculturists in water management research. It is worth exploring the possibilities of establishing a focal point for the direction and coordination of social science research on irrigation.

Notes and References

1. The Mahaweli *Ganga* project envisages the provision of irrigation water for the intensive cropping of 250,000 acres of land already under cultivation; a further 650,000 acres of new lands too will be provided with irrigation water. The project envisages the planned resettlement of peasants on newly opened land. The Mahaweli Development Programme which was phased over a period of thirty years is now telescoped to be completed in six years.
2. The generality of this situation and the causative factors emerge in two studies by Chambers. See Chambers, R., 1978(a) 'Identifying Research Priorities ia Water Development in Carl Widstrand (ed.) *The Social and Ecological Effects of Water Development, Pergammon Press* pp. 389—397, and Chambers, R., 1979, 'In Search of a Water Revolution: priorities for irrigation management in the 1980's'. Paper for IDS Workshop on Irrigation Bureaucracy and Performance.
3. It may be useful to attempt in-depth historical research on all aspects of irrigation. The ancient methods of distribution, allocation, regulation and control of irrigation water and the temporal and spatial variations in irrigation systems suggest some possible lines of investigation. It is also possible to have more historical data on the technological aspects of irrigation such as the construction, designing and the minimisation of conveyance and seepage losses. However, see Harriss, J., 1979, *The Use of Documentary and Historical Evidence in Irrigation Studies*, Development Studies Discussion Paper, University of East Anglia.
4. Coward, E. W., 1976, 'Indigenous Organisations, Bureaucracy and Development: the case of irrigation, *The Journal of Development Studies* 13, 92–105. Coward develops the hypothesis that indigenous roles can be used for articulating bureaucracy and locality, if accountability for job performance largely remains with the local water user groups.
5. Leach, E. R., 1961, *Pul Eliya, a Village in Ceylon. Cambridge.* Since the study is primarily concerned with land tenure and kinship it does not provide detailed information on irrigation practices.

6. The utilisation of perennial rivers or streams for irrigation is particularly evident in the hill country. Bailey 1856 describes the *sirita* (rules of irrigation) of the Uva region, see *Irrigation*, Colonial Office Printed Memoranda, HMS. Irrigation based on non-perennial river systems is primarily observed in the Eastern Dry Zone, e.g. in the Moneragala district. In local parlance the non-perennial streams are known as *malan-kanduru*; to the writer's knowledge there is no information available on irrigation practices relating to their use.

7. Ho-Sung, Oh, 1978, 'Customary Rules of Water Management for Small Irrigation Reservoirs in Korea', *Journal of Rural Development* 7, 96–109. The paper deals with the organisation of *Soosike* (a non-formal grass-roots organisation for irrigation management) water distribution rules and the cost distribution. The paper also devotes a section to the formulation of a theoretical framework to evaluate customary rules of water management.

8. Geertz, C., 1967, 'Tihingan: A Balinese Village' in Koentjaringrat (ed.) *Villages in Indonesia*, pp. 210–243, Cornell and Birkelbach, A. W., 1973, 'The Subak Association', *Indonesia* 16, 153–169. Their studies of the *Subak* show that it is an irrigation association composed of all irrigators served by an irrigation system. The *subak* is independent of the residential community since the members of the *subak* may come from several different villages and the members of a village may belong to several different *subaks*. The *subak* is involved in more than just the maintenance of the irrigation system and the settling of disputes as they arise and performs an active role in controlling and regulating critical on-farm decisions of irrigators.

9. A discussion of the constraints of customary irrigation practices on land consolidation in a Dry Zone *purana* village is found in Karunanayake, M. M., 1978, 'A Strategy for Land Consolidation in Dry Zone Purana Villages', *Economic Review*, September/October, 17–30. Studies on similar lines will prove to be useful for policy making.

10. This is well illustrated by the failure of Cultivation Committees to discharge responsibilities relating to village irrigation. The *Vel-Vidane* (irrigation headmen) system was replaced by the Cultivation Committees under which an Irrigation Agent was responsible for the enforcement of irrigation rules. The Irrigation Agent was accountable to the Cultivation Committee. The delay in amending the Irrigation Ordinance in keeping with the changes postulated by the Paddy Lands Act and the functional weakness of Cultivation Committees had a disastrous impact on village irrigation. See for example, Weerawardene, I. K., 1975, *Lessons of an Experiment: the Paddy Lands Act of* 1958, Ministry of Agriculture and Lands, Colombo.

11. Chambers, R., 1977(a), 'On Substituting Political and Administrative Will for Foreign Exchange: the potential for water management in the dry zone, in S. W. R. de A. Samarasinghe (ed.), *Agriculture in the Peasant Sector of Sri Lanka*, Ceylon Studies Seminar; Chambers, R., 1977 (b) 'Men and water: the organization and operation of irrigation, in B. H. Farmer (ed.) *Green Revolution, Technology and Change in Rice Growing Areas of Tamilnadu and Sri Lanka*; Chambers, R., 1978(b), 'Water Management and Paddy Production in the Dry Zone of Sri Lanka', Occasional

Publication No. 8, ARTI and Harriss, J., 1977, 'Problems of Water Management in Hambantota District in B. H. Farmer (ed.), *Green Revolution, Technology and Change in Rice Growing Areas of Tamil Nadu and Sri Lanka*, Macmillan.

12. Chambers, R., 1977(a) ibid.
13. Leach, E. R., 1961, *Pul-Eliya: a Village in Ceylon*, Cambridge; Karunanayake, M. M., 1977, 'The Attitude of Peasants to Land Consolidation : a case study of a Dry Zone village in Sri Lanka', *National Geographer* 12. 25–34.
14. Weerawardene, I. K., 1975, op. cit. The 1978 Agrarian Services Act institutes Agrarian Services Committees to replace the Cultivation Committees and the Agricultural Productivity Committees. The Act empowers the Commissioner of Agrarian Services to appoint Cultivation Officers who will, among other things, "attend to all matters relating to minor irrigation works and the maintenance of minor irrigation works and to prevent as far as practicable any act or omission which is contrary to any rule in force relating to irrigation or cultivation rights or to established customs relating thereto."
15. Wade, R., 1979, 'Man Mismanagement in Canal Irrigation: a south Indian example', paper for IDS workshop on 'Water Bureaucracy and Performance'. For a further discussion, see Wade, R., 1978, 'Managing Irrigation Canals in South India', *Development Research Digest*, 2, 52–55.
16. Moore, M. P., 1979, 'The Management of Irrigation Systems in Sri Lanka: a study in practical sociology', paper for IDS workshop on Water Bureaucracy and Performance. Moore presents a reasoned case for the reform of the irrigation bureaucracy of Sri Lanka. The discussion relates mainly to the more senior cadres. It is equally important to take a bottom-up view of the bureaucracy.
17. See for example UNDP/FAO 1969 *Mahaweli Ganga Irrigation and Hydropower Survey, Ceylon*, UNDP/FAO, Rome.
18. Barnabas, A. P., 1967, 'Sociological Aspects of Mahaweli Ganga Project, FAO and Irrigation Department of Ceylon, Colombo.
19. Chambers, R., 1979, op. cit.
20. Chambers, R., 1979(6) op. cit.
21. See for example, Wickham, T. and A. Valera, 1978, 'Practices and Accountability for Better Water Management' in *Irrigation Policy and Management in Southeast Asia*, IRRI, Philippines.
22. Reidinger, R., 1974, 'Institutional Rationing of Canal Water in Northern India: conflict between traditional patterns and modern needs , *Economic Development and Cultural Change*, 23, 79–104, and Wade, R., 1976, 'Water Accounting in Irrigation Projects: a technique from Maharashtra , *Economic and Political Weekly*, 11 (35), 28 August.
23. Coward, E. W., 1976, op. cit.; Coward, E. W., 1970, 'The Differentiation of Synaptic Leadership in Rural Laos', *Journal of Asian Studies*, 1, 135–7 and Moerman, M., 1969, 'A Thai Village Headman as a Syanaptic Leader' *The Journal of Asian Studies*, 28, 539–549.
24. Chambers, R., 1979, op. cit. The term 'political engineering' implies the creation of irrigation constituencies for a management committee to make decisions about water allocations between groups. Any such committee might include an over-representation of tail-enders to off-set their natural disadvantages.

25. A preliminary discussion of Mahaweli farmer groups is found in a paper by Montgomery, D. J. 1979, 'Engineering Designs and Organizational Designs for Systematic Land Development in the Mahaweli and Pochamped Irrigation Systems' (in draft).
26. Gillespie, V. A., 1975, 'Farmer Irrigation Associations and Farmer Co-operation', *Food Institute, East–West Centre*, and Parker, D. and D. Bromley, 1978, 'Institutional Aspects of Farmer Water Management in the LDC's: empirical evidence from Pakistan' mimeo, Department of Agricultural Economics, University of Wisconsin.
27. Moore, M. P., 1979, op. cit.
28. Wade, R., 1979, op. cit.
29. Report of the Gal Oya Project Evaluation Committee, 1970, Government of Ceylon, Colombo.
30. See for example, Vander Velde, E. J. (1971), *The Distribution of Irrigation Benefits: a study in Haryana, India* unpublished Ph.D. thesis, University of Michigan, and Wade, R., 1976, 'How not to redistribute with growth: the case of India's command area development programme', *Pacific Viewpoint*.
31. Kumar, P., 1977, *Economics of Water Management* (*a study of field channels*), Heritage Publishers, New Delhi.
32. Patnaik, S., 1979, 'Improved Fertilizer, Soil and Water Management Practices for Increasing Productive Employment in Indian Agriculture', *Paper for National Seminar on Employment Expansion in Indian Agriculture*, Bangalore.
33. In Sri Lanka water pricing hitherto has not been an objective of government policy, but a charge on irrigation water seems to be a reasonable proposition for the future. There are, of course, pratical difficulties in introducing a water pricing policy based on the volume of water consumed. Existing practices in practically all parts of the developing world seem to be based on the unit of area irrigated rather than on the unit of water consumed. In Sri Lanka there was an abortive attempt to introduce a land betterment charge in 1976. See Land Betterment Charges Law No. 28 of 1976, Government of Sri Lanka.
34 See for example, Karunanayake, M. M., 1974, 'The Dambarawa Settlement Scheme: a Study of Human Ecology in Sri Lanka', *International Relations*, 4, 649–657
35. Karunanayake, M. M., 1976, 'The Adaptation to Droughts in a Dry Zone Village of Sri Lanka', *Geographic Dimensions of Rural Settlements*, 41–49.
36. Ranatunga, A. S. and W. A. T. Abeysekera, 1978, *A Study of Five Settlement Schemes Prior to Irrigation Modernization*, Vol. 1, Mahawilachchiya, ARTI, Colombo.
37. Bailey, F. G., 1966, 'The Peasant View of the Bad Life' in T. Shanin (ed.), *Peasants and Peasant Societies*, Penuin, pp. 399–409.
38. Coward, E. W., 1974, 'Water Runs Down Hill and Evaporates: Human Organization and the Management of Water Environments', *Paper for the Mekong Development Seminar, Thailand.*
39. Geertz, C., 1972, 'The Wet and the Dry: traditional irrigation in Bali and Morocco', *Human Ecology*, 1, 23–39.
40. Bottrall, A., 1978, 'Irrigation Organization and Management', *Development Research Digest*, 2, 48–51.