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Volume 3
Policies, Institutions and Data Needs for Water Management

K.Jinapala, Sanjiv De Silva and M.M.M. Aheeyar, editors

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International Water Management Institute

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HARTI

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INTERNATIONAL WATER MANAGEMENT INSTITUTE

The editors: K. Jinapala, Researcher/Institutions Specialist, International Water Management Institute (IWMI), Colombo, Sri Lanka; Sanjiv De Silva, Research/Program Officer, International Water Management Institute (IWMI), Colombo, Sri Lanka; M. M. M. Aheeyar, Head, Environmental and Water Resources Management Division, Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI), Colombo, Sri Lanka.

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Please direct inquires and comments to: *iwmi-research-news@cgiar.org*

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We would also like to express our thanks to all the researchers who presented papers at the conference, and for preparing reports for this volume of the conference proceedings, without whom this event would not have been possible. There were many participants from various national and international organizations whose attendance and valuable contributions to the workshop sessions made this event both productive and interesting.

Professor M. S. Swaminathan from India delivered the key-note speech and the Hon. Prime Minister of the Democratic Socialist Republic of Sri Lanka, Rathnasiri Wickremanayaka attended as the chief guest. Both provided us with some very enlightening information and interesting observations, and we are extremely grateful to them for sharing their opinions with us and enriching the conference.

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This workshop is a collaboration of the following organizations:

International Water Management Institute (IWMI)

Irrigation Department (ID)

Department of Agriculture (DoA)

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Overview: Institutions and Policies for Water Resources Management

K. Jinapala and Sanjiv De Silva
International Water Management Institute (IWMI), Colombo, Sri Lanka

Background of the Conference

This is the third volume of the proceedings of the national conference on 'Water for Food and Environment', which was held from June 9 –11, 2009 at the Bandaranaike Memorial International Conference Hall (BMICH). The volumes 1 and 2 have been produced as separate documents of this report series. In response to a call for abstracts, 81 abstracts were received from government institutes dealing with water resources and agriculture development, Universities, other freelance researchers and researchers from the International Water Management Institute (IWMI). Forty seven of the eighty-one abstracts that were submitted were accepted for compiling full papers.

Need for the Conference

In the past couple of years the sharp increase in food prices worldwide has raised serious concerns about food security, especially in developing countries. To effectively address these concerns a holistic approach is required that encompasses improved agricultural water productivity, adaptation to climate change, targeted and appropriate institutional and financial measures, and a consideration of environmental issues. The main purpose of the conference is to share experiences in these areas and to find opportunities to improve farmers' incomes and food production, and to promote environmentally sustainable practices in Sri Lanka in the face of growing water scarcity and the challenges of climate change. The conference brought together researchers, policymakers and practitioners to address these key issues.

The conference had several inter-linked objectives, which were to:

- provide a level platform for participants to share experiences and lessons learned;
- develop practical approaches for sustainable development;
- promote partnerships among disciplines and organizations on land and water management for food security; and
- identify future directions on key issues such as water scarcity, food security and climate change in Sri Lanka.

The conference was structured so as to focus on three main themes for presentations and discussions.

Theme 1: Irrigation for Food Security (Volume 1 of the Conference Proceeding)

The role of irrigation in the progress towards food and environmental security in Sri Lanka cannot be overemphasized. The following sub-themes were focused on, at the conference under this main theme:

- Revitalizing Irrigation Systems for Food Security
- Rain-fed Agriculture and Food Security: Opportunities and Constraints
- Enhancing Water Productivity on Irrigated and Rain-fed Lands

Theme 2: Water Quality and Environment (Volume 2 of the Conference Proceeding)

The three sub-themes mentioned below were discussed in the light of their effect in Sri Lanka:

- Water Quality, Irrigation, Environment and Health
- Water Recycling for Productive Use
- Climate Change and Agriculture

Theme 3: Policies and Institutions for Water Management (Volume 3 of the Conference Proceeding)

The sub-themes that were discussed under this theme were:

- Policy Interventions to Improve Water Productivity and Access to Water
- Data and Information Management for Water Management
- Methodologies for a National Water Resources Assessment
- Policies and Institutional Reforms to Enhance Rain-fed and Irrigated Agriculture

Synthesis of Papers Presented under Volume 3 - Policies and Institutions

Ten papers on the different aspects of policy adaptation and institutional mechanisms for water resources and agriculture system management were presented at the conference. This introductory paper includes a synthesis of the key issues highlighted in the 10 papers that were presented at the conference (one of the 10 papers is written in Sinhala - the local language).

The following main areas have been highlighted in these papers:

- Policy issues on water resources management
- Participatory irrigation management, capacity building of farmer organizations and also irrigation infrastructure systems managed by public institutions

- Groundwater use in conjunction of irrigation water
- Economic valuation of irrigation water
- Spatial variation of water supply and demand in Sri Lanka and also the need for national level water resources assessment/audit in the country.

Policy Issues on Water Resources Management

The issues surrounding the adoption of policies on water resources development and management were discussed by Nanayakkara in the paper he presented at the conference titled 'Sri Lanka's Water Policy: Themes and Issues'. Other papers that were presented at the conference also discussed certain policy-related issues such as policies relating to participatory irrigation management, groundwater development, economic values of water and also water resources assessment/audit etc. Nanayakkara's paper exclusively focused on the water resources policy of the country and included his opinions and views on the issue.

The author argues that in the case of water, the question of 'ownership' is not as important as determining and regulating its use, given that user rights of this common property resource is always in a state of flux. According to Nanayakkara, abstraction of bulk water from its natural state in a regulated manner that is left to the will of individuals and agencies, virtually results in the creation of a 'free for all' situation. Commenting on the existing institutional mechanisms of water resources management, he points out that the domain of water is characterized by over 50 legislative enactments and a plethora of agencies numbering over 40, but lacks a single neutral agency to determine the appropriate balance between the demands for off stream consumption and the volume of water flows needed by the river system. Water rights are linked to land ownership and, as such, in Sri Lanka, a landowner is regarded as owning the water underneath his land and has the right to pump all the water from the common aquifer, lowering the water table. Furthermore, he may use or abuse all the rain which falls on his land. In Sri Lanka, all the streams that flow across a private land fall within the public domain.

The lack of a clear policy on water allocation is another issue raised by Nanayakkara. He says that there is no proper bulk allocation system. Some large consumptive users allocate water to themselves. The agency that operates the water abstraction structures also controls the water allocation. The most serious deficiency observed in water allocation has been the tendency by large water users to allocate water to themselves regardless of the needs of others.

He refers to the proposal made by the water resources secretariat once established under an ADB funded project, and points out that the challenge for the national water resources authority proposed under the ADB project is to establish a set of allocation principles that are rational and that can accommodate long-term demands. The share of water used by the urban population in Sri Lanka is projected to increase to 45 % by 2015 and 65 % by 2030. Such expanding water requirements in the growing urban populations will aggravate the institutional conflicts in re-allocation of water that were previously devoted to agricultural use, particularly in the dry zone. According to Nanayakkara, the absence of any principles for sharing water between the upper and lower riparian as well as between drinking and irrigation purposes has hindered the developmental planning efforts of both the Irrigation Department and the National Water Supply and Drainage Board (NWSDB).

Policies on groundwater use are another area on which Nanayakkara expressed his views. A water policy should address both surface water and groundwater resources. Currently, a doctrine of territorial sovereignty is applied in groundwater extraction, which means that 'what is beneath our feet is ours to use'. Groundwater use is rapidly increasing, intensifying smallholder cultivation and improving the standards of living of poor farmers in the dry zone. Nanayakkara mentions that a survey conducted by IWMI revealed that "…in Sri Lanka, some aquifers are already being pumped dry by the end of the dry season, and some communities have been left without drinking water. The implications of stream-aquifer connectivity and the need for a conjunctive management approach are the most under-appreciated issues in Sri Lanka. A management policy should stipulate that groundwater should not be regarded as a resource separate from surface water. The policy should recognize that both surface and groundwater are hydrologically connected and are complementary components of a larger single system."

In his final analyses of the paper, Nanayakkara suggests that there is a need for an institutional arrangement at the national level, such as a proposed National Water Resources Authority (NWRA), capable of defining the overall directions when devising water policies, and adjudicating disputes. He points out that water resources planning and management frequently fails to consider the river basin as the natural unit for hydrologic management, resulting in the inefficient use of water and inadequate concern for stream and ecosystem values. Therefore, it is imperative to recognize the environment as a legitimate user of water.

Jinapala et al., in their paper on '…Participatory Irrigation Management (PIM) in Sri Lanka' argue that institutions/policymakers need to lend careful attention to enhancing the effectiveness of institutional mechanisms used for participatory irrigation management in the country. The major conclusion in their paper is that, despite its partial failure to achieve some of the main goals, participatory management has clear benefits and should be continued and supported. The study team suggests that the government should have an effective way of keeping track of the progress of Farmer Organizations (FOs), Joint Management Committees (JMCs) and the turnover of irrigation management that they generate.

Participatory Irrigation Management, Capacity Building of Farmer Organizations and also Irrigation Infrastructure Systems Managed by Public Institutions

Jinapala et al. summarized/synthesized the results of a national level study on the 'Participatory Irrigation Management (PIM)' approach in the country. The analyses of their paper represent the current situation of PIM and its relevance and impact as an institutional mechanism in managing irrigation systems.

This paper aims to review participatory irrigation management (PIM) approaches adopted in medium and major irrigation systems in Sri Lanka with a view to identifying past and present trends and future directions of such management. The authors point out that the need for pursuing irrigation development and management has become more important in the country in the face of rapid population growth and increasing food prices in the world market. In this context, managing irrigation schemes for productivity improvement is becoming increasingly important.

The results of the study indicate that farmer involvement is much more relevant and essential in irrigation schemes where water is a scarce resource. A participatory management policy has clearly succeeded in getting farmers much more involved in system management than they were in the past, except in the case of some of the MANIS (Medium Irrigation Systems Managed by the Irrigation Department) systems that were studied, which had been somewhat neglected by the irrigation agencies. Improving the turnover of irrigation management (operation and maintenance or O&M) below the distrbutory canal was one of the main objectives of the PIM policies in the country. However, turnover has not progressed as expected for two major reasons:

- On the one hand, the agreements reached in all programs are fewer than the expected number. Only the Integrated Management of Agricultural System INMAS program has progressed in achieving some form of turnover, although the Sri Lanka Mahaweli Authority MASLprogram is now seriously trying to improve turnover. There has been very little progress in the MANIS schemes, although the National Irrigation Rehabilitation Project (NIRP) mandated improved turnover in its post rehabilitation phase.

- On the other hand, full turnover has not occurred in any of the three systems and progress has stopped at a joint management stage. In particular, both agencies and farmers are reluctant to bear the full responsibilities for maintenance turned over to the FOs. Payments continue to be made by agencies for operation and maintenance (O&M) activities to FOs that have taken over responsibilities, either informally or formally.

The major conclusion of the study is that, despite its partial failure to achieve some of the main goals, participatory management has clear benefits and should be continued and supported. The study team suggested that the government should have an effective way of keeping track of the progress of FOs, Joint Management Committees (JMCs) and the turnover for irrigation management that they can generate.

Badra Kamaladasa, in her paper on' Interventions Necessary in Capacity Building in Existing Water Organizations to Improve Productivity and Access to Water', points out that institutions need to play a critical role in managing water in the irrigation systems of the country in order to enhance the productive capacities of these systems. She highlights the role of individual and institutional capacities in determining the quality of water management and service delivery. The paper emphasizes the need for addressing poor capacities by devising more project proposals to effectively meet today's water sector challenges. She makes the point that good sector performance is also the responsibility of civil society and can be promoted in terms of individuals' water use practices, and that capacity can be increased by improving the public's awareness on water conservation and use. This would entail not only awareness in the personal use of water but public participation in decision-making processes for the management of water as a resource. Finally she observes that this process highlights the importance of having policy and institutional frameworks that enable public participation in decision-making.

The paper of S. Thiruchelvam (Enhancement of Capacity of Farmer Organizations for Sustainable Irrigation Systems in Anuradhapura and Kurunegala Districts) focuses on the same aspects as mentioned above, and highlights the need for enhancing the capacity of farmer organizations (FOs) in order to ensure sustainable irrigations systems. He has studied irrigation schemes in the Anuradhapura and Kurunegala districts to provide evidences for his arguments in the paper. A stratified random sample of 48 FOs selected from major, medium and minor irrigation systems in the Anuradhapura and Kurunegala districts were studied during 2008.

The author argues that over the past decades public investment in major, medium and minor irrigation systems has not yielded the expected results. The solution to the growing water crisis lies in the institutional changes of social systems established to manage the demand for water. Poor participation of farmers in FO activities is common and the paper reports that about 38 % of farmers participate in FO activities in both districts. The most common causes for such low participation were the lack of accountability and transparency of the FOs functions.

The author recommends that FOs need a lot of capacity-building on technical and institutional aspects to sustain irrigation systems. There is a need to establish strong linkages between the FOs and the Irrigation Department for successful irrigation management.

Thiruchelvam highlights in his paper, one problem common to all the irrigation rehabilitation projects of Sri Lanka. Irrigation development funds were initially used to provide physical structures to the irrigation systems, but little attention was extended to the efficiency of the investments in economic terms. As a result, the return of investments in this sector has fallen below expectations. Very few attempts have been made to develop the management capacities of FO leaders, their members, and village extension workers. Community organizations and facilitation skills are not part of staff training programs. Most of the services and resources were usurped by the elite of the rural communities, while the poor and women were left out or received little benefit.

Another area contributing to the poor irrigation management capacity of FOs is the lack of clear understanding of the Agrarian Development Act of 2000 and the registration process. There is, therefore, an urgent need to give more attention to the formalization of the registration process.

Thiruchelvam also found that women's participation in FOs was low in both districts. The presence and behavior of drunken men in the FOs, the lack of benefits attached to FO membership and the overall malfunctioning of the FOs are some of the existing problems in FOs. . Even when women attended FO meetings, their participation was limited to listening only.

There was a lack of accountability and transparency of the functions of FOs, which had led to only 34 % and 25 % of the farmers being satisfied with FOs in the Anuradhapura and Kurunegala districts, respectively. There was no real networking of Community Based Organizations (CBOs), which would have helped in sharing and exchanging information and ideas on water management.

Although FOs had been established in all irrigation schemes, they are hampered by various problems such as lack of maintenance activities for irrigation facilities, low member participation in FO activities, lack of good leadership and poor communication.

The weak status of FOs in minor tanks schemes in both districts was reflected in the inadequacy of infrastructure facilities and extent of undeveloped land for cultivation in both districts. Membership fee and money earned through various contractual activities was low and the accounts of such details were not available in the majority (78 %) of FOs, indicating the lack of accountability and transparency.

The analysis shows that small and homogeneous FOs had better methods of conflict resolution in O&M.

Comparing the head and tail-enders of the irrigation canals shows a higher degree of disparity in income in the tail end of the irrigation canal. Inequitable distribution of irrigation water was the major cause of the disparity.

The difference in water productivity between major and medium irrigation schemes was insignificant but was considerably lower in minor systems.

The Irrigation Department (ID) plays a significant role in managing the irrigation infrastructure of medium and major irrigation schemes in the country. Namalee Madawalagama and Badra Kamaladasa describe the degree of importance of the ID's role in irrigation scheme maintenance in their paper on 'Irrigation Infrastructure Management by Public Funds –How it Can be Made Justifiable'. This paper aims to compare the actual annual fund requirements and the available funds to operate and maintain (O&M) an irrigation scheme. The Hurulu Wewa Irrigation Scheme was selected as the study area. The study shows that the labor input from farmers and their families in O&M is enormous, but suggests that this labor input is frequently ignored in the financial analysis due to difficulties in accounting. By comparing actual needs against funds available for repair and improvements to the system, the authors show that due to inadequate funds, general improvements and immediate repairs cannot be attended to when needed. Delays in attending to repairs and improvements eventually lead to a self-sustaining cycle of more damages and an increased demand for funds for maintenance, which undermines the guaranteed life span of the systems. The authors also argue that further contributions from farmers for improvements and repairs cannot be expected as their income is marginal. The study also shows that when compared with government expenditure on O&M activities, the value of production of the scheme is very high. However, inclusion of the fertilizer subsidy amounting to Rs. 122 million (the hidden cost) in the calculations, significantly reduces the value of production in Huruluwewa. The authors thus argue for an increase in the government's input for O&M to reduce the rehabilitation costs and improve system performance. Further justification for this is provided by showing that the contribution to the national economy by an irrigation scheme is much higher than the investment in O&M by the government. They also suggest that this scenario may apply to a large percentage of the paddy production area in the country as 80 % of paddy production occurs under major and medium irrigation schemes.

Groundwater Use in Conjunction with Irrigation

Use of groundwater in conjunction with irrigation water is becoming popular in countries like India. Sivakumar in his paper on 'Policy Alternatives for the Management of Minor and Medium Irrigation Schemes to Develop Groundwater Systems in Restricted Catchments for the Improvement in Food Productivity in the Dry Zone of Sri Lanka' discusses the possibilities existing in the country. Recent studies reveal that in some irrigation systems, less than 50 % of the family income is derived from irrigated agriculture and a greater part of the family income is derived from non-agricultural activities. Furthermore, it was revealed that, 10 acres of irrigated agriculture has to ensure at least 250 person-days of employment to be the major source of income for farmers. In order to overcome this situation, the availability of irrigation water must be increased economically.

Probably the most profound challenge facing world agriculture today, and in the foreseeable future, is producing more food with less water. Over 90 % of liquid fresh water that is available at any given moment, lies beneath the land surface. Groundwater, unlike surface water, is available in some quantity in almost every place that man can settle in, and is a more dependable source of water than surface water during periods of drought.

Sri Lanka is the world's second highest user in terms of the percentage of the overall population, in utilizing fresh water withdrawals for agriculture. The combination of the surface irrigation water and groundwater is the best alternative for improved water productivity. It was observed that the water table will reduce by 60 % to 70 % in between two consecutive seasons in 95 % of the catchment area under study. This implies that the boundary treatment combined with changing the operational policy of minor and medium irrigation schemes by foregoing a part of the cultivation is an economically feasible policy alternative with certain limitations such as a minimum project life period of 20 years and a maximum borrowing rate of 7.5 %. After completion of the project investment, the average cost of irrigation water will reduce considerably due to lower energy costs and this in turn will increase the extent of cultivation per unit of irrigation water.

Minor/medium irrigation schemes conserve surface runoff and convey the most part of it to recharge groundwater and, as such, serve as a recharge shed for the wells situated in the zone of influence. It is an insurance against water scarcity, as the yield increases considerably for every unit of rainfall. The minor/medium irrigation schemes prevent soil erosion and depletion of soil fertility. In the context of impending and looming water deficiency, the construction of minor/medium irrigation schemes will be a dependable infrastructure in the development of water potential in any catchment. Acknowledgement of the remarkable role played by the minor/medium irrigation schemes on replenishment of groundwater and its spread over a large area would be a great asset in planning and execution of settlement and crop production projects.

This research leads to the conclusion that a change in the operational policy of minor/ medium irrigation schemes by foregoing one-third of the cultivation under minor/medium irrigation schemes. Retaining one-fourth of the storage of these irrigation schemes at any season will gain an average of 45 % to 65 % of the loss of water table. Construction of new or reconstruction of abundant minor /medium irrigation schemes, reserving 25 % of the storage exclusively for recharging groundwater, and changing the operational policy to retain 25 % of the present storage of existing minor/medium irrigation schemes to recharge groundwater. The sill of the sluice can be raised to store 25 % of the total capacity of the scheme as dead storage, which in turn will reduce considerably the average cost of irrigation water for Other field Crops (OFC) cultivation, given the lower energy costs, and thus increase the extent of cultivation per unit of irrigation water and lead to an overall increase in water productivity.

Hence, the authors recommend constructing new irrigation schemes, which can accommodate a dead storage of 25 % of the full capacity. Furthermore, during any reconstruction of existing sluices, the sill has to be raised to retain 25 % as dead storage in the future.

Economic Valuation of Irrigation Water

The paper by P.Sivarajah and A.N. Ahamad titled 'Economic Valuation of Irrigation Water under a Major Irrigation Scheme (Gal Oya) in Eastern Sri Lanka' deals with the economic valuation of irrigation water. The authors attempt to highlight the value of water used for producing food with irrigation water. The study estimated the value of irrigation water using the principle of 'Marginal Value Product in a Linear Programming Approach' that maximizes net returns for a specific farm plan. The analyses are based on a survey carried out at the Right Bank System in the Gal Oya Irrigation Project using a sample of 30 farmers.

The 'Shadow' or 'Dual Price' of water was used to estimate the economic value of irrigation water for paddy and chili cultivation. It was found that the farmer can obtain a maximum profit of Rs. 59,127.88 per season by cultivating paddy and chilies on 2 acres of land. The water constraint had a Shadow/ Dual Price of Rs. 6,159.76, which implies that the farmer can increase his net profits by this amount by using additional acre-feet of irrigation water in his optimal farm plan. This suggests that it is profitable for the farmer in the area to purchase water at a price close to or less than Rs. 6,159.75 per two acre-feet. Water has such a high Shadow/Dual Price because of its limited availability.

Spatial Variation of Water Supply and Demand in Sri Lanka and also Need for National Level Water Resources Assessment/Audit in the Country

Upali Amarasinghe of IWMI in his paper titled 'Spatial Variation of Water Supply and Demand in Sri Lanka' analyzes the spatial variation of water supply and demand based on time series socioeconomic data. His analyses at macro-level conditions are useful in generating an understanding of water supply and demand in the country as whole. This paper discusses spatial variation of water supply and the increased demand situation in Sri Lanka in recent years and assesses regional and seasonal water stresses.

Amarasinghe shows that renewable fresh-water resources of Sri Lanka vary significantly across river basins and seasons. For example, water availability varies significantly even within some water-rich basins, most significantly in the Mahaweli River. Of the 103 river basins, 12 river basins with 46 % of the geographical area generate 72 % of the total renewable water resource (TRWR) in the country.

The TRWR of 75 basins including Mahaweli and Gal Oya has significant seasonal variation where rainfall in the *maha* season contributes to two-thirds of the runoff. Intra-annual variation in water availability is the major constraint for productive agriculture in these basins. Thus, storing water for irrigation in the *yala* season (April to September) is essential in many river basins.

Water storage is even more important due to inter-annual variation of TRWR. The 75 % probability dependable runoff is only 83 % of the average TRWR. Thus, in the presence of increasing intra- and inter-annual variability of rainfall due to climate change, water storage in these basins becomes very important. In spite of large intra- and inter-annual variation of rainfall, Sri Lanka's storage capacity is very low at present. By 1996, Sri Lanka had developed about 6 bcm of storage capacity. This translates to a per capita storage of only 291 m^3 in 2005. However, this capacity is very low.

Water security through higher storage was a crucial base for early economic development in many developed countries. However, many of the potential sites for large surface storage in Sri Lanka are already exploited. Moreover, social and environmental concerns for new large storage structures are also increasing. Thus, increasing natural groundwater recharge by exploiting the resource in the non-rainy seasons, or through artificial groundwater structures in the rainy seasons could increase the storage capacity much more.

Most of the water-scarce basins are located in the dry zone. A large part of irrigation withdrawals recharges groundwater. However, in Sri Lanka reuse of this water in terms of groundwater withdrawals is negligible at present. Many river basins are already physically water-scarce, where even irrigation water withdrawals are a significant part of the TRWR. Physical scarcity will exacerbate the situation in many basins if domestic and industrial water withdrawals (10 -15 %) are also taken into account. This situation is very severe in water-scarce basins in the dry zone, and can be further aggravated if estimates of utilizable water resources exclude environmental water needs. The environmental water demand of many river basins in Sri Lanka could be about 15 - 30 % of the TRWR and, if this amount is subtracted from TRWR for estimating productive use of Water Resources (PUWR) , many of the basins in the dry zone could fall into the physically water- scarce category.

In this context Amarasinghe attempts at answering the question of what options are available for Sri Lanka in meeting future water demand? At the present rate of growth, Sri Lanka's population will peak in the early 2040s, with an increase of 15 % from the current population (UN 2006). If the present self-sufficiency levels of different crops are to be maintained and the present level of crop productivity persists, the irrigation demand for meeting food demand for this maximum population could increase by, at most, 15 %.

Given the high level of water development for irrigation, increasing irrigation efficiency is one of the feasible options available for meeting future water demands. If irrigation efficiency is increased to 45 % from the currently assumed level of 35 %, the irrigation demand shall decrease by 22 %. If irrigation efficiency is increased to 55 %, irrigation demand will decrease by 35 %.

The paper presented by Matin et al. at the conference highlights the need for 'Development of a Water Resources Assessment and Audit Framework for Sri Lanka' The authors point out that to meet the growing problems of water resources, it is necessary to carefully assess the existing water stocks and future trends in a country. The accuracy of such an assessment highly depends on the quality of data and information used for it. In most developing countries, the lack of readily accessible and quality controlled data is the major obstacle for scientifically-based water resources assessments, water development planning and evaluating the status and trends of water resources. Sri Lanka is in a similar position. Sri Lanka experiences high seasonal and spatial variations in rainfall due to the bi-monsoonal climatic pattern (north-east monsoon from October to March and south-west monsoon from April to September) — (Amarasinghe et al. 1999). Large tracks of the country are drought-prone. Therefore, a better understanding of the national water situation is critically important. The IWMI researchers are in the process of developing this framework, taking Sri Lanka as a case study in the hope of extending the application of methodology to the situations in other countries.

Interventions Necessary in Capacity Building in Existing Water Organizations to Improve Productivity and Access to Water

Badra Kamaladasa
Deputy Director (Assets Management), Irrigation Department, Sri Lanka

Introduction

To improve the accessibility, productivity and sustainability of water services, capacity-building of existing organizations and stakeholders has become a priority requirement in the water sector. Installation of physical infrastructure and implementation of direct training sessions alone will not fully consolidate the social and economic benefits of the water services unless proper interventions are made to improve the legal, regulatory and institutional environments. The dynamic nature of the water sector, demands that institutions handling water management also be dynamic institutions that can adapt to changing demands and circumstances. It is possible to transform the existing institutions into more responsive and accountable entities by enhancing their capacity without undermining their current position within the sector. Sustainability of the physical infrastructure depends entirely on the capacity of the institutions, organizations and individuals. Proper social behavior is also needed to complement the improved institutional and organizational capacities. It is time to identify the requirements of capacity development referred to as the 'software component' in the current water sector investments that would address the current needs of the country. The objective of this theme paper is to discuss gaps apparent in the current system and interventions necessary for capacity-building in the Sri Lankan water sector to fill these gaps.

Definitions of Knowledge and Capacity

The knowledge of an individual relates to the individual's ability to identify and describe issues, challenges or problems confronted and to articulate effective solutions to them. At the same time, the individual must possess the skills to communicate and share relevant information and ideas with other experts, peers and decision-makers before any action is taken (Alaerts and Kaspesma 2009).

Capacity can be defined as the capability of an individual, institution or society/ community to identify and understand its development issues; to act to address and learn from the experience and accumulate knowledge for the future (ibid). The capacity of an individual is normally measured in terms of the knowledge base, educational background and skills possessed, while for organizations, the effectiveness of general managerial and administrative set up, wealth of human resources, existing laws and regulations and enabling policies, and environment, are the indicators of its capacity.

Capacity Development Needs

When compared with other service sectors such as housing, roads, transport etc., the water sector inherits a series of complications not present in the case of other sectors. This partly results from the temporal nature of decisions linked to the time gap between raising an issue and implementing the decision on how it should be addressed, and the fact that may need short-term, medium-term or long-term solutions which would entail different time spans for implementation. Short-term solutions may need to be taken hourly in cases such as irrigation water distribution, while the medium-term time frame may span daily, weekly, monthly or seasonal requirements. Long-term solutions may consider issues that span decades.

Apart from the time span, the scale of the issue (whether local, regional or national) is another major consideration to be taken into account when handling the water sector. This issue of scale will have different impacts at different levels, from one scale to another. Furthermore, the solution suitable for one scale will not be suitable for another despite many similarities in the nature of the problem.

Sub-sectors such as irrigation, domestic water supply, industrial water, hydro-power, urban drainage, river-flood management, coastal management and the environment, each covers a wide sphere of management challenges that require an immense capacity and knowledge base to properly address these issues.

All these factors call for the intervention of strong institutions as well as competent individuals to handle the issue in the best possible manner. Hence, the water sector is considered an arena that demands more intensive knowledge and capacity than any other sector.

Methodology for Capacity Development

Competencies of individuals, organizations and civil society must be developed along with the creation of an enabling environment for sector performances to be effective. Generation and dissemination of knowledge for individuals in an organization normally takes place not only through formal training but by the practical use of such knowledge, learning from peers, and learning through formal and social networks. In an organization, capacity development can take place through change management, human resources management, acquiring services of specialists etc. Continuous processes of knowledge and capacity development is an indicator of a healthy environment of an institution.

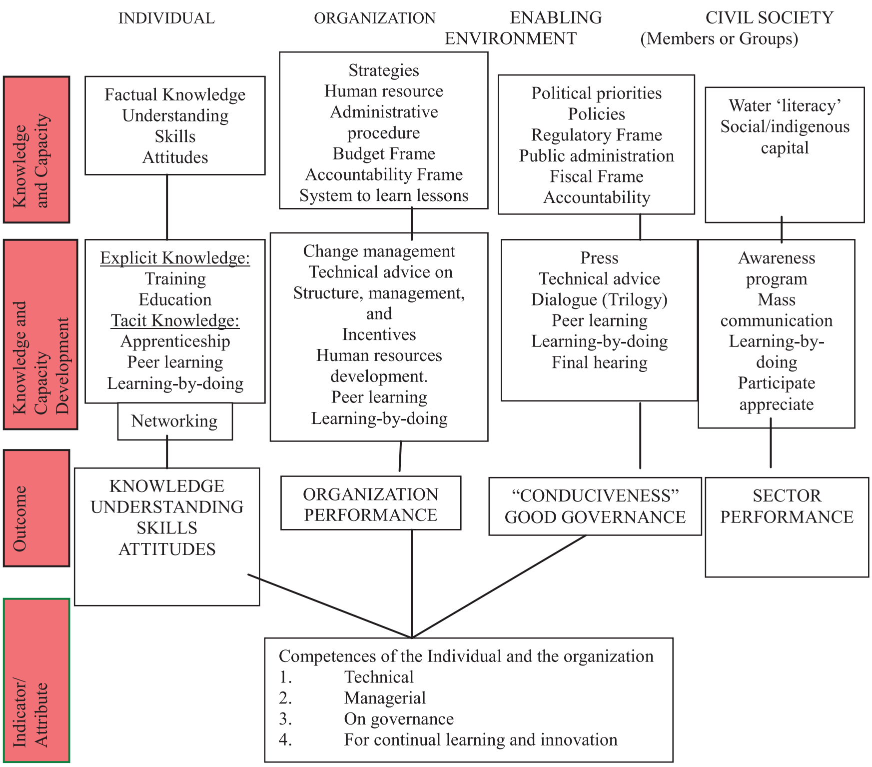
Apart from the formal institutions, each individual in society also takes decisions on water use in their day to day life. Such decisions may be in relation to livelihoods, sanitation, community health, pollution of the environment and so on. Such individual interventions in water use are vital and can influence policy formulation to operation and service deliveries.

Hence, knowledge and capacity development pertains not only to the formal organizations and their personnel, but also to individuals and informal groups in society. Civil society too, should therefore, be strengthened with proper water literacy programs so that the public will utilize water efficiently and participate in decision-making processes with awareness.

However, the effectiveness of developing the knowledge and capacity of individuals and institutions can only be seen if a suitable environment is created for them to apply such knowledge and capacity. This enabling environment can be created with the introduction of suitable policies, regulatory frameworks, and sound fiscal management.

The schematic diagram in Figure 1 suggests the knowledge and capacity requirements for each category, mode of development and the final outcome and indicators to measure the effectiveness of such knowledge and capacity (Alaerts and Kaspesma 2009).

Figure 1. Knowledge and capacity development requirements, outcomes and indicators for success (after Alaearts, 2009) as quoted in (Alaerts and Kaspesma 2009).



Creating a conducive environment for individuals and institutions to perform is defined as a sign of good governance. (UN HABITAT 2002). However, to make the changes necessary to achieve good governance, individuals and organizations must be capable of accurately appreciating the present and future needs of the sector. Efforts taken during the last decade to introduce policy and institutional frameworks for the water sector in Sri Lanka have failed due to the lack of such appreciation.

The Water Management Secretariat (or popularly known as the 'Water Panel'), which functions under the administration of the Mahaweli Authority, can be quoted as a pilot intervention made in the water sector to create an enabling environment for decision-making in sharing water among different users and different organizations. However, it has not been expanded substantially to absorb the requirements of the changing environment in Sri Lanka and to perform the role of a regulator in water sharing. It would have been upgraded to assume the role of regulator if the unit was detached from the Mahaweli Authority. As long as it is attached to any organization, it cannot be accepted as a regulator due to the conflict of interest created by such an institutional affiliation.

Current Institutions and their Functions

It is estimated that there are more than 50 government and semi-government institutions dealing with subjects relating to the water in Sri Lanka (IMPSA Secretariat 1988). These organizations have evolved under different historical backgrounds to fulfill the need of the day. Their intervention in the water sector may be at different levels and in different forms. For example, community-based organizations (CBOs) play a vital role in the irrigated agriculture sector, while interventions of both NGOs and CBOs are more significant in the domestic water and sanitation sectors than in others.

Annex 1 shows the main institutions and organizations and their functional areas in the water sector in a broader sense as service providers or beneficiaries. There are some areas that lack an institution with direct responsibility, while in some areas responsibility is seen to overlap between institutions. Absence of an institution to regulate the development activities in water resources can be observed as a major drawback in the system as clearly shown in the matrix in Annex 1. The disintegration of a single subject into several ministries can be highlighted as a cause for the overlap in responsibilities. For example, the subject of irrigation is handled by two main cabinet ministries at the national level, while the nine Provincial Councils deal with the same subject separately within their own provinces.

It is a common allegation that in developing countries like ours, institutions possess weak administrative systems due to state and bureaucratic behavior. The government institutions are further blamed for preoccupation with technical aspects and standardized solutions, while financial regulations seem to be the impediment of development activities. Due to the exodus of professionals, there is a vacuum in the service organizations aggravating the situation further. A good indicator of these weaknesses is the low percentage of disbursement of finances received by these institutions from the national budgets and from funding agencies. The failure to fully use the available funds suggests that it is the lack of proper knowledge or capacity to deliver feasible project proposals or implementation schedules that hinders development and not the shortage of funds.

Local government institution are far behind the national or provincial level institutions in providing the services required by the public, and this is largely because of the limited opportunities extended to the officers to gain and share experiences and enhance their knowledge. Overlapping responsibilities among local, provincial and national authorities has created confusion in the institutions. This can be witnessed in areas such as the regulation of water pollution, groundwater management, catchment management and urban drainage. Urban wastewater and solid waste deposited in rivers and tributaries contribute significantly for polluting water in the rivers. The local government authorities do not have sound strategies to address these issues, even though such pollution is a serious problem common to all and affecting the entire country.

Integration of Decisions

The fragmentation of subject areas among several institutions has created the need for a strong coordination system within these institutions for proper service delivery. In the absence of such a coordination mechanism, the translation of individual policies and functions of these institutions into action is always confronted with issues resulting from the interdependent nature of the water resources. There are many instances that demonstrate the need for the integration of decisions taken by organizations. It has been well understood that physical and institutional integration in river basins are essential for better water resources management and to address water allocation and water pollution issues, but unfortunately, such mechanisms for integration are not available. This situation means that it is not possible for any given organization to operate in a secluded environment as may have been envisaged at the inception of the organization, and instead organizations must develop close ties with all those engaged in water management activities.

Furthermore, the development of many other sectors depends on the efficiency of the water sector. If urban development plans are considered, domestic water supply and proper drainage are prime concerns for the planner, and with regards to which only water experts can intervene. Similarly, if one considers road and railway infrastructure, industrial development or the fast developing agricultural industry, the capacity of the water sector has a direct influence over the efficiency and sustainability of the development of these sectors. The water needed to keep the river environment in a healthy condition also cannot be forgotten in this context. Sharing water in the irrigation reservoirs for domestic use is such an example of promoting environmentally-friendly methods of water allocation. When planning irrigation schemes for rural areas, especially in the first half of the last century, pipe-borne water supply for the inhabitants or locality was neither a requirement nor a feasible option. However, when the locality is developed and after the scheme has been in operation for a few decades, the requirement for domestic water supply becomes a basic requirement. It is the responsibility of the institutions at that point to take cooperative decisions while considering national interests. However, it should be mentioned that whether a locality is developed or not, access to safe water for the people in the area is first priority and a basic right. The demand for safe water has been increasing with increasing public awareness.

To fulfill such local, regional and national level needs, sectoral groups must be formed as an enabling environment, and knowledge and capacity development be facilitated to analyze problems and reach consensus with respect to solutions. The sectoral groups formed should include representatives from multiple water uses, including civil societies. The capacity of individuals, organizations and sectoral groups may need to be enhanced separately as well as collectively. Furthermore, organizational frameworks are needed to provide forums to bring together the views of all stakeholders in order that there may be a continuously updated response to local water requirements. An important aspect here is that individuals (from a community member to the minister in charge of water) and the institutions they work in and operate, should work hand-in-hand to reach effective responses and practical outcomes.

Sharing information, data and research findings is another way to develop the capacity of the team, and which becomes simpler to effect given the current development in the IT sector. There can be mechanisms developed to share water-related data and information among key stakeholders to make common decisions related to water resources management. In the present context, information sharing among key water management agencies is rather poor.

Conclusion

Notwithstanding the nature and amount of investment for infrastructure development, the sustainability of the system depends on the competency of the personnel and institutions that mange the system, and the society that uses the system. Hence, investment in knowledge and capacity development (KCD) as well as creating enabling environments should be part and parcel of the current development projects. There are immense advantages in implementing KCD programs, such as possibilities of making decisions with the consensus of all the stakeholders and of utilizing human, financial and physical resources in a more effective manner. Thus the expenditure in terms of money and time on KCD will be an investment in the country in the long term.

References

Alaerts, G. J.; Dickson, N. (Eds.). 2007. Water for Changing World - Developing Local Knowledge and Capacity, (As quoted in Capacity Development for Improved Water Management UNESCO-IHE, UNW-DPC, UN Water Publication).

Alaerts, G.; Kaspersma, J. 2009. Program and Challenges in Knowledge and Capacity- building. Pre-print copy of Capacity Development for Improved Water Management, UNESCO-IHE, UNW-DPC, UN Water Publication.

IMPSA Secretariat. 1988. IMPSA Staff Working Paper, No. 18. Colombo, Sri Lanka: IMPSA Secretariat.

UN HABITAT. 2002. Abstract of UN Habitat concept paper, 2nd edition, reading materials for Logotri Regional Training on Knowledge Infrastructure for Governance.

Enhancement of Capacity of Farmer Organizations for Sustainable Irrigation Systems in Anuradhapura and Kurunegala Districts

S. Thiruchelvam
Department of Agricultural Economics and Business Management
Faculty of Agriculture, University of Peradeniya, Sri Lanka

Abstract

Over the past decades public investment in major, medium and minor irrigation systems has not yielded the expected results. The solution to the growing water crisis lies in the institutional reform of existing social systems so as to manage the demand for water. In recent times, there has been an emphasis on capacity-building of farmer organizations (FO) in irrigation projects. This study focuses on investigating the institutional capacities of FOs in irrigation systems in the Anuradhapura and Kurunegala districts. Primary data was collected from a stratified random sample of 48 FOs selected from major, medium and minor irrigation systems in the Anuradhapura and Kunurnegala districts during 2008. The Group Dynamics Effectiveness Index (GDEI) of FOs was developed by weighing the significance of important parameters and employed in the calculation of the overall effectiveness of FOs.

Most of the FO members in both districts were landowners and there was a powerful dominance from farmers. Generally, the marginal participation in FO activities was about 38 % in both districts. The most common causes for the low participation were the lack of accountability and transparency of the functions of FOs. Farmer organizations (FOs) in major and medium irrigation systems had 51 % and 29 % higher GDEI, respectively, than FOs in minor irrigation systems. The values of 'Gini Coefficients' in major, medium and minor irrigation systems were 0.38, 0.43 and 0.48, respectively, thus indicating that FOs play an important role in minimizing inequalities among farmers. There was no significant difference in water productivity (0.19–0.20 $/m^3) between major and medium irrigation systems, but the water productivity was low (0.07 $/m^3) in minor irrigation systems. Farmer organizations (FOs) with medium size (30–40 members) and economically homogeneous members had better irrigation management. Chi-square results show that while the income equity had no significant effect on the overall GDEI, the participation rate and water productivity that reflects the success of operation and maintenance (O & M) had a significant impact of 5 % and 10 % probability levels to the GDEI of FOs.

There is a need to establish strong linkages between the FOs and the Irrigation Department for successful irrigation management. The behavioral change that is required to facilitate the adoption of technology can be effected through institutional changes. It is recommended that FOs need a lot of capacity building in technical and institutional issues to sustain the irrigation systems.

Introduction

Background

The devolution of responsibility in natural resource management from the state to 'communities' or local user groups has become a widespread trend that cuts across countries and resource sectors. Programs such as Joint Forest Management, Irrigation Management Transfer, and Fisheries Cooperative Management can all be seen as variations of attempts to establish or strengthen 'community-based natural resource management' (ADB 2000). The widespread trend of such decentralization has by and large ignored the implications of intra-community power differences for the effectiveness and equity of natural resource management. The method of organizing farmers and forming farmer organizations (FO) needs to be revised to meet the following development challenges of the twenty-first century: 1) the increasing absolute and relative poverty in many countries; 2) the degradation of natural resources such as soil, water and vegetation; 3) the low involvement of women in agriculture, and other development programmers; 4) the poor health and education facilities in rural areas; and 5) the increasing sociopolitical unrest among communities.

In the above context, FOs can help harness this synergetic power for its members' survival, growth, and development. Empowered FOs can act as convergent points or platforms for solving local problems and mobilizing human and financial resources for sustainable development. Many studies have been carried out on FO effectiveness in irrigation management and the general conclusion has been that in the past, attention has been diverted to matters other than irrigation system management and maintenance (Thiruchelvam 2009). At the beginning, although irrigation development funds aimed to provide physical structures to the irrigation systems, adequate attention was not given on the efficiency of investments in economic terms. As a result the return of investments in this sector has fallen below expectations.

Legal Background of Farmer Organizations (FOs)

The organizations registered under the Agrarian Development Act No. 46 of 2000 are the recognized FOs. Earlier, Clauses 42, 58A and 58B of the Agrarian Service Act of 1979 were amended by Act No. 4 of 1991 and Act No. 13 of 1994 for the formation of FOs. The Agrarian Development Act No. 46 of 2000 replaced the Agrarian Service Act. It enabled tenant cultivators to become owner operators. The Agrarian Service Committee was replaced by the Agricultural Development Council with powers to take over and cultivate lands that were not productively used. This new Act also authorized FOs to be informed of any construction projects etc. Now all the by-laws in the study area have been prepared in accordance with the Agrarian Service Act of 2000.

Institutional reform and capacity-building are taking place under government initiatives and with external assistance. However, the necessary reforms have not been initiated in many irrigation rehabilitation projects. Capacity-building of FOs is considered as a prerequisite for the sustainable management of irrigation systems. Farmer organizations (FOs) were given legal recognition in 1991 and capacity-building of FOs received particular emphasis in 1994. Since 1998 under the Participatory Irrigation Management (PIM) programs, FOs were further encouraged to act on independently. However, when looking at projects and implications, there is still a wide gap between policy objectives and project realities (Thiruchelvam 2004).

The solution to the growing water crisis lies in institutional reform in existing social systems so as to better manage the demand for water. In recent times, the focus of agricultural development has gradually shifted more towards the economic advancement of the poor in irrigation schemes through irrigation system rehabilitation, community empowerment, and other related activities. The rehabilitation of irrigation projects in the North Central and Western provinces emphasized the need for improved capacity-building for FOs. This process adopted social mobilization processes to improve efficiency and pave ways to strengthen FOs, and find ways and means to improve the commercial and income generation activities of the FOs.

In this context, this study focuses on investigating the impact of these project interventions on the capacity-building of FOs in irrigation systems in the Anuradhapura and Kunurnegala districts. Specifically this study aims to investigate project intervention on FOs' functions, membership participation, performance in irrigation management, and group effectiveness.

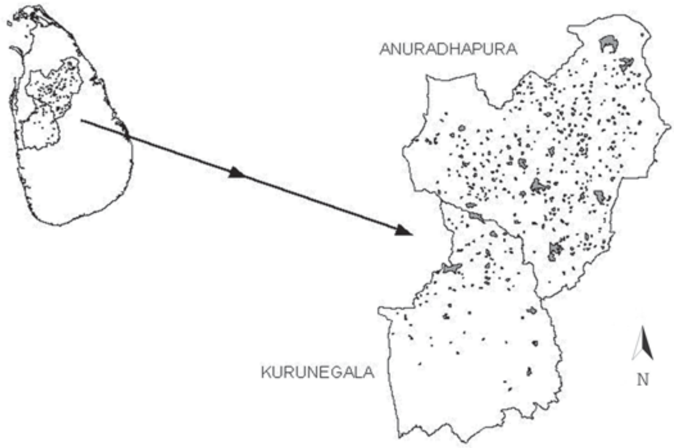
Methodology

Study Area, Sampling and Data Collection

The study areas of the Anuradhapura and Kurunegala districts principally fall under three agro-ecological zones namely, Low-country Intermediate Zone 1(IL1), Low-country Intermediate Zone 2 (IL2) and Low-country Dry Zone from South to North. The annual rainfall in IL1 is less than 1,016 mm (Figure 1). It covers sections of the North Western, North Central and Central provinces. Irrigation schemes under gravity irrigation are divided into major, medium and minor on the basis of the land extent served (command area) by these schemes. Major irrigation systems are defined as those that have command areas of more than 1,000 ha, while systems between 80 and 1,000 ha are considered to be medium irrigation systems. Minor irrigation systems are those with command areas of 80 ha or less. However, in terms of the total extent and total number of farmers served in the country, minor irrigation systems, often referred to as village tanks, occupy an important place.

Primary data were collected from a total of 48 FOs, including 25 and 23 FOs in the Anuradhapura and Kurunegala districts, respectively, from the selected major, medium and minor irrigation systems. The data used stratified sampling, which was based on the location of the farms in the irrigation systems in relation to water distribution and channel network. Semi-structured questionnaires were used to collect data during February and March 2008. Secondary data was obtained from the reports of the Department of Agriculture, Irrigation Department, and District Offices of the Department of Agrarian Development of Anuradhapura and Kurunegala districts.

Figure 1. Map of study area with irrgation tanks in the Anuradhapura and Kurunegala districts.

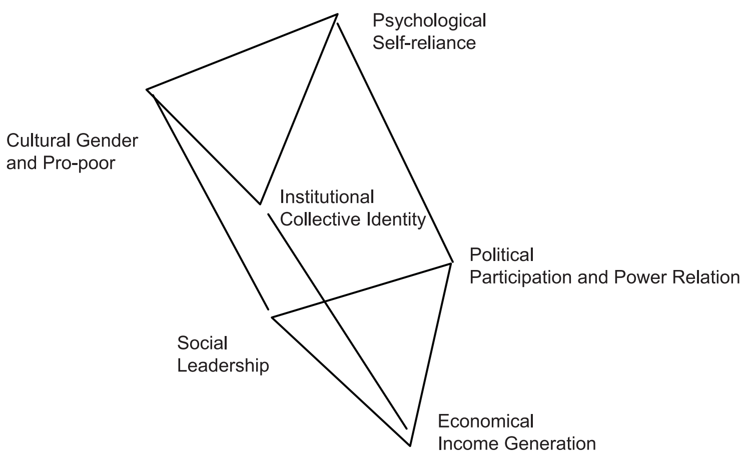


Conceptual Framework

Dimensions of Community Empowerment

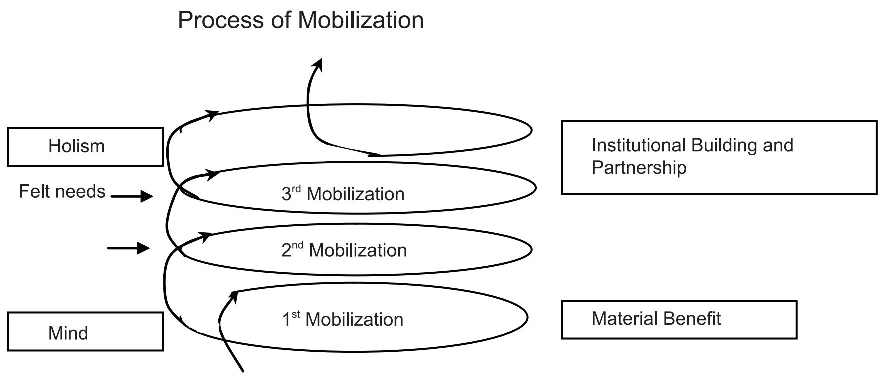
Empowerment could be defined as the process by which people, organizations, or groups, who are otherwise powerless, are formed into a group to consolidate their rights. Under the rehabilitation project, activities in social mobilization processes, participatory development and empowerment help the community to improve efficiency, strengthen co-ordination and find ways and means to visualize their economic resources. The community becomes aware of the power dynamics at work in the context of their life and are therefore, able to appreciate the effect of changes in any political culture (Figure 2).

Figure 2. Dimensions of community empowerment and economic advancement.



Understanding the above characteristics of the community is important for capacity-building, which is given an important place in the rehabilitation project. The above process intends to uplift the mindset of the people to use self-reliance as a process approach (Figure 3).

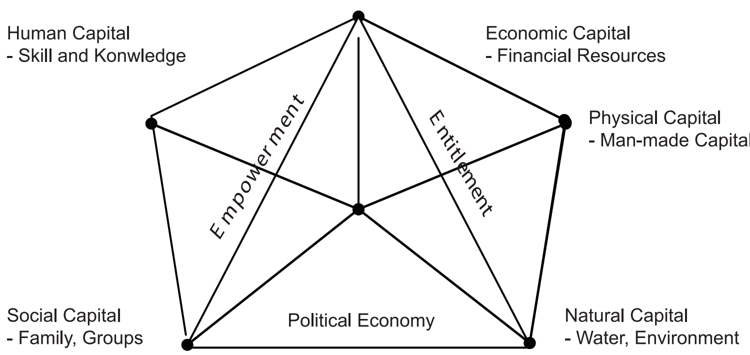
Figure 3. Process approach.



Sustainable Irrigation Framework - Livelihood Capital/ Assets

Strategies for 'Sustainable Irrigation Management' include five capitals of community development. The broad conceptual framework is presented in Figure 4.

Figure 4. Sustainable irigation framework - livelihood capital/assets.



Group Effectiveness of Farmer Organizations

To understand the effectiveness of FOs, a Group Dynamic Effective Index (GDEI) was used on the basis of five different parameters, which were afforded different weights in calculation of overall group effectiveness. Parameters like participation, decision-making, operation and maintenance (O&M) functions, fund generation and focus on women and poor, were considered. Each parameter was assessed using three statements from which farmers' responses were taken, based on a five-point continuum ranging from very low to very high. Mean and standard deviation values of each initiator were calculated as a first step and thereafter, overall group dynamics effectiveness was calculated on the basis of the different weights given to the five factors in GDEI.

A representation of about 10 % in the total number of members in the sampled FOs under the selected three different irrigation systems, including three office bearers, was considered adequate. Accordingly, a total of 123 and 139 farmers were interviewed under the three irrigation systems in Anuradhapura and Kurunegala districts, respectively. The Chi-square test was used to assess the contribution of the group dynamics performance of FOs among major, medium and minor irrigation systems for the two districts. The 'Gini Coefficient' and water productivity were estimated using standard methods.

Results and Discussion

Functioning of Farmer Organizations

Generally, it was observed that there was no clear understanding of the Agrarian Development Act of 2000 and the registration process, and there is therefore, an urgent need to give more attention to the formalization of the registration process. According to the information collected, the general marginal participation in FO activities was about 38 % in both districts. The participation of women was low in both districts. The most common causes for the overall low participation rate at FO meetings were dissatisfaction with the way the FOs function and, especially the suspicion of misallocation of funds, distrust and jealousy. These concerns were manifest mostly in minor tanks compared to medium and major irrigation systems.

The lack of accountability and transparency in the functions of FOs had resulted in the level of satisfaction in the function of FOs to be at approximately 34 % and 25 % in the Anuradhapura and Kurunegala districts, respectively. In both districts, most of the FO members were landowners and there was a powerful farmer domination in the decision-making of FOs.

Table 1 highlights that the FOs were not strong enough to solve their problems and were unable to effectively fulfill their responsibilities. Many factors, both external and internal, determined the strength and the sustainability of FOs. Profit-oriented leaderships guided many FOs. Linkages with other community-based organizations such as Rural Women Societies, Youth Clubs etc., may assist FOs to obtain funds and services when their resources become insufficient. There was no real networking of community-based organizations (CBOs), which would have helped in sharing and exchanging information and ideas. Such a system of networking would have enabled FOs and other CBOs to operate more effectively and efficiently, and with a greater impact on the community they represent.

Table 1. Activity of farmer organizations in the Anuradhapura and Kurunegala districts.

Irrigation Systems	Linkages with other CBOs			Problems Solved by FO			Difficulties/Conflicts Types in FO			
	% of Farmers Reported									
	Poor	Average	Good	Occasionally	Often	Always	Shortage of irrigation	Reservation/Chena cultivation	Animal/Elephant damage	Poor Communication
Anuradhapura										
Major	22	36	42	52	31	17	35	14	11	40
Medium	14	37	49	56	36	08	37	13	16	34
Minor	23	44	33	60	27	13	43	16	18	23
Average	20	39	42	56	31	13	38	14	15	33
Kurunegala										
Major	27	29	44	47	39	14	32	19	14	35
Medium	29	30	41	54	29	17	43	16	14	27
Minor	37	24	39	58	27	13	47	21	17	15
Average	31	28	41	53	32	15	41	18	15	26

Note: FO stands for farmer organizations; CBO stands for community-based organizations

Performance of Farmer Organizations (FOs)

Although FOs had been established in all irrigation schemes, they have various problems such as poor maintenance of irrigation facilities, low member participation in FO activities, lack of good leadership and poor communication.

Table 2 shows that farmers perceive that FO strengthening can enable them to manage scarce water, increase cropping intensities and realize high yields. The focus on the poor and improving the participation of women was less, amounting to only an average of 13 % and 17 % of FOs in Anuradhapura and Kurunegala districts, respectively, reporting. These figures generally did not change among the three schemes. Farmers and women had no formal land rights and did not have a strong voice. However, should women decide to become members of FOs, they can participate in decision-making, and will be entitled to receive the benefits of FO membership such as access to seeds, fertilizer, credit, income-generating activities, etc. Approximately 75-85 % of the women in all the schemes in both the districts are actively involved in paddy and chena cultivation. A small percentage of women (2 to 3 %) were compelled to assume responsibility for their cultivation by virtue of being widows. The number of poor farmers in relation to the total farmer population was approximately 20 %. There were particular reasons why women deliberately

Table 2. Performance of farmer organizations in the Anuradhapura and Kurunegala districts.

Irrigation Systems	Consultation with members		Involvement of the poor and participation of women		Internal linkages and functional linkages		Account keeping	
	% of FOs Reporting							
	Not satisfactory	Satisfactory	Low	Average	Not satisfactory	Satisfactory	Officers only know	No records in the office
Anuradhapura								
Major	82	18	91	09	90	10	64	36
Medium	85	15	83	17	82	18	72	28
Minor	88	12	87	13	92	08	80	20
Average	85	15	87	13	86	12	72	28
Kurunegala								
Major	89	11	87	13	81	19	73	27
Medium	81	19	82	18	86	14	85	15
Minor	92	08	79	21	89	11	90	10
Average	87	13	83	17	85	15	83	17

chose not to attend FO meetings: they were engaged in domestic tasks; the presence and behavior of drunken men in the FO; lack of benefits from FO membership and malfunctioning of the FOs. When they did attend meetings, their participation was limited to listening only. These findings fall in line with the outcome of other studies such as Irna van der Molen (2001).

As regards the effectiveness of FOs in resolving problems, a little over 50 % of the problems were solved occasionally and less than 25 % of the problems were solved completely. In most decision-making cases, only a small group of the ruling party decides on matters related to FOs. Farmer organizations (FOs) in major irrigation systems had sufficient production and infrastructure facilities. The weak status of FOs in minor tank schemes was reflected in inadequate infrastructure facilities and the extent of undeveloped land for cultivation in both districts. Membership fee and money earned through various contractual activities was low and the accounts of such details were not available in the majority (78 %) of the FOs, thus indicating the lack of accountability and transparency of FOs.

Chi square analysis (Table 3) shows that small and homogeneous FOs had better conflict resolution mechanisms in O&M matters. The majority of the FOs had paid less attention to solving their problems by themselves. The expectation was that FOs that were of a small size and that had less inequity between members would be more successful at conflict management. However, the study found, as demonstrated in Table 3, that FOs with memberships between 30 and 60, and less inequity didn't demonstrate a conflict management level as high as what was expected, amounting to 61 %. The null hypotheses that there was no relationship between the size and equity of FO membership, with conflict management were rejected at 0.05 level of probability.

Table 3. Relationship between the capacity of conflict management, and the size and homogeneity of members in irrigation systems in the Anuradhapura and Kurunagela districts.

FO Membership Size	Level of conflict management		
	Low	Medium	High
Low < 30	3 (19 %)	4 (25 %)	9 (56 %)
Medium 30< <60	2 (10 %)	6 (29 %)	13 (61 %)
Large >60	1 (10 %)	6 (60 %)	3 (30 %)
Total FO No. 47	6	16	25

Note: (Chi-square= 13.24, P<0.05) (Given in parenthesis are row percentages)

Group Effectiveness of Farmer Organizations

Levels of indicators of group dynamic effectiveness in major, medium and minor irrigation system FOs in the Anuradhapura and Kurunegala districts are presented in Table 4. Since the values obtained were not different in the two districts, the table reports the average estimated figures of both districts. It is revealed that the member farmers of FOs who perceived that there was participation in FO activities were 4.64, 3.52 and 2.82 in major, medium and minor irrigation systems, respectively, in both districts. The perception on decision-making in FOs was 6.40, 5.50 and 4.51 in major, medium and minor irrigation systems, respectively.

Operation and maintenance (O&M) was perceived to be relatively high and was at 7.3 and 6.1 %, respectively, for members of FOs in major and medium irrigation systems, followed by 4.46 in minor irrigation systems. Farmers' perceptions on fund generation activities had a higher percentage than the participation of women and poor farmers in all irrigation systems.

Table 4. Group dynamics efficiency index of farmer organizations in three selected irrigation systems in the Anuradhapura and Kurunegala districts.

Indicators of GDEI	Major Irri. Sys. HHs No. 91	Medium Irri. Sys. HHs No. 101	Minor Irri. System HHs No. 70
Participation	4.46 (0.74)	3.52 (0.98)	2.82 (1.09)
Decision-making	6.40 (0.42)	5.50 (1.49)	4.51 (1.99)
O & M function	7.30 (1.09)	6.10 (0.82)	4.46 (0.73)
Fund generation	4.30 (0.31)	4.14 (0.51)	3.71 (0.94)
Focus on women and poor	3.70 (0.91)	3.60 (0.91)	3.42 (0.91)
Overall GDEI (Weighted Average)	6.27 (1.15)	5.35 (1.64)	4.15 (1.68)

Note: Figures in parenthesis are standard deviation. Maximum and minimum possible scores are 10 and 0, respectively

The lower participation of women and poor farmers in FO activities indicates the general lack of understanding and concern for the situation of such persons among the FO members. The variation in the response of farmers was less in the case of major irrigation systems, as compared to medium and minor irrigation systems. The perception of member farmers in minor irrigation systems was strikingly low for all of the indicators of GDEI. This kind of variation in the perception of member farmers of FOs may be due to the spatial difference of the location of FOs in the systems. The value of overall GDEI was 6.27, 5.35 and 4.15 at major, medium and minor irrigation systems, respectively, in both districts. These figures indicate that FOs in major and medium irrigation systems had 51 % and 29 % higher GDEI than FOs in minor irrigation systems in both districts.

The calculated values of 'Gini Coefficients' in major, medium and minor irrigation systems were 0.38, 0.43 and 0.48, respectively. These indicate that FOs play an important role in minimizing inequalities among farmers. They did not differ significantly between the two districts. A comparatively higher inequity exists in the minor irrigation schemes. Comparing the head and tail-enders of the irrigation canals shows a higher degree of disparity in income in the tail-end of the irrigation canal. The major reason for this inequality is the inequitable distribution of irrigation water.

There was no significant difference in water productivity (0.19 – 0.20 $\$/m^3$) between the major and medium irrigation systems, but water productivity was seen to be low (0.07 $\$/m^3$) in minor irrigation system, possibly caused by water scarcity. Farmer organizations (FOs) with medium size (30–40 members) and economically homogeneous members had better irrigation management.

Chi-square results (Table 5) show that income inequity had no significant effect on the overall GDEI. The participation rate had a significant impact of a 5 % probability level to the GDEI of FOs, while water productivity that reflects the success of O&M had a less significant impact of 10 % probability level to the GDEI of FOs.

Table 5. Factors affecting the overall group dynamics effective index results.

Variable	Chi-square	Significance (3-tailed)
Income equity	0.712	0.413
Participation rate	01.054	0.000*
Water Productivity (O&M)	00.180	0.000**

Notes: *Significant at 0.05

** Significant at 10 % level.

Conclusions

This study highlights the need for pragmatic capacity-building and empowerment of FOs to improve self-management in both districts. Effective FOs will be more likely to increase their functions and membership size with better linkages with other CBOs, Government Organizations (GOs) and Non-governmental Organizations (NGOs). It is recommended that FOs need considerable capacity-building in technical and institutional issues to sustain the irrigation systems. Farmer organizations (FOs) in major and medium schemes were comparatively well organized. The FOs in minor irrigation systems, however, demonstrated a poor level of capacity to function and manage in both districts. Minor irrigation systems require more software-oriented interventions such as training and capacity-building of FOs. Efforts to improve the position of targeted focus groups and the introduction of a self-help approach are important for transforming human resources into human capital in the capacity-building process. In conclusion it has to be reiterated therefore, that FOs would need a lot of capacity-building on technical and institutional issues to ensure the sustainable management of irrigation systems.

References

Asian Development Bank (ADB). 2000. Institutional Development and Capacity Building for Integrated Water resource Management. Water Resources Council and Secretariat, Colombo, Sri Lanka.

Development, Agrarian Development Act - No. 46 of 2000. (Sri Lanka).

Government of Sri Lanka. 1991. Interim Constitution for Farmer Organizations: Agrarian Service Amendment Act No. 4. Colombo, Sri Lanka: Ministry of Lands and Agriculture.

Thiruchelvam, S. 2004. Weighted Composite Performance Index for Assessing the Performance of Distributory Canal Farmer Organizations under Participatory Irrigation Management in Mahaweli System H, Sri Lanka. Proceedings International Conference on Sustainable Water Resources Management in the Changing Environment of the Monsoon Region, BMICH, Colombo, Sri Lanka, November 17–19, 2004. pp. 718-727.

Thiruchelvam, S. 2009. Agricultural Water and Poverty, Linkages: Case Studies on Large. Medium and Minor Irrigation Systems in North Central Sri Lanka. Proceedings Fourth South Asia Water Research Conference on Interfacing Poverty, Livelihood and Climatic Change in Water Resources Development: Lessons in South Asia, Kathmandu, Nepal May 4-6, 2009. pp. 1–13.

van der Molen, I. 2001. *An assessment of female participation in minor irrigation systems of Sri Lanka.* IWMI Working Paper 8. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Spatial Variation of Water Supply and Demand in Sri Lanka

Upali A. Amarasinghe
International Water Management Institute, New Delhi Office

Introduction

At an aggregate level, Sri Lanka, the so called 'tear drop' island in the Indian Ocean, has a rich freshwater endowment. In a geographic area of 65,000 km^2, Sri Lanka is blessed with 103 small and medium rivers, collecting about 52 billion cubic meters (bcm) of annual surface runoff. In per capita terms, the annual runoff in 2001 was 2,799 m^3, which willl decrease to about 2,232 m^3 by 2050. Thus, Sri Lanka is well within the generally accepted national water scarcity threshold of 1,700 m^3/person suggested by Falkenmark et al. (1989). However, underneath the aggregate statistics, there lies a stark spatial and temporal variation of water supply, which is generally a common feature in countries with arid to semi-arid to humid tropics (Amarasinghe et al. 2005). In fact, Sri Lanka's freshwater availability varies significantly across river basins and seasons.

Monsoonal weather patterns have a major influence on the spatial and temporal variation of water availability within the country. The wet-zone districts with only 23 % of the land area account for 51 % of the annual surface runoff, and in the yala season (April-September), they account for 81 % of the surface runoff (Amarasinghe et al. 1999). Only the north-east monsoon from October to March (maha season), influences rainfall patterns in the dry-zone, leaving large parts with severe water shortages in the yala-season. In fact, as many as 49 small river basins are mainly seasonal, where the yala-season contributes to less than 15 % of the annual runoff.

In addition to low availability, water-use patterns in agriculture also aggravate water stress in river basins. In 1991, a large part of the dry-zone in Sri Lanka was under severe seasonal water stress (Amarasinghe et al. 1998). Many drivers including demographic patterns, economic growth, and consumption patterns, which contribute to an increase in water demand, have changed significantly since the early 1990s. So has the associated water stress.

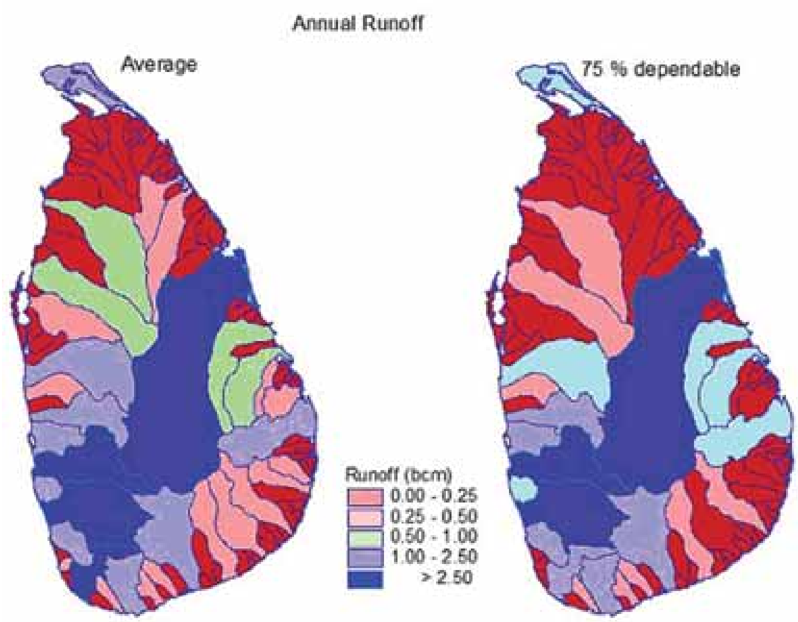
This paper discusses spatial variation of water supply and increased demand situation in Sri Lanka in recent years and assesses regional and seasonal water stress.

Water Supply

Renewable Water Resources

Generated from bi-monsoonal rainfall patterns, renewable fresh-water resources of Sri Lanka vary significantly across river basins and seasons. Of the 103 river basins, 12 river basins with 46 % of the geographical area generate 72 % of the total renewable water resource (TRWR)—(Figure 1). These river basins, which receive rainfall from both monsoons, are perennial. Each generates more than one bcm of annual runoff.

Figure 1. Surface runoff of Sri Lanka's river basins.



Source: Amarasinghe et al. 1998

Draining into the sea from the west and south-west, the Kalu, Kelani, Gin, Bentota, and Nilwala river basins have only 13 % of the land area, but account for 30 % of the population and 38 % of TRWR. The agriculture in these river basins is mainly rain-fed, and dominated by plantation crops such as rubber, coconut and tea. Draining into the sea from the east, the Mahaweli, the longest river and the most important for irrigated agriculture in the island, contains 17 % of the area, supports 17 % of the population and carries 19 % of TRWR. The basin of the Gal Oya River which flows east, known for its irrigated paddy production, has 3 % of the land area and 2 % of TRWR. The Jaffna Peninsular, which mainly uses groundwater for agriculture requirements, accounts for 2 % land area, 3 % population and 2 % TRWR.

Water availability across space varies significantly even within some water-rich basins, most importunately in the Mahaweli River It starts from the central hills and cuts across many agro-climatic regions on its way to the sea from the east. The Central Province, located in the wet- to intermediate zones, intersects 43 % of the Mahaweli Basin, and generates 57 % of its annual runoff. In contrast, the North-Central and Eastern provinces in the dry-zone have 27 % and 13 % of the basin area, respectively, but generate only 19 % and 7 % of the runoff. Much of the agriculture in the latter two provinces depends on irrigation from the water diverted from the up-stream of Mahaweli.

The majority of the remaining 91 basins, which mainly receive rainfall from the north-east monsoon, are mainly seasonal. As many as 71 basins located in coastal regions generate less than 0.25 bcm runoff. Of these, 48 basins generate more than 85 % of the runoff in the *maha* season (October-March). Furthermore, 16 of these basins get more than 75 % of its runoff in the *maha* season. Regionally, 20 small basins mostly in the Northern Province have 8 % of the total land area, but account for only 1 % of the TRWR; 26 basins mostly in the Eastern Province have 8 % of the total land area and 5 % of TRWR; 17 basins, mostly in the Southern Province, have 5 % of the land are and 5 % of TRWR.

In fact, the TRWR of 75 basins, including Mahaweli and Gal Oya, have significant seasonal variation where rainfall in the *maha* season contributes to two-thirds of the runoff. Intra-annual variation in water availability is the major constraint for productive agriculture in these basins. Thus, storing water for irrigation in the *yala* season (April to September) is essential in many river basins.

Dependable Runoff

Water storage is even more important due to inter-annual variation of TRWR. The 75 % probability of dependable runoff is only 83 % of the average TRWR (Table 1). Mahaweli has exactly 83 % of dependable runoff, mainly because of its origins in the wet-zone. But many of the river basins that flow to the sea from the north-west to the south (in a clock-wise direction) with their watershed in the dry-zone have much less dependable runoff. Water availability of these basins, especially in the *yala*-season during dry years, is very low. Thus, in the presence of increasing intra- and inter-annual variability of rainfall due to climate change, water storage in these basins becomes very important.

Table 1. Runoff estimates of Sri Lankan river basins.

ID	River Basin(s)[1]	Annual runoff (km^3)			Per capita water resources (m^3)			
		P75[2]	P50[2]	Average	Total	*Maha*	*Yala*	*Maha*-% of total
1	Kelani Ganga	5.3	5.6	5.7	2,085	882	1,203	42
2	Bolgoda Lake	0.9	1.0	1.0	670	292	378	44
3	Kalu Ganga	6.9	7.6	7.9	5,385	2,400	2,985	45
4	Bentota Ganga	1.6	1.7	1.8	4,272	1,921	2,352	45
5	Bentota - Nilwala	3.4	3.8	3.9	3,374	1,590	1,785	47
6	Nilwala Ganga	1.3	1.6	1.7	2,768	1,420	1,348	51
7	Nilwala-Walawe	0.9	1.1	1.1	2,421	1,304	1,117	54
8	Walawe Ganga	1.6	2.1	2.1	3,228	1,851	1,378	57
9	Walawe-Krindi Oya	0.3	0.3	0.3	3,970	2,387	1,583	60
10	Kirindi Oya	0.4	0.4	0.5	2,753	1,826	927	66
11	Krindi Oya- Manik Ganga	0.0	0.0	0.0	2,051	1,375	677	67
12	Manik Ganga	0.2	0.3	0.3	2,382	1,633	749	69

(Continued)

Table 1. Runoff estimates of Sri Lankan river basins *(Continued)*.

ID	River Basin(s)[1]	Annual runoff (km³)			Per capita water resources (m³)			
		P75[2]	P50[2]	Average	Total	*Maha*	*Yala*	*Maha*-% of total
13	Manik Ganga-Kumbumkan Oya	0.1	0.1	0.1	3,910	2,987	922	76
14	Kumbukkan Oya	0.4	0.5	0.5	3,610	2,952	657	82
15	Kumbukkan Oya-Karanda Oya	0.5	0.6	0.7	15,016	13,026	1,990	87
16	Karanda oya-Gal Oya	0.4	0.5	0.6	5,775	5,198	577	90
17	Gal Oya	0.9	1.1	1.3	2,623	2,453	170	94
18	Gal Oya-Mundini Aru	0.5	0.7	0.8	1,670	1,596	74	96
19	Mundini aru+Miyangolla	0.7	0.9	1.0	8,342	7,970	372	96
20	Maduru Oya	0.5	0.7	0.8	4,701	4,231	470	90
21	Maduru Oya-Mahaweli Ganga	0.2	0.2	0.2	26,714	20,286	6,428	76
22	Mahaweli Ganga	8.1	9.1	9.7	2,836	1,905	931	67
23	Mahaweli - Yan Oya	0.3	0.5	0.5	3,186	2,863	323	90
24	Yan Oya	0.2	0.4	0.4	3,271	2,928	343	90
25	Mee + Ma Oya	0.2	0.3	0.3	5,254	4,683	571	89
26	Ma oya- Kanakarayan Aru	0.2	0.3	0.3	1,945	1,710	236	88
27	Kanakarayan Aru	0.1	0.2	0.2	3,248	2,816	432	87
28	Kanakarayan Aru-Parangi Aru	0.2	0.2	0.3	2,396	2,058	338	86
29	Parangi + Nay Aru	0.2	0.3	0.3	2,103	1,790	313	85
30	Aruvi Aru	0.4	0.6	0.8	2,167	1,837	330	85
31	Kal Aru-Modaragam Aru	0.1	0.2	0.3	2,686	2,233	453	83
32	Wilpattu+Kala Oya	0.3	0.5	0.7	1,624	1,334	291	82
33	Moongil oya+ Rathambala Oya	0.2	0.3	0.4	875	680	195	78
34	Deduru Oya	0.8	1.0	1.1	1,290	872	417	68
35	Karabalan Oya + Maha Oya	0.4	0.5	0.5	1,170	680	491	58
36	Maha Oya	1.3	1.5	1.5	1,576	827	749	52
37	Attanagalu Oya	1.2	1.3	1.3	1,046	473	573	45
38	Jaffa Peninsula	1.2	1.2	1.2	2,021	1,672	349	83
	All basins	42	49	52	2,513	1,522	992	61

Source: Amarasinghe et al. 1998

Notes: [1] Shaded rows include more than one river basin
[2] P75 and P50 runoff estimates are based on 75 % and 50 % dependability rainfall

Water Storage

In spite of large intra- and inter-annual variation of rainfall, Sri Lanka's storage capacity is very low at present. By 1996, Sri Lanka had developed about 6 bcm of storage capacity. This translates to a per capita storage of only 291 m³ in 2005. However, this capacity is very low, compared to 5,961 m^3 in the U.S.A., 4,717 m^3 in Australia, and 2,500 m^3 in China. Like Sri Lanka, many of these countries have large arid to semi-arid climate areas. Water security through higher storage was a crucial base for early economic development in many developed countries (Kumar and Shah 2008). Thus, low storage capacity resulting in economic water scarcity could be a major constraint for economic development in many parts of the island in the future.

However, many of the potential sites for large surface storage in Sri Lanka are already exploited. Moreover, social and environmental concerns for new, large storage structures are also increasing. Thus, increasing natural groundwater recharge by exploiting the resource in the non-rainy seasons, or through artificial groundwater structures in the rainy seasons could increase the storage capacity much more. This could facilitate the rapid diffusion of groundwater use in the dry-zone (Kikuchi et al. 2001), thereby generating spatially distributed benefits to a large rural population in the dry-zone.

Water Demand

Irrigation is by far the highest water use sector in Sri Lanka, accounting for 92 % of the water withdrawals in 1991 (Amarasinghe et al. 1998), and still is high at 90 % in 2000 according to FAO estimates (FAO 2008). There are no exact estimates of water withdrawals for the domestic and industrial (D&I) sectors or for the project efficiency of irrigation at present. Assuming 10 to 15 % of D&I water use and 35 % irrigation efficiency, total water withdrawals in Sri Lanka in 2005 could range from 13.3 to 12.6 bcm (Table 2). This is about a quarter of the TRWR at present.

Table 2. Total water withdrawals in Sri Lanka in 2005.

Water withdrawals in 2005 (million cubic meters)	Project Irrigation Efficiency		
	35 %	45 %	55 %
Irrigation withdrawals for paddy	10,634	8,271	6,767
Irrigation withdrawals (IW) for all crops	11,314	8,877	7,325
Total water withdrawals (TW) (IW at 85 to 90 % of TW)	12,572- 13,331	10,134- 10,873	8,582- 9,322
% of total withdrawals	24.1 - 25.5	19.5 - 20.9	16.5 - 17.9

Source: Authors' estimation

Irrigation Withdrawals

Irrigated Area

We considered 12 crops or crop categories for estimating irrigation withdrawals (Table 3). In 2005, gross crop area (GCA) was 1,945,000 ha. The dry-zone districts account for two-thirds of the GCA (Annex 1). Within this, the Eastern, North-Western and North-Central provinces account for 46 % of the GCA.

Table 3. Cropped area (1,000 ha) in 2005/06.

Crops or crop categories	Irrigated crops			Rain-fed crops			Total		
	Maha	*Yala*	Total	*Maha*	*Yala*	Total	*Maha*	*Yala*	Total
Paddy	423.5	276.3	699.9	162.4	37.9	200.3	585.9	314.3	900.2
Maize	0.0	0.7	0.7	23.5	3.7	27.2	23.5	4.4	27.9
Other cereals	0.0	0.1	0.1	4.7	0.9	5.6	4.7	1.1	5.7
Pulses	0.0	0.8	0.8	18.2	6.4	24.7	18.2	7.2	25.5
Oil crops	1.4	2.8	4.1	10.3	7.9	18.2	11.6	10.7	22.3
Roots and tubers	0.0	4.3	4.3	21.1	16.9	37.9	21.1	21.2	42.2
Vegetable	3.8	5.5	9.3	43.4	28.7	72.1	47.2	34.2	81.4
Total seasonal crops	428.7	290.5	719.2	283.6	102.4	386.0	712.2	393.1	1,105.2
Fruits			7.4			91.8			99.2
Sugar			17.4			-			17.4
Cotton			-			0.0			0.0
Tea			-			212.7			212.7
Rubber			-			116.5			116.5
Coconut			-			394.8			394.8
Total	428.7	290.5	744.0	283.6	102.4	1,201.8	712.2	393.1	1,945.8

Irrigation covered 38 % or 744,100 ha, of the GCA of Sri Lanka. The dry-zone districts account for 91 % of the gross irrigated area (GIA). Two-thirds of the GIA are located in Eastern, North-Western and North-Central provinces. Over 80 % of the GCA in Ampara, Manner and Polonnaruwa districts are irrigated.

Among the irrigated crops, paddy is the dominant crop. In 2005, paddy accounted for only 46 % of the GCA, but accounted for 94 % of the GIA. Of the total paddy area of 900,000 ha, 78 % was irrigated. Dry-zone districts account for 80 % of the gross rice area, and 91 % of the irrigated rice area. Within the dry-zone, the Eastern, North-Western, North-Central and Southern provinces account for 77 % of the irrigated rice area.

The irrigated area of other seasonal crops is very small at present. Only 44,000 ha of non-paddy crops are estimated to be irrigated at present. This is only 14 % of the non-plantation, non-paddy crop area. Much of the irrigation of these crops is in the *yala* season.

Plantation crops such as tea, rubber and coconut occupy a large part of the cropped area. As much as 38 % of the GCA is under tea, rubber and coconut. These crops are considered to grow under rain-fed conditions.

Net Irrigation Requirement

We estimate the monthly net irrigation requirement (NIR of different crops for two seasons. NIR is the product of crop coefficients and the difference of potential evapotranspiration and effective rainfall. For details we refer to Amarasinghe et al. 2005. Details of the seasonal paddy area are available at the DS Division level (GOI 2008), and therefore, for paddy, we estimate

NIR at the DS division level. Other crop areas are only available at the district level. Here, first we estimate the average NIR (in mm) for the districts based on DS division data, and then multiply from the district area to get the total NIR. The NIR estimates at district level are given in Annex 2.

Irrigation Efficiency

A systematic assessment of irrigation efficiencies across regions is not available. Estimating irrigation withdrawals in 2000, FAO-AQUASTAT assumed project irrigation efficiency to be at about 35 %.

Irrigation withdrawal is the ratio of NIR and irrigation efficiency. We estimate irrigation withdrawals under three irrigation efficiency scenarios (Table 4), where 35 % is perhaps closest to the reality. Efficiencies of 45 % and 55 % show the extent of reduction in water withdrawals possible with improved efficiency scenarios.

Table 4. Irrigation withdrawals.

Provinces/ Districts	Irrigation withdrawals at project irrigation efficiency 35 %, 45 % and 55 %								
	Total			Rice – major irrigation			Rice – minor irrigation		
	35 %	45 %	55 %	35 %	45 %	55 %	35 %	45 %	55 %
Sri Lanka	11,314	8,877	7,325	8,076	6,281	5,139	2,558	1,990	1,628
Wet-zone	716	557	456	314	244	200	393	305	250
Dry-zone	10,598	8,320	6,869	7,762	6,037	4,940	2,166	1,684	1,378
Provinces[1]									
Western	0.6	0.6	0.6	0.2	0.2	0.2	2.1	2.1	2.1
Central	4.8	4.7	4.7	3.1	3.1	3.1	10.4	10.4	10.4
Southern	7.9	7.8	7.8	9.3	9.3	9.3	5.4	5.4	5.4
Northern	6.1	6.1	6.0	5.5	5.5	5.5	5.7	5.7	5.7
Eastern	24.4	24.2	24.0	32.4	32.4	32.4	5.5	5.5	5.5
North-western	13.3	13.2	13.0	6.9	6.9	6.9	33.5	33.5	33.5
North-central	31.5	31.2	31.0	36.3	36.3	36.3	21.9	21.9	21.9
Uva	9.1	9.9	10.6	5.1	5.1	5.1	9.7	9.7	9.7
Districts[1]									
Colombo	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4
Gampaha	0.3	0.3	0.3	0.0	0.0	0.0	1.2	1.2	1.2
Kalutara	1.6	1.6	1.6	1.2	1.2	1.2	3.2	3.2	3.2
Kandy	2.5	2.5	2.5	1.6	1.6	1.6	5.1	5.1	5.1
Matale	0.6	0.6	0.6	0.2	0.2	0.2	2.1	2.1	2.1
Nuwara Eliya	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Galle	6.7	6.7	6.6	8.3	8.3	8.3	3.2	3.2	3.2
Hambantota	1.2	1.1	1.1	0.9	0.9	0.9	2.1	2.1	2.1
Matara	0.6	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0

(Continued)

Table 4. Irrigation withdrawals *(Continued)*.

Provinces/ Districts	Irrigation withdrawals at project irrigation efficiency 35 %, 45 % and 55 %								
	Total			Rice – major irrigation			Rice – minor irrigation		
	35 %	45 %	55 %	35 %	45 %	55 %	35 %	45 %	55 %
Sri Lanka	11,314	8,877	7,325	8,076	6,281	5,139	2,558	1,990	1,628
Wet-zone	716	557	456	314	244	200	393	305	250
Dry-zone	10,598	8,320	6,869	7,762	6,037	4,940	2,166	1,684	1,378
Districts[1]									
Jaffna	1.8	1.8	1.8	2.4	2.4	2.4	0.2	0.2	0.2
Kilinochchi	1.2	1.2	1.2	1.4	1.4	1.4	0.7	0.7	0.7
Mannar	1.2	1.2	1.2	1.1	1.1	1.1	1.4	1.4	1.4
Mullaitivu	1.3	1.3	1.3	0.5	0.5	0.5	3.3	3.3	3.3
Vavuniya	15.5	15.3	15.2	21.0	21.0	21.0	1.9	1.9	1.9
Ampara	4.8	4.8	4.7	6.2	6.2	6.2	1.6	1.6	1.6
Batticaloa	4.1	4.1	4.1	5.2	5.2	5.2	2.0	2.0	2.0
Trincomalee	10.5	10.5	10.4	5.3	5.3	5.3	28.5	28.5	28.5
Kurunegala	2.7	2.7	2.7	1.7	1.7	1.7	5.0	5.0	5.0
Puttalam	16.1	16.0	15.9	15.5	15.5	15.5	19.5	19.5	19.5
Anuradhapura	15.4	15.2	15.1	20.7	20.7	20.7	2.3	2.3	2.3
Polonnaruwa	3.6	3.6	3.6	3.2	3.2	3.2	5.0	5.0	5.0
Badulla	5.4	6.2	7.0	1.8	1.8	1.8	4.7	4.7	4.7
Moneragala	0.3	0.3	0.3	0.0	0.0	0.0	1.5	1.5	1.5
Kegalle	1.9	1.9	1.9	1.3	1.3	1.3	4.3	4.3	4.3
Ratnapura	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4

Source: Authors' estimates

Notes: [1] Area values at provincial and district levels are given as a percent of Sri Lankan total

Irrigation Withdrawals

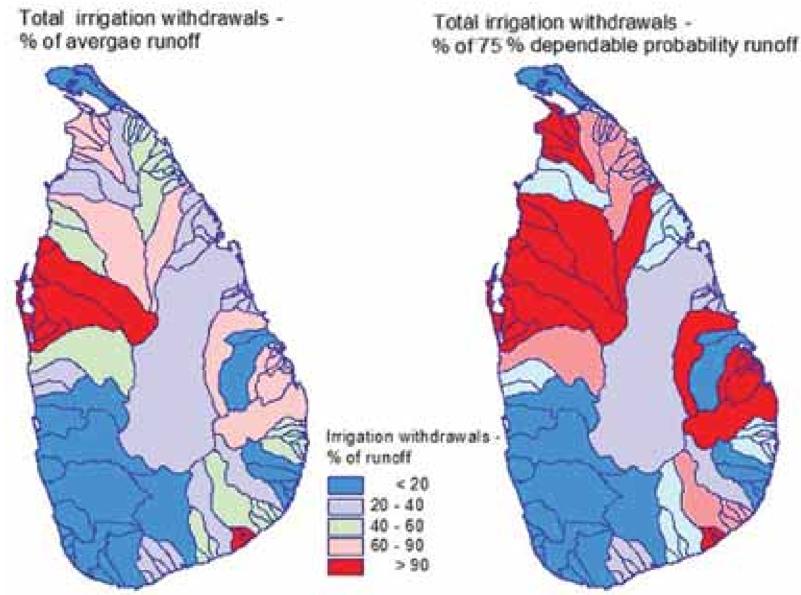
The total irrigation withdrawal in 2005 was 11.3 bcm, which is about 22 % of the TRWR. Given the larger irrigated area and greater irrigation requirements, the dry-zone districts account for 94 % of the total irrigation withdrawals. The Eastern, North-Western, and North-Central provinces and Hambantota in the Southern Province account for 76 % of total withdrawals.

Paddy in major irrigation schemes, of which many are located in the above four regions, accounts for 71 % of total irrigation withdrawals. Paddy in minor irrigation schemes accounts for another 23 %. Non-paddy crops account for 6 %.

Irrigation Withdrawals as % of TRWR

Figure 2 shows the river basin wise irrigation water withdrawals in comparison to their total water resources. This indicates that many basins withdrew large parts of their water resources

Figure 2. Irrigation withdrawals as a percentage of TRWR and of the 75 % dependable runoff.



for irrigation. Most of the water-scarce basins are located in the dry-zone. Of the 38 river basins or group of basins, 9 basins withdraw more than 60 % of the TRWR. This number increases to 16 basins when irrigation withdrawals are compared with 75 % dependable runoff. The latter is a realistic comparison in terms of long-term water resources management planning.

However, a large part of irrigation withdrawals recharges groundwater. But in Sri Lanka, reuse of this water in terms of groundwater withdrawals is negligible at present. Unlike in other South Asian countries, conjunctive water use in major irrigation command areas in Sri Lanka is almost non-existent. Only a small part of minor-irrigation schemes located in the North-Western Province has groundwater irrigation in the command areas (Kikuchi et al. 1998).

Thus, most of the water withdrawn for irrigation can be considered as primary water withdrawals (Seckler et al. 1998). Hence, many river basins are already physically water- scarce, where even irrigation water withdrawals are a significant part of the TRWR. A physical scarcity will exacerbate the situation in many basins if domestic and industrial water withdrawals (10-15 %) are also taken into account. This situation is very severe in water-scarce basins in the dry-zone, and can be further aggravated if estimates of utilizable water resources exclude environmental water needs.

At present, environmental water needs are not factored in the estimation of potentially utilizable water resources (PUWR). But, if the hydrological variability and the status of current development are considered, the environmental water demand of many river basins in Sri Lanka could be about 15-30 % of the TRWR (Smakhtin and Anputhas 2008). If this amount is subtracted from TRWR for estimating PUWR, many of the basins in the dry-zone could fall into physical water-scarce category. In theory, there is hardly any water available in these basins for further development. Thus, meeting future water demand for food production, in the presence of increasing demand for domestic, industrial and environmental water needs, is indeed a challenge.

Meeting Future Water Demand

What options are available for Sri Lanka in meeting future water demand? At the present rate of growth, Sri Lanka's population will peak in the early 2040s, with an addition of 15 % to the population (UN 2006). If the present self-sufficiency levels of different crops are to be maintained and the present level of crop productivity persists, the irrigation demand for meeting food demand for this maximum population could increase by at most 15 %.

Increasing Irrigation Efficiency

Given the high level of water development for irrigation, increasing irrigation efficiency is one of the feasible options available for meeting future water demand.

If irrigation efficiency is increased to 45 % from the currently assumed level of 35 %, the irrigation demand shall decrease by 22 % (Table 4). The major irrigated areas will contribute to 78 % of the reduction in demand through this level of efficiency increase.

If irrigation efficiency is increased to 55 %, irrigation demand will decrease by 35 %. Decrease in irrigation demand in such a scenario is more than 3.9 bcm, which is equivalent to about 32 % of the total water demand.

Such scenarios of efficiency growth show that if the currently developed water supply is properly managed, only a part of these water savings is adequate for meeting future irrigation demand.

Conclusion

The spatial and seasonal variability of water supply and demand are causes of regional water scarcities in Sri Lanka. Dry-zone districts, comprising 75 % of land area, contribute to only 49 % and 29 % of the *maha* and *yala* season runoff. But, equivalent to half of the water consumed for food production in the dry-zone is transferred as virtual water to the wet-zone. Thus, many river basins in the dry-zone are already facing severe physical water scarcities.

However, the water use efficiency of the developed water resources is very low at present. Due to the low level of reuse of groundwater return flows, significant scope exists for increasing irrigation efficiency. An increase in irrigation efficiency by 10-20 % could reduce irrigation demand by 22 % and 35 %, respectively. The water saved by increasing water use efficiency could meet a large part of the additional water demand in the future.

References

Amarasinghe, U. A.; Mutuwatta, L.; Sakthivadivel, R. 1999. *Water scarcity variations within a country: A case of Sri Lanka.* IWMI Research Report 32. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Amarasinghe, U. A.; Sharma, B. R.; Aloysius, N.; Scott, C.; Smakhtin, V.; de Fraiture, C. 2005. *Spatial variation of water supply and demand across river basins of India.* IWMI. Research Report 83. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Falkenmark, M.; Lundqvit, J.; Widstrand, C. 1989. Maroc-scale Water Scarcity Requires Micro-scale Approaches: Aspects of Vulnerability in Semi-arid Development. *Natural Resources Forum* 13 (4): 258-267.

FAO (Food and Agriculture Organization). 2008. AQUASTAT database. http://www.fao.org/nr/water/aquastat/countries/sri_lanka/index.stm . Rome, Italy: Food and Agriculture Organization.

FAO. 2009. FAOSTAT database. http://faostat.fao.org. Rome, Italy: Food and Agriculture Organization.

GOSL (Government of Sri Lanka) 2009. Population Census 2001. http://www.statistics.gov.lk/PopHouSat/index.asp. Colombo, Sri Lanka: Department of Census and Statistics.

GOSL (Government of Sri Lanka). 2009. Paddy Statistics. http://www.statistics.gov.lk/agriculture/Paddy%20Statistics/PaddyStats.htm

GOSL (Government of Sri Lanka) 2009. Highland Crops. http://www.statistics.gov.lk/agriculture/hcrops/index.html.

Kikuchi, M.; Weligamage, P.; Barker, R.; Samad, M.; Kono, H.; Somaratne, H.M. 2001. *Agro-wells and pumps in irrigation schemes in the dry zone of Sri Lanka: Past trends, present status and future prospects.* IWMI Research Report 66. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Seckler D.; Amarasinghe, U.A.; Molden, D.; de Silva, R.; Barker, R. 1998. *World water demand and supply 1990-2025: Scenarios and issues.* IWMI Research Report 19. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Shah, Z.; Kumar, D. 2008. In the Midst of the Large Dam Controversy: Objectives, Criteria for AssessingLarge Water Storages in the Developing World. In *Strategic Analyses of the National River Linking Project (NRLP) of India, series 2.* Proceedings of the Workshop on Analyses of Hydrological, Social and Ecological Issues of the NRLP, eds. Upali A. Amarasinghe and Bharat Sharma. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Smakhtin, V.; Anputhas, M. 2008. *An assessment of environmental flow requirements of Indian river basins.* IWMI Research Report 107. Colombo, Sri Lanka: International Water Management Institute (IWMI).

UN (The United Nations). 2006. World Population Prospects: The 2004 Revision. New York, USA: The United Nations.

Annex 1. Cropped in area (1,000 ha) in 2005

Provinces and Districts of Sri Lanka	Gross cropped area in 2005 (GCA)[1]	Gross irrigated Area (GIA) in 2005									
		Total (GIA)	GIA % of GCA	Rice cropped area (RCA)	RCA % of GCA	Irrigated area (RIA)	RIA % of GIA	Major irrigation		Minor irrigation	
								Maha	*Yala*	*Maha*	*Yala*
Sri Lanka	1,946	744	38	900	46	699	94	281	217	129	49
Wet-zone	638	67	11	152	24	65	98	10	8	26	8
Dry-zone	1,308	677	52	748	57	634	94	271	209	113	41
Provinces											
Western	9	1	4	4	23	1	100	1	0	3	3
Central	10	6	23	6	26	6	95	4	4	13	14
Southern	12	8	27	11	42	9	99	9	11	5	9
Northern	5	6	51	6	65	5	83	7	3	8	2
Eastern	13	23	70	24	86	25	100	31	36	5	6
North-western	18	13	28	14	36	13	93	7	7	29	40
North-central	15	30	77	24	76	31	97	36	34	25	15
Uva	9	9	39	6	32	7	71	6	6	11	11
Sabaragamuwa	10	3	13	5	20	3	96	2	2	7	14
Districts											
Colombo	1	0	6	1	23	0	100	0	0	1	0
Gampaha	3	0	4	1	16	0	100	0	0	1	0
Kalutara	4	0	4	3	30	0	100	0	0	1	3
Kandy	3	2	24	2	31	2	97	1	2	4	5
Matale	3	3	38	3	42	3	91	2	2	6	6
Nuwara Eliya	4	1	10	1	10	1	100	0	0	4	3
Galle	4	0	0	2	28	0	100	0	0	0	0
Hambantota	5	7	50	6	52	7	99	8	9	3	4
Matara	3	2	18	3	41	2	100	1	1	2	4
Jaffna	1	1	27	1	45	0	0	0	0	0	0
Kilinochchi	1	2	45	2	76	2	94	2	2	0	0
Mannar	1	1	84	1	84	1	100	3	0	1	0
Mullaitivu	1	1	45	1	62	1	87	1	1	2	1
Vavuniya	1	1	64	1	58	1	88	1	0	5	1
Ampara	7	15	81	13	85	16	100	20	25	2	3
Batticaloa	4	5	48	7	86	5	99	6	7	2	2
Trincomalee	2	4	72	4	86	4	100	5	4	2	2
Kurunegala	14	11	28	12	39	11	95	5	5	25	33
Puttalam	4	3	27	2	23	2	83	2	1	4	7
Anuradhapura	9	16	69	13	68	16	96	18	13	24	11

Polonnaruwa	6	13	88	11	89	14	100	18	22	1	3
Badulla	5	4	35	4	36	4	93	4	4	7	6
Moneragala	4	5	43	3	28	3	50	2	2	5	5
Kegalle	4	0	5	2	18	1	100	0	0	2	3
Ratnapura	6	3	18	3	22	3	96	2	2	5	11

Source: GOSL 2006

Notes: [1] Gross cropped area includes seasonal crops (rice, maize, other coarse cereals, pulses, oil crops, roots and tubers and vegetables), perennial crops (fruits, cotton, tea, rubber, and coconut)

Annex 2. Net irrigation requirements of different crops

Provinces/ Districts	Net irrigation requirement (NIR) in million cubic meters											
	All crops		Rice irrigation requirements									
	Total TNIR	Seasonal crops - % of TNIR	Total RNIR	RNIR-% of TNIR	Major irrigation *Maha*	Major irrigation *Yala*	Major irrigation Total	Total % of RNIR	Minor irrigation *Maha*	Minor irrigation *Yala*	Minor irrigation Total	Total % of RNIR
Sri Lanka	2,560	93	2,322	91	481	1,334	1,814	78	267	240	508	22
Wet-zone	118	98	115	97	19	39	57	50	25	32	58	50
Dry-zone	2,442	93	2,207	90	462	1,295	1,757	80	242	208	450	20
Provinces												
Western	11	100	11	100	2	1	3	29	7	1	8	71
Central	105	97	96	91	12	38	50	52	18	28	46	48
Southern	192	99	189	99	66	97	163	86	14	13	27	14
Northern	169	89	132	77	54	48	102	78	24	6	30	22
Eastern	620	100	617	100	77	511	588	95	8	21	29	5
North-western	341	95	312	91	52	75	127	41	98	88	185	59
North-central	819	99	792	96	187	490	676	85	68	47	116	15
Uva	263	53	134	51	26	62	88	65	23	24	47	35
Sabaragamuwa	41	95	39	95	7	12	18	47	8	13	21	53
Districts												
Colombo	2	100	2	100	0	0	0	10	2	0	2	90
Gampaha	4	100	4	100	2	1	3	63	1	0	2	37
Kalutara	5	100	5	100	0	0	0	5	4	1	4	95
Kandy	34	100	33	96	3	17	20	60	4	9	13	40
Matale	61	95	54	87	8	20	28	52	12	14	26	48
Nuwara Eliya	9	100	9	100	1	2	2	23	2	5	7	77
Galle	0	100	0	100	0	0	0	0	0	0	0	100
Hambantota	169	99	166	99	60	89	149	90	9	8	17	10
Matara	23	100	23	100	6	8	14	61	4	5	9	39
Jaffna	26	48	0	0	0	0	0	0	0	0	0	0
Kilinochchi	51	97	48	94	13	34	47	98	1	0	1	2
Mannar	28	100	28	99	24	0	24	87	4	0	4	13
Mullaitivu	32	95	30	93	10	12	22	74	5	3	8	26
Vavuniya	32	96	25	79	7	2	9	34	14	3	17	66
Ampara	389	100	387	100	41	336	377	97	2	8	10	3
Batticaloa	122	99	121	99	12	101	113	93	2	7	8	7
Trincomalee	109	100	109	100	24	74	98	90	5	6	11	10
Kurunegala	267	98	253	95	38	58	96	38	84	73	157	62
Puttalam	75	85	59	78	14	16	31	52	13	15	28	48

Anuradhapura	413	99	386	93	114	170	284	74	66	36	102	26
Polonnaruwa	408	100	406	100	73	320	392	96	3	12	14	4
Badulla	84	96	76	91	12	42	55	72	9	13	21	28
Moneragala	180	33	58	33	13	20	33	57	14	11	25	43
Kegalle	6	100	6	100	0	0	0	0	3	3	6	100
Ratnapura	35	94	33	93	7	12	18	56	5	9	14	44

Source: Authors' estimates

Managing Irrigation Jointly with Farmers: History, Present Status and Future - Review of Participatory Irrigation Management in Sri Lanka

K. Jinapala[1], Lal Premadasa[2], P. G. Somaratne[3] and M. Samad[4]
[1]Researcher International Water Management Institute, Colombo, Sri Lanka
[2]Project Manager of Irrigation Management Division, Irrigation Department, Colombo, Sri Lanka
[3]Former Researcher International Water Management Institute, Colombo, Sri Lanka
[4]Regional Director (South Asia) International Water Management Institute, India

Abstract

Agriculture development has been the main strategy for the socioeconomic development in the country since time immemorial, even though its contribution to GDP has been declining recently. Successive governments of Sri Lanka since independence have invested heavily in the irrigated agriculture sector to address the food security concerns of the country. The continuous investment in irrigation was required to address problems such as spatial and temporal variations in monsoonal rainfall in the country, which has a serious negative impact on food production and livelihoods of people. The need for pursuing irrigation development and management has become more important in the country in the face of rapid population growth and increasing food prices in the world market.

In this context, managing irrigation schemes for productivity increase is becoming increasingly important and different irrigation management models have also emerged through attempts made in this direction by countries including Sri Lanka, where irrigation plays a leading role in food production and nation development. Farmers' active involvement in irrigation management, especially operation and maintenance (O&M) and decision-making as well, has been identified as a key requirement to attain productivity goals and the sustainability of irrigation systems.

This paper aims at reviewing participatory irrigation management approaches adopted in medium and major irrigation systems in Sri Lanka with a view to identifying their past and present trends and future directions. The review will contribute to an improved understanding by policymakers, managers of irrigation schemes and farmers of the role of participatory irrigation management, its past and present including institutional structures, responsibilities and performance and the directions it should take to meet future challenges as a dynamic institutional mechanism. As all the medium and major irrigation schemes in the country are

jointly managed by farmers and government agencies, the inferences drawn from the review would be important for the agencies and farmers alike to introduce necessary changes in their programs to address future needs and requirements.

Introduction

Objectives and Organization of the Paper

The objective of this paper is to analyze the adoption of the Participatory Irrigation Management (PIM) approach in the country, and suggest some strategic directions for this institutional mechanism for the further improvement of its effectiveness to face the ongoing and future challenges in irrigation management.

In achieving the main objective of the paper, three aspects of PIM will be addressed. As a first step of the analyses, the evolution of PIM is briefly reviewed. The current progress of the PIM approaches in managing irrigation schemes is summarized in step two. Step three involves the analysis of likelihood challenges for the PIM approach to be further progressed and sustained in the long run.

In this context the paper is organized into five sections: In the second section (followed by the introductory section) titled 'The Methodolgy' describes the evolution of PIM in Sri Lanka. The third section titled 'Performance of PIM in Sample Irrigation Schemes Studied' provides key information on the progress/outcomes of the PIM approach in managing irrigation schemes. The challenges being faced and also to be faced in the future are discussed in section 4 titled 'Assessment of Irrigation Management under PIM'. The final section, section 5 titled 'Conclusions and Recommendations' suggests some strategic directions to make PIM approaches sustainable and more progressive.

The Methodology

Sample Irrigation Schemes and Sample FOs

The analysis of this paper is mainly based on information obtained from IWMI/HARTI conducted research. The International Water Management Institute (IWMI) and the Hector Kobbakaduwe Agrarian Research and Training Institute (HARTI) carried out a 3-year monitoring and evaluation study during 1992 to 1994 covering a significant number of irrigation schemes that are managed with PIM approaches. The irrigation schemes managed by the Irrigation Department (ID) (medium and large irrigation schemes) and the Mahaweli Authority managed schemes were selected for the study. The PIM approach in large irrigation schemes is known as the Integrated Management of Major Irrigation Settlement Schemes (INMAS) program and the medium schemes are managed by a program called Management of Irrigation Systems (MANIS). This study adopted several methods for data collection from several irrigation schemes in these three programs, while six irrigation schemes from the three programs were selected for documenting the process of irrigation management during the entire study period. Process documentation in each scheme was carried out by a full time stationed research assistant in the specific irrigation scheme. Research officers of IWMI and HARTI carried out recurrent surveys in 18 schemes covering 30 farmer organizations (FOs). Finally, a large-scale questionnaire survey was carried out in 49 irrigation schemes from the three programs covering 172 FOs.

Evaluation Criteria used for the Analysis

The key components of PIM were assessed based on certain criteria and indicators. These indicators were used to assess the progress, outcomes and impacts of irrigation schemes that are managed through PIM. Since there are no common or universally accepted criteria and indicators to measure the performance of PIM, these indicators would provide objectively verifiable values for the readers interested to know the progress of the PIM approach used for managing irrigation schemes. Three different indicator values were developed to measure the conceptual base, performance and outcome of different components of PIM. Different aspects are used to develop conceptual base, performance and outcome indicators under six different criteria as summarized in Table 1. The detail scoring system used for measuring the values of each indicator is shown in Annex 1.

Table 1. Criteria and different aspects used for developing indicators.

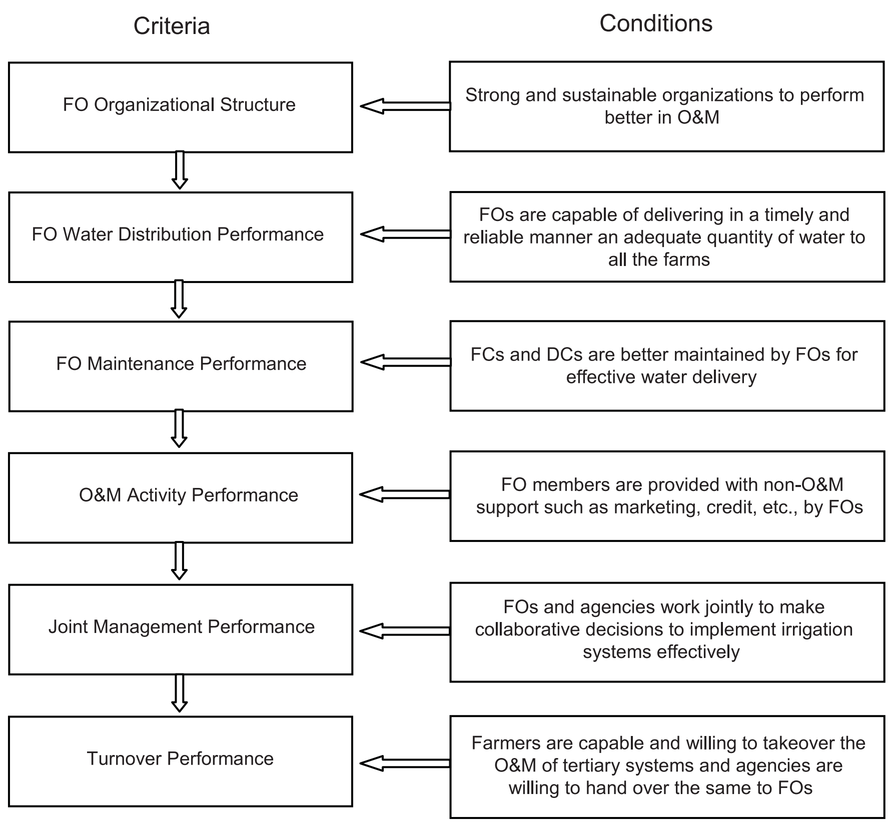
FO organizational strengths	FO water distribution performance	FO maintenance performance	FO non-O&M activity performance	Joint-management performance	Turnover performance
Structure	Schedule preparation within Field Canal (FCs) and Distributory Canals (DCs)	FC cleaning / de-silting and structure repairs	Input coordination and supply	Seasonal planning	Turnover of operations (FCs, DCs, Branch Canals (BCs) and Main Canals (MCs)
Membership	Operations within FCs and DCs	DC cleaning / de-silting and structure repairs	Crop storage and trading	Maintenance planning	Turnover of maintenance (FCs, DCs, BCs and MCs)
Leadership	Problem resolution	Preventive measures	Credit providing	Monitoring of system performance	-
Funding	-	-	Other income generation activities	Problem solving	-
Financial Management	-	-	Sponsoring community rituals and activities		-
Use of Funds	-	-	Provide community facilities		-
Internal Communication	-	-	Sponsoring activities for special groups (women, youth etc.)		-

Relevance of the Criteria and Indicators Developed for Assessing PIM

The main purpose of the criteria and indicators developed was to apply them in assessing the degree of achievement in the objectives of PIM. The government expected the achievement of two primary objectives from PIM policy when it was formally passed in 1988 in a cabinet paper. These primary objectives were to improve the productivity of irrigation systems and the reduction of government costs of the routine O&M of irrigation system management. The government expected to achieve these two objectives by enhancing farmer involvement/ contribution in irrigation system management and also implementing strategies for both farmers and irrigation managers to work together in the planning and implementation of irrigation management functions in the systems.

The indicators under each criterion have a logical sequence to measure the effectiveness of different components of the PIM model in achieving enhanced performance of irrigation system management. The usefulness of the six criteria applied for the assessment is depicted in Figure 1.

Figure 1. Criteria and indicators used to assess the combined impact of PIM.



Historical Development Process of Participatory Irrigation Management

Participatory irrigation management (PIM) that was formally accepted as a policy in 1988 has a long history. The small irrigation systems (small tanks and anicut systems) were originally constructed by communities as a reliable source of water for their agricultural land as they are completely dependant on rainfall. Therefore, small irrigation systems can be regarded as farmer-managed systems historically. Even the major irrigation systems constructed by ancient kings had some farmer involved management systems. This is because water distribution in canals cannot be done without the participation of farmers.

The Government of Sri Lanka after independence attempted to intervene in irrigated agriculture system to enhance its productivity. The series of government interventions later became the participatory irrigation management policy accepted by the government by a cabinet paper in 1988. All the major historical events had a basis for their government-sponsored implementation, whether such a basis was due to political or economical reasons. The major events leading to changing irrigation management are summarized below.

The Historical Events from 1958 to Date

The Paddy Land Act, No. 1 of 1958 established cultivation committees replacing the traditional 'Velvidane System'. This committee consisted of elected farmer representatives and was responsible for the resolution of land disputes, coordination of rice cultivation activities and distribution of water. Irrigation committees were established in irrigation schemes. The 'Velvidane' (normally a land owner) was elected in each village tank system by cultivators. The village headman arranged a meeting with cultivators to elect the Velvidane. He was mainly responsible for water distribution, maintenance and conflict resolution. The role of the Velvidane existed from ancient times and was abolished in 1958. However, after 1958 up to recent times farmers unofficially accepted this position for water management in small irrigation systems.

The Agricultural Productivity Act of 1972 abolished cultivation committees and established agricultural productivity committees.

The Agrarian Services Act of 1979 established agrarian services committees with the Cultivation Officer to be responsible in cultivation matters at the village level. These committees comprised farmer representatives and government officials. Velvidanes at the local level assisted Cultivation Officers to perform water management tasks in small irrigation systems.

The Gal Oya Left Bank Rehabilitation Project was implemented during 1979-1982 to rehabilitate the physical system, but it recognized the need for farmer participation. The Cornell University and Agrarian Research and Training Institute (ARTI) developed a model for a federation of farmers' organizations at district hydrological areas. Institutional Organizers (IOs) were employed to help farmers to form FC groups, DC organizations and project management committees.

Mr. N. G. R. De Silva, the Deputy Director of Irrigation in charge of the region of Kandy rehabilitated the irrigation system in Minipe, and also set up water management committees to increase farmer participation in decision-making. Farmer representatives were selected for these committees. Also a non-governmental organization, National Heritage Program (NHP) and influential local persons were used to educate farmers about the importance of farmer participation.

Mr. A. M. S. S. Gunadasa, Technical Assistant of the Kimbulawana Oya Scheme, employed farmers to engage in rehabilitation activities. He also prepared a rotation system to save water and implemented it with farmer participation. A Water Issue Board was set up to prepare water allocation schedules and farmer representatives were active members in this committee.

During 1983 to 1986, several rehabilitation projects were implemented in the country, which encouraged farmer participation in rehabilitation work and then in post rehabilitation O&M work. Two significant rehabilitation projects included the Major Irrigation Rehabilitation Project (1983) and the Irrigation System Management Project (1986). The Mahaweli Agriculture and Rural Development Project (MARD) was also commenced in System B of the Mahaweli Project and catalysts designated as Irrigation Community Organizers (ICOs) were employed to develop farmer organizations.

In April 1984 the Irrigation Management Division (IMD) was established for the implementation of the Integrated Management of Major Agricultural System (INMAS) in 25 major irrigation systems. A batch of Project Managers was trained and stationed in each system to form farmer organizations and project management committees. In 1987, management of Irrigation System (MAINS) similar to INMAS in terms of objectives was implemented by the ID to establish farmer organizations and project management committees in about 175 medium systems. Technical Assistants were appointed as Project Managers.

The Government of Sri Lanka formally approved and accepted the policy for participatory irrigation management by a Cabinet Paper in 1988. The turnover of O&M responsibilities and transfer of ownership of irrigation canals and structures to farmer organization were accepted as major objectives.

In 1990, the Irrigation Management Policy Support Activity (IMPSA) was initiated by the Ministry of Land and Land Development in association with the Ministry of Agriculture and International Irrigation Management Institute (IIMI as IWMI was known as at that time) to prepare strategies and guidelines for the implementation of the PIM policy approved by the government. In 1991 the Agrarian Services Act was amended to grant legal recognition to farmer organizations. In 1992 under the National Irrigation Rehabilitation Project, the management of irrigation systems was handed over to farmer organizations after physical rehabilitation. Farmers were also involved in planning and implementing O&M activities in addition to their labor contributions. The Irrigation Ordinance was amended in 1994 to grant more power and responsibilities to registered farmer organizations including the management of distributory canal areas in major schemes and collection of O&M fees.

Performance of PIM in Sample Irrigation Schemes Studied

Pre and Post Irrigation Management under Participatory Approach

PIM has brought significant changes to irrigation management and some changes have been institutionalized with the effect that the need for farmers to participate in irrigation management has become a 'must' in irrigation management. Most of the essential functions in irrigation management are managed differently in the participatory system. The changes occurred as a result of PIM are in Table 2.

Table 2. Comparison of pre-participatory management and participatory management systems.

Management Function	Pre-participatory Management	Participatory Management
1. Seasonal planning	Done by agencies and ratified at 'Kanna' meetings	Done by Project Management Committees
2. Operations planning	Done by agencies, basic plans ratified by 'Kanna' meetings	Done by agencies, basic plans ratified by PMCs
3. Head works, main canal, branch canal operation	Carried out by irrigation agencies	Carried out by irrigation agencies. Operation schedules are shared with joint-management committees
4. Distributory canal operation	Carried out by irrigation agencies	Carried out by FOs after turnover
5. Field canal operations	Carried out by irrigation agencies	Carried out by FOs
6. Head works, main canal, branch canal maintenance	Planned and carried out by irrigation agencies	Carried out by irrigation agencies in priority order determined by PMCs
7. Distributory canal maintenance	Planned and carried out by irrigation agencies	Planned and carried out by FOs after turnover
8. Field canal maintenance	Done by individual farmers under the direction of the irrigation agencies	Done by FOs

Government Initiated Programs for Achieving Participatory Management

Three different management systems have been introduced to manage irrigation schemes under the participatory approach, these include:

- The integrated management of major agricultural systems (INMAS), which was introduced in 1984 to manage major irrigation systems (irrigation schemes that have a command area greater than 400 ha) under the Irrigation Department. The Irrigation Management Division (IMD) created by the Ministry of Irrigation is responsible for the INMAS system in implementing about 35 irrigation schemes in the country.

- MANIS (Management of Irrigation System) introduced in 1986 by the Irrigation Department to manage the medium (schemes that have less than 400 ha of command) irrigation schemes of the country.

- The Mahaweli Participatory Management Program was established in different years in different schemes (for example, 1980 in system 'H', 1985 in Udawalawa, 1987 in system 'B'). There are four large irrigation schemes under the Mahaweli System (121,000 ha in total under four systems).

The objectives of PIM tested in all these three systems are more or less similar. The short- term and long-term objectives of the PIM are summarized in Table 3.

Table 3. Objectives of participatory irrigation management.

Short-term	Long-term
Increase agricultural production per unit of irrigation water	Integrated development of the farms to commercial holdings
Increase agricultural production per unit of land	Crop diversification and rotation
Distribute irrigation water to farmers adequately and equitably	Social and economic development of the farming community
Arrange for the timely supply of agricultural inputs and sale of products	Improved marketing of agricultural produce and by-products
Organize and develop farmer organizations to facilitate farmer participation in management	Local processing of agricultural produce to semi-finished or finished products
Recover O&M costs from farmers in major irrigation schemes	Handing over to farmer organizations some management and operational functions of the system
Maintain irrigation systems at an optimum level of performance	
Identify major systems needing urgent rehabilitation	

Assessment of Irrigation Management under PIM

The performance of the major components of PIM is used as the basis for assessment. These components include farmer organizations, joint management committee systems and turnover of irrigation management to farmer organizations. It was assumed that greater performance of these components would be needed to contribute to the overall performance of the irrigation schemes and achieving the objective of the PIM system.

Performance of the Farmer Organizations

In almost all the sample irrigation schemes studied by IWMI and HARTI it was found that the farmers have been mobilized into Farmer Organizations. The structure prescribed by PIM (FC groups, DC groups, System-level FOs) has not been followed exactly in some of the irrigation schemes of MANIS. This was mainly due to the lack of inputs needed for MANIS schemes to help farmers organize in to FOs. The INMAS and Mahaweli irrigation schemes have separate organization units to deal with farmer organization whereas MANIS schemes are managed by technical assistants of the ID without other additional assistance. Even in the Mahaweli scheme, system-level farmer organizations have not been established, perhaps because such higher level organization don't require farmer organization given that the system level needs of farmers are handled by the system level joint committees. This may be the reason for INMAS irrigation schemes also neglected to organize farmers into system level organizations (system-level farmer organization (SLFO) were formed in 58 % of the schemes in INMAS and 20 % of the MANIS schemes).

Farmer Organization (FOs) Strength

A FO as an organization was established to support implementing irrigation management activities, and is assessed under farmer organization strength. Most of the FOs have been established under constitutions provided by the irrigation management agencies. The strength of FOs is measured through:

- Membership of farmers in FOs
- Leadership
- Income for FOs
- Financial management
- Internal communication

The participation of individual farmers as members and their active involvement of the farmer organization are essential factors for FOs to survive and function as effective organizations. Table 4 indicates the total number of farmers of the command area under each irrigation scheme of the three systems assessed in the study, the percentage of members, and the active members in the organizations. These data show the essential elements of these organizations if they are to be sustained as community-based organizations.

Table 4. Overall membership percentages.

Program	Farmers	Members	Percentage members %	Active members	Active members as	
					% of farmers	% of members
INMAS	10,483	7,709	74	4,399	42	57
MANIS AB	3,101	1,648	53	823	27	50
MANIS C	2,784	1,471	53	764	27	52
Mahaweli	7,230	5,118	71	3,146	44	61
Overall	23,598	15,946	68	9,132	39	57

Source: IIMI and ARTI (1995)

FO Leadership

Finding leaders committed and also acceptable to most of the farmer members is a difficult task according to the qualitative information collected in the study. Therefore, the farmer members tend to be satisfied with the available leaders who are prepared to work on a voluntary basis. Although most of the farmers have certain personal opinions in the survey they have expressed that they are satisfied with the voluntary leaders of FOs. For example, 82 % farmers interviewed in INMAS schemes, 75 % in MANIS, and 80 % in the Mahaweli scheme stated that they are satisfied with their leaders.

FO Financial Management

Most of the FOs except a few organizations in the Mahaweli scheme had small FO funds. It was discovered that in all the schemes, there was always a considerable percentage of FOs that had no funds in their bank accounts. For example 80 % of the FOs in the INMAS, 90 % in MANIS and 95 % in the Mahaweli scheme were reported as organizations having some funds in their bank accounts. The average funds available in the FOs of irrigation schemes in the three programs ranged from Rs. 5,000 to Rs. 40,000.

Nearly 80 % or more of the FOs collected membership fees. But only less than 50 % of the FOs earned money from the construction contracts that were undertaken. Majority of general farmers expressed in the survey that they are satisfied with the method applied for managing funds. This high-level of satisfaction is due to two reasons: the money that each individual farmer contributes for the FO fund is small, and they appreciate the volunteer work done by their fellow farmers. More than 80 % of the individual farmers mentioned that their organizations keep books and follow other rules of financial management.

Internal Communication

In the INMAS and Mahaweli systems more than 75 % of the farmer organizations held monthly meetings with their committee members, while 47 % did so in the MANIS system. Most of the farmer leaders reported that they have a lower number of general farmer meetings. The general farmer meetings are held when there is a conflict between farmers. Only about 10 % to 32 % of farmer leaders mentioned that they hold general meetings. In the MANIS system, only about 15 % or less hold their general meetings.

FO Performance in Water Distribution

Farmer organizations play a critical role in water distribution at the DC level of all the irrigation schemes. The results of the study indicate that farmer involvement is much more relevant and essential in irrigation schemes where water is a scarce resource. The water distribution problems are due to five different reasons according to the study. These reasons and their magnitude in sample schemes studied are shown in Table 5.

Farmer organizations as an institution established by irrigation managers with the willingness of the farmers have become an essential element for water distribution. Nearly 74 % of irrigation officers who were interviewed in sample irrigation schemes categorically mentioned that farmer organizations are essential to manage water in irrigation schemes. However, there are some problems with the water distribution performance of the farmer organizations. This is due to the varying levels of performance of the FOs. The level of satisfaction of individual farmers with the performance of FOs in water distribution was measured by asking whether farmers are satisfied on the FO performance, and Table 6 includes the percentage of farmers who replied “yes” to several indicators of water delivery.

Table 5. Major causes of water distribution problems.

Program	Causes (See list below for Key)*					
	A	B	C	D	E	Other
INMAS	8 %	50 %	8 %	75 %	17 %	17 %
MANIS AB	45 %	82 %	27 %	91 %	36 %	27 %
MANIS C	29 %	71 %	14 %	43 %	21 %	50 %
Mahaweli	25 %	25 %	25 %	25 %	75 %	50 %

Source: IIMI and ARTI (1995)

Note: *Multiple answers mean that the numbers add up to more than 100 %. Numbers of sample schemes are: INMAS-12, MANIS AB-11, MANIS C-14, and Mahaweli-4

Key:
A- Inadequate water supply
B- Physical deficiencies in the system
C- Poor agency water distribution performance
D-Inadequate O&M funds
E- Poor farmer – officer cooperation

Table 6. Farmer organization water distribution performance - percentage of farmers answering "yes."

Location within FO Area	Stage of Season	Indicator	INMAS	Mahaweli	MANIS AB	MANIS C
Head	Crop Growth	Adequacy	85	92	78	36
		Timeliness	84	92	78	36
		Reliability	84	90	78	36
	Land Preparation	Adequacy	77	89	74	36
		Timeliness	74	89	74	36
		Reliability	75	92	74	36
Tail	Crop Growth	Adequacy	70	54	65	24
		Timeliness	61	65	65	24
		Reliability	62	70	65	24
	Land Preparation	Adequacy	64	51	57	28
		Timeliness	56	60	57	28
		Reliability	56	68	57	28

Source: IIMI and ARTI (1995)

FO Irrigation Infrastructure Maintenance Performance

The FO performance of irrigation infrastructure maintenance in general is poor according to the information generated by the study. Maintenance is difficult to organize with the voluntary participation of the farmers. If the canal becomes really constrained to take water to the agriculture fields, farmers are tempted to attend to the maintenance. Where such a critical stage has not been reached, it needs repeated attempts to mobilize farmers at least to clean the distributory canals (DCs). In INMAS schemes, only 33 % of the irrigation officials and, in MANIS, 20 % of the officials were satisfied with the FO performance in the maintenance of the canals that the FOs were supposed to oversee. Mahaweli officers indicated that they were satisfied with farmer participation in DC maintenance, but this may have been mainly due to Mahaweli Authority involvement in such maintenance. The officers' views on the impact of participatory management on tertiary canal maintenance are shown in Table 7.

Table 7. Impact of participatory management on system maintenance (officers' views).

Impacts	INMAS	MANIS AB	MANIS C	Mahaweli
Improved maintenance	42 %	75 %	50 %	25 %
Worsened maintenance	17 %	8 %	-	-
No change	33 %	17 %	29 %	25 %
No response	8 %	-	21 %	50 %

Source; IIMI and ARTI (1995)

Note: Irrigation department officers are of the opinion that 54–60 % of INMAS and MANIS irrigation schemes need additional funds for maintenance. In the other schemes, 40–46 % needs rehabilitation to improve the physical performance

Lack of farmer participation is a common phenomenon observed in DC maintenance. It is difficult to get 100 % farmer involvement in any event organized by the farmer organizations for DC maintenance activities. This is evident in the data collected from farmer leaders on the involvement of farmers in DC maintenance as shown in Table 8.

Table 8. Percentage of active participation of farmers in DC maintenance.

Participation percentage	Percentage of DCOs			
	INMAS	Mahaweli	MANIS AB	MANIS C
0 – 25	30 %	22 %	34 %	24 %
26 – 50	24 %	39 %	26 %	24 %
51 – 75	15 %	24 %	9 %	24 %
Over 75	31 %	14 %	30 %	28 %

Source: IIMI and ARTI (1995)

It was observed that jungle cleaning and de-silting of distributory canals are performed by FOs with the participation of the individual farmers, but minor repairs of the DCs are done by the FOs with the annual operation and maintenance funds provided by the government to each FO. There are some performance differences in de-silting and jungle cleaning, but it is at a satisfactory level according to the survey.

FO Performance in Non-O&M Activities

It was observed that FO performance in business activities to earn funds for FOs is at a poor level. Most of the FOs are involved in agriculture input sales to their members and also undertake operation and maintenance contracts from the government. Table 9 includes the results of the survey on the performance of FOs in undertaking non-O&M fund earning activities. Table 10 includes the information on percentages of FOs undertaking different contracts from the irrigation management agencies on DC maintenance and rehabilitation.

Table 9. Farmer organizations involvement in business activities.

Program	Total FOs responded	Yes		No	
		#	%	#	%
INMAS	60	27	45	33	55
MANIS AB	21	1	5	20	95
MANIS C	19	3	16	16	84
Mahaweli	63	14	22	49	78

Source: IIMI and ARTI (1995)

Table 10. Farmer organizations taking contracts from irrigation agencies.

Program	# of Sample FOs	FOs taking maintenance contracts (%)	FO taking rehabilitation contracts (%)	FOs taking both contracts (%)
INMAS	61	56	2	10
MANIS AB	24	29	8	8
MANIS C	24	42	0	8
Mahaweli	63	60	5	10

Source: IIMI and ARTI (1995)

Providing credit to farmers has been observed as an insignificant assistance provided by the FOs to the individual farmer members. Some FOs provide direct credit to their members and others act as guarantors for the farmers to obtain credit from banks and other organizations. The data in Table 11 indicate its insignificant nature in the sample farmer organizations.

Table 11. Farmer organizations providing credit assistance to farmers.

Arrangement	INMAS (N = 61)	Mahaweli (N = 63)	MANIS AB (N = 24)	MANIS C (N = 24)
Through FO	7 (11 %)	7 (11 %)	1 (4 %)	2 (8 %)
Guarantor of Bank loan	3 (5 %)	8 (12 %)	5 (20 %)	0
Guarantor of other loan	4 (7 %)	1 (1 %)	1 (4 %)	1 (4 %)

Source: IIMI and ARTI (1995)

Performance of Joint Management Committees

In all the irrigation schemes under the three programs, joint management committees or at least some arrangements for joint meetings have been established to provide a forum for different stakeholders and also to farmer leaders to meet together to discuss significant activities of cultivation programs in the particular irrigation scheme. These committees, especially project management committees, play a critically important role in the planning of cultivation seasons (seasonal planning) and also in the monitoring and evaluation of the cultivation program and also some other functions of irrigation management. Each irrigation scheme of the INMAS system has a 'Project Management Committee' comprising key stakeholder agencies and representatives of farmer organizations. This committee is organized by the project manager in IMD. The same structure can be observed in MANIS schemes although IMD is not involved in the management functions of the MANIS system, and technical assistants of the Irrigation Department act as the project managers in this system. Mahaweli has a three-tier Joint Management Committee (JMC) system. The JMCs have been established based on the Mahaweli management structure. The lowest level of the Mahaweli management structure is the unit and, therefore, unit management committees have been organized at the unit level. The second tier is block management committees established at administrative blocks of the Mahaweli management structure. A project management committee is the highest JMC that is based at the Resident Project Manger Level (Scheme Level).

The consultative seasonal planning procedure established by the joint management committees has led to two benefits to the farmers and also agency officers. The farmers benefited by voicing their concerns about the seasonal plans. The agencies benefited by learning from farmer experience for improved seasonal planning. The monthly meetings of JMCs have helped to give effect to the basic principals of participatory management such as frequent dialogue between stakeholders, learning from each other and seeking solutions jointly and effectively.

The JMC is not a management unit responsible for the performance of the system. JMCs can design plans and discuss various problems existing in irrigation systems, but the success in implementing these plans is heavily dependent on the performance of functional agencies and their officials. For example, the PMCs in INMAS can design various plans, but unless the Department of Agriculture, the Irrigation Department, the Land Commissioners Department and the Irrigation Management Division play their relevant roles, these plans cannot be realized. On the other hand, farmer organizations also play a key role in implementing the decisions of JMCs. Some FOs become ineffective due to their inability to implement decisions in the field through the farmers. It can, therefore, be stated that the success of the JMCs in implementing plans is heavily dependent also on the strength of the FOs.

Turnover

Under the participatory management policy of the government, it is intended to turnover some of the system management responsibilities at and below the DC level to farmers. Before this became government policy, some attempts had been made to implement this policy informally in certain schemes such as Kimbulwanaoya and Minipe, through the efforts of a few enthusiastic irrigation officials. Turnover was later initiated in other schemes under the three programs that we studied, namely INMAS, MANIS and Mahaweli. The cabinet paper adopting this policy specially stated that those farmers who accept responsibility for the turnover under O&M for DCs will be exempted from paying of irrigation fees. The amended Irrigation Ordinance authorizes FOs to takeover the O&M of their areas and in return they are exempted from paying irrigation fees.

Turnover has occurred in the three study programs at various levels and in different forms. In the sample irrigation schemes that were studied, several categories of turnover have taken place under operation and maintenance. Operation of FC and DC gates and other main system level canals have taken place under operations and DC jungle clearing, de-silting, minor repairs, greasing and painting of structures and main canal level cleaning and de-silting have taken place under the maintenance category.

Slow progress is reported on turnover in the three programs we studied. Table 12 includes the information on sample FOs reported as turned-over and responsibilities turned over in the FOs.

Table 12. Responsibilities turned-over in LSS sample farmer organizations.

Program	Sample FOs	Turnover Cases	Responsibilities Turned-over (Cases)					
			A	B	C	AC	ABC	Other
INMAS	61	49	4	1	2	21	21	-
MANIS AB	24	9	2	1	2	-	2	2
MANIS C	24	5	-	-	3	-	2	-
Mahaweli	63	23	3	-	6	20	4	-

Source: IIMI and ARTI (1995)

Notes: Key A - Distributing water within the DC (FC gate operation)
B - Operating DC gates
C - DC jungle clearing and de-silting

At present the operation of FC gated and jungle clearing and the de-silting of DCs are the major activities taken over by FOs. Whether paid or not, farmers now clearly know that certain operating and maintenance responsibilities will be handed over to them. What is now necessary to decide on is how turnover can be continued so that both agencies and farmers will know what the goal of the program is.

The study found that water distribution has improved due to turnover and that DC and FC maintenance has not suffered from turnover. The study also found that farmers can affect turnover as long as the profitability of irrigated agriculture dose not fall. Full turnover would mean that FOs are given the full responsibility for O&M below the DC head or an equivalent point in systems without DCs. Full responsibility would include paying all of the cost, and there would be no subsidies beyond those provided in the O&M of the main system. The arguments in favor of full turnover include:

- Making farmers completely responsible for the maintenance of distributory canals and below, clarifies and simplifies responsibilities. At the moment, some FOs perform only the maintenance work they are paid for and others do not undertake repairs even if they are well within the farmers capability, and instead try to get the government to make the repairs. Once responsibilities are clarified, this would not happen.

- Complete turnover will make it possible for the agencies to focus their attention on the maintenance of the main system and may improve the sustainability of the systems as a whole.
- Complete turnover means that financing the maintenance of distributaries and below will not be subject to problems of public finance.

The current situation is unsatisfactory because some farmers continue to expect government assistance that is only intended to be partially provided. It has been found that full turnover in operation responsibilities for DCs and below to FOs would be possible, and even now it is taking place successfully in many irrigation schemes. The problem is maintenance. This evaluation suggests alternatives mentioned below to convey full turnover of responsibilities to FOs.

- Alternative 1 (low technical financial burden on farmers)
  - FOs would take complete responsibility for jungle cleaning and de-silting (except when the silt is exceptionally heavy) for both FC and DC. As pointed out, FOs are already doing this and farmers have come to accept it.
- Alternative 2 (low technical moderate financial burden on farmers)
  - FOs would take complete responsibility for jungle clearing and de-silting (except when the silt is exceptionally heavy) for both FOs and DCs
  - FOs would take responsibility for painting, greasing, etc.
  - FOs would take responsibility for small earth work repairs.
  - All other work, including heavy de-silting and major earth work would be the responsibility of the ID.
- Alternative 3 (moderate technical financial burden of farmers)
  - FOs would take complete responsibility for jungle clearing and de-silting (except when the silt is exceptionally heavy) for both FCs and DCs
  - FOs would take responsibility for painting, greasing etc
  - FOs would take responsibility for small earth repairs
  - FOs would take responsibility for simple structural repairs
  - All other work, including heavy de-silting, major earth work, and large or complicated structure repairs, would be the responsibility of the irrigation agency.

Participatory management policy has clearly succeeded in getting farmers much more involved in system management than they were in the past, apart from some of the MANIS systems that were studied that had been neglected by the irrigation agencies. However, turnover has not progressed as expected in two different ways:

- On the one hand, fewer than expected agreements have been reached in all the programs. Only the INMAS program has made much progress in achieving some form of turnover, although the MEA is now seriously trying to make turnover work. There has been very little progress in the MANIS schemes, although the NIRP mandated turnover in its post rehabilitation phase.

- On the other hand, full turnover has not occurred in any of the three systems and progress has stopped at a joint management stage. In particular, there is reluctance on the part of both agencies and farmers to have the full responsibilities for maintenance turned over to the FOs. Payments continue to be made by agencies for O&M activities to FOs that have taken over responsibilities, either informally or formally.

Evaluation of Key Indicators used for Measuring PIM Performance

As explained in the methodology, the performance of six aspects of PIM was measured using the scoring system that was developed. The details of the scoring system used for the assessment are shown in Annex 1. The intensive data collected using recurrent surveys and process documentation methods was used to calculate the scores obtained by sample FOs in different irrigation schemes under the three programs. The potential scores for each indicator area and the average scores, and also the range actually obtained by different programs studied, are summarized in Table 13. The scores obtained by each sample FO studied using recurrent survey and process documentations in the three programs are shown in Annex 2.

Table 13. Average indicator scores by program for RS/PD sites.

Indicator	Max Score	INMAS		MANIS		Mahaweli	
		Av.	Range	Av.	Range	Av.	Range
FO Strength	36	29.4	23-35	20.0	7-35	15.9	5-24
FO Water Distribution	20	15.3	9-18	8.3	4-13	12.8	5-15
FO Maintenance	19	10.2	7-13	9.3	5-14	9.0	5-10
FO Non O&M Activities	28	8.5	5-11	3.2	0-11	6.8	0-13
JMC Performance	15	10.4	8-12	4.8	3-9	12.5	12-13
Degree of Turnover	48	13.8	12-17	13.6	1-17	18.5	15-21

Source: IIMI and ARTI (1995)

Conclusions and Recommendations

The major conclusion is that, despite its partial failure to achieve some of the main goals, participatory management has clear benefits and should be continued and supported. Also, basic participatory management of formal multifunctional farmer organizations and joint management committees should be continued. At the end of the IMII/HARTI study a national workshop was held to discuss the study results and recommendations were made for strengthening PIM policy. It is found that most of these main recommendations are still realistically valid to improve the PIM in the present context.

Recommendation No.1

The IMII/HARTI team recommended that steps be taken to make government agencies dealing with agriculture more responsive and more supportive of farmer organizations and joint management committees. These steps include:

- Each agency should redefine the job descriptions of its officers to reflect the tasks and attitudes needed to provide explicit support for farmer organizations and joint management committees. This redefinition should make certain activities mandatory, including attendance at JMC meetings and providing technical assistance and advice to FOs and JMCs. In particular, the job descriptions of Technical Assistants/ Project Managers (TAs/PMs) in MANIS schemes should be redefined to ensure that the TAs/ PMs have the time and motivation to play their roles as 'Project Managers' effectively. (Workshop) An Inter-agency committee may be set up to redefine job descriptions.
- Intensive training should be provided to government officers in all relevant agencies about their roles and functions with respect to farmer organizations and joint management committees, and about the rights and responsibilities of the FOs and JMCs.
- In order to ensure that officers act in supportive ways, their performance in supporting farmer organizations and joint management committees may be made an explicit part of their performance evaluations.
- The government may make it a policy to support farmer organization and JMC decisions. This may mean delegating greater authority to local agencies so that they can respond effectively to JMC decisions. It also means that government officers should support farmer organization decisions against complaints from individual members.
- (Workshop) The Secretaries of Irrigation and Agriculture may issue a joint declaration of the participatory management policy. The policy should be widely publicized through various media.
- A major effort may be made to publicize among the farmers the rights and responsibilities of farmer organizations and joint management committees as defined in by-laws to the amended Agrarian Services Act and in the amended Irrigation Ordinance.
- (Workshop) Farmers should be consulted about any future amendments to the relevant legal acts.
- (Workshop) Regular monitoring and evaluation of the progress of the policy should be undertaken. An annual workshop may be held as a routine task to review the performance of the irrigation management policy activities.

Recommendation No.2

We recommend that catalyst efforts, farmer training, and other direct support activities for FOs and JMCs be continued. These efforts are needed for the following:

- Catalyst efforts are needed to facilitate the organization of farmers in schemes where no farmer organizations exist. Catalysts are also needed to assist agencies and farmer representatives in the creation of joint management committees in schemes where they do not exist (relevant to MANIS schemes).

- Catalyst efforts, training, and publicity should focus on educating all farmers, not just farmer organization leaders, about participatory management. Specific efforts should be made to educate farmers about organizational management, including handling finances, selecting leaders, etc.

- (Workshop) Training should be provided to the farmers at the appropriate time on the functions and responsibilities of the farmer organization during each stage (initial, joint management, and turnover) of farmer organizational development.

- (Workshop) When needs arise, farmer organizations should be encouraged to hire trained persons (e.g., bookkeepers and auditors) to carry out specific organizational management tasks.

- Widespread training about the technical aspects of irrigation should be continued.

- (Workshop) The relevant government agencies should make technical information on the irrigation schemes available to the farmer organizations.

- Where special problems exist, e.g., land tenure problems, support efforts should focus on finding solutions to those problems.

- Special efforts should be made to offer opportunities to farmer organizations to take up new businesses. One business that should be fully supported by the government agencies is paddy marketing. Government agencies should assist in establishing linkages to other relevant markets.

- Efforts should be made to prevent the development of dependency of the farmers on the catalyst agents as has been reported from some INMAS schemes. This can be done by constant monitoring of catalyst activities; catalyst should not provide direct services but only instruction, advice, and guidance. Catalyst assistance should be time-bound.

- (Workshop) Efforts should be made to mobilize other community members, such as teachers, *Grama Niladharies* and religious leaders in support of participatory management.

Recommendation No.3

We recommended that alternative organizational forms be developed for the various types of schemes for which the INMAS model is not appropriate.

- (Workshop) Farmer organizations should be organized on the basis of hydrological units whenever possible (mostly relevant to MANIS schemes).

Recommendation No.4

We recommend that the government clarifies the policy on turnover, including defining what powers and responsibilities will be turned over and how the government will continue to support irrigation services. We suggest that the following should be part of this clarification:

- Turnover should be publicly declared to be a fixed policy that applies to all FOs in all schemes. If necessary, it can be explained that this is an alternative to imposing the irrigation service fee mandated by law.

- (Workshop) To ensure an effective and united policy, both agriculture and irrigation should be placed under one ministry. Alternatively, the policy can be implemented and supervised by a unified secretariat under a board drawn from both ministries. These measures will ensure a unified policy.

- (Workshop) Funding for farmer organizations and turnover activities should be provided on a program basis to deal with the whole sector rather than on a project basis that deals with only a few schemes at a time.

- (Workshop) For turnover, farmer organizations must be formally recognized by the government; for this many farmer organizations need to be strengthened.

- (Workshop) The irrigation agency personnel in a turned-over scheme will be answerable to the Project Management Committee for that scheme.

- Operations of distributory canals and below, or equivalent portions of systems without distributory canals, should be turned over to farmer organizations as soon as the canals are repaired to make them operable.

- Operations of distributory canal head gates, branch canals, main canals and headworks should be turned over to appropriate level farmer organizations or joint management committees upon the request of the farmer organizations or joint management committees with the proviso that the farmer organizations or joint management committees take full responsibility for hiring, paying and supervising the necessary operating personnel. The exact details can be negotiated following a request from the relevant group of farmers to the Project Management Committee in each scheme.

- (Workshop) For operation of distributory canal head gates, it is suggested that they be jointly operated for a period of less than 5 years, following which operations should be handed over to farmer organizations.

- (Workshop) Farmer organizations should be made responsible for the safety of structures and protecting reservations from encroachments and damage.
- Jungle clearing and regular de-silting of DCs and FCs or their equivalents should be made the unambiguous sole responsibility of farmer organizations; no funds should be provided to farmers for this activity.
- The government should come to a decision about how much it is willing to subsidize other aspects of distributory canal and FC maintenance, including painting and greasing of metal controls, major and minor earthworks such as the repairs of scours and washouts, and repair of concrete and masonry structures.
- (Workshop) Once the basic decision about the obligations of farmer organizations and government are worked out at the national level, specific subsidies and subsidy levels should be worked out at the scheme level based on an assessment of needs. These subsidies can include salaries, equipment, operation funds and others.
- The mechanism for providing subsidies should be defined. There are several alternatives ranging from giving the irrigation agency full responsibility and the necessary funds to making the FOs responsible but giving them a simple annual cash grant may not be advisable
- The government should define a period of time by the end of which the transfer of responsibilities must be accomplished. No more than 5 years should be reqired, following the completion of needed repairs, to complete the transfer to FOs. During this period, a time of 'joint management' should be defined during which the agency officers supervise and assist the farmer organizations in undertaking responsibilities.

Suggestions for Monitoring the Policy in the Future

As a part of the study, the IWMI/HARTI team documented the monitoring and evaluation systems being used by the implementing agencies, interviewed managers about their information needs, developed indicators of key characteristics of farmer organization and joint management committee performance, and tested these in the field in an experiment in improved monitoring.

At present, the IMD uses the Monitoring, Evaluation and Feedback (ME&F) System. A major problem is that many FO office-bearers do not prepare the required monthly reports. The ME&F system has now been introduced in INMAS schemes. In the ID managed MANIS schemes various formal and informal initiatives are underway, the most important of which may be the establishment of Irrigation Management Cells (IMACs) in each range office; one of whose functions is monitoring institutional development activities. MEAs Institutional Development Unit (IDU) collects data and reports on various aspects of participatory management.

To help provide quantifiable measures for the purpose of monitoring and evaluating participatory management, the IIMI/ARTI team developed and tested a set of indicators for:

- FO (Farmer Organization) Strength
- FO Water Distribution Performance

- FO Maintenance Performance
- FO Performance In Non-irrigation Management Activities
- JMC (Joint-management Committee) Performance

These are given in Annex 1. Properly used, the indicators provide a reasonably accurate way to measure FO and JMC progress. To provide an objective way to evaluate the strength and performance of FOs before considering them for turnover, the study team suggested a first approximation of minimum acceptable percentage scores for turnover. These numbers can be refined over time as more experience is gained in rating FOs and JMCs.

The study team believed that the government should have an effective way of keeping track of the progress of FOs, JMCs and turnover. Based on these experiences and findings, they recommended:

1. The IMD could consider the idea that FOs will be interested in collecting data for themselves and for the IMD.

2. That the ID considers developing a recurrent survey-type monitoring program for MANIS schemes based in the IMACs.

Annex 1 - Detailed Criteria and Indicators for Measuring PIM

Table 1. Farmer organization strength indicator.

Feature	Conceptual Base	Performance	Outcome
Structure	0 = FO has no constitution or no clear structure 1 = FO has a constitution and a formal structure 2 = FO has both a constitution and a formal structure	0 = FO has no farmer approval for a constitution 1 = FO has farmer approval for a constitution	0 = Required characteristics of FO structure are not met 1 = Required characteristics are partially met 2 = Required characteristics are fully met
Membership	0 = No clear definition for eligibility 1 = There is a clear definition for membership		0 = Less than 50 % of potential farmers are active members 1 = Between 50 % - 75 % are active 2 = More than 75 % are active
Leadership	0 = No procedure or criteria for selecting a leader 1 = There is a procedure but no criteria 2 = There are both procedures and criteria	0 = Neither procedure nor criteria are followed 1 = Only procedure is followed 2 = Both procedure and criteria are followed	0 = Leaders are not selected by farmers 1 = Leaders are selected by farmers but not by majority of farmers 2 = Leaders are selected by majority of farmers
Funding	0 = No planned ways to raise funds 1 = Funds are raised in an adhoc manner 2 = Funds are raised mostly from agency allocations 3 = Funds are raised through a sustainable procedure	0 = FO has a poor funding position 1 = FO has a satisfactory funding position	0 = No funds 1 = Funds are primarily obtained from agency O&M allocations and contributions 2 = Funds are primarily obtained from membership levies 3 = Funds are obtained from contracts and other FO business activities
Financial management	0 = FO has no financial reporting or disbursement procedures 1 = FO has reporting procedures but no disbursement procedures 2 = FO has all needed procedures	0 = FO does not follow financial reporting and disbursement procedures 1 = FO follows financial reporting and disbursement procedures	0 = Funds management not reported to membership 1 = Funds management acceptable to some farmers 2 = Funds management and disbursements acceptable to most farmers
Use of funds	0 = No plans prepared to use funds 1 = Plans are prepared to use funds	0 = Funds are not used 1 = Funds are used for FO activities	0 = Use of funds brought no benefit to FO 1 = FO activities are diversified with the use of funds 2 = Stronger financial position through diversified activities

(Continued)

Table 1. Farmer organization strength indicator *(Continued)*.

Feature	Conceptual Base	Performance	Outcome
Internal communication	0 = No defined channel of communication 1 = Information passed through informal channels 2 = Regular channel is established through meetings	0 = No FO meetings held 1 = Meetings held irregularly 2 = Regular meetings are held	0 = No systematic information flow between farmers and FRs 1 = Information is passed mainly between FRs and DCO officers 2 = Systematic information flow between farmers and FRs

Note: For purposes of judging membership, 'potential members' is defined as all farmers (including renters and squatters) served by the distributory canal. The number of 'active members' is defined by asking the DCO officers to identity the member of 'active members' in their organizations

Table 2. Farmer organization water distribution performance indicator.

Activity	Responsibility	Performance
Preparation of schedules within DCs	0 = No schedules or scheduling done by agency 1 = Scheduling done by agency and FO 2 = Scheduling done by FO	0 = Scheduling done only after problems arise 1 = Scheduling done in time or as appropriate 2 = Scheduling done in time and as appropriate
Within FCs	0 = No schedules or scheduling done by agency 1 = Scheduling done by agency and FO 2 = Scheduling done by FO	0 = Scheduling done only after problems arise 1 = Scheduling done in time and as appropriate 2 = Scheduling done in time and as appropriate
Operations within DCs	0 = Schedules implemented by agency 1 = Schedules implemented by agency and FO 2 = Schedules implemented by FO	0 = There is disparity between head and tail in both adequacy and timeliness 1 = There is disparity only in timeliness 2 = No disparity in either adequacy or timeliness
Within FCs (for FCs, performance is scored only if water supply to FC is adequate and timely)	0 = Schedules implemented by agency 1 = Schedules implemented by agency and FO 2 = Schedules implemented by FO	0 = There is disparity between head and tail in both adequacy and timeliness 1 = There is disparity only in timeliness 2 = No disparity in either adequacy or timeliness
Problem resolution	0 = FO does not monitor and resolve problems 1 = FO resolves problems in an adhoc manner 2 = FO resolves problems through an established mechanism	0 = Less than 50 % of problems solved 1 = Between 50 % and 75 % of problems solved 2 = Over 75 % of problems are solved

Table 3. Farmer organization maintenance performance indicator.

Activity	Responsibility	Adequacy
FC maintenance cleaning/de-silting	0 = Done by agency 1 = Done jointly 2 = Done by FO	0 = Done poorly 1 = Done adequately 2 = Done adequately and on time
Structure repairs/ Preventive maintenance	0 = Done by agency 1 = Done jointly 2 = Done by FO	0 = Done poorly 1 = Done adequately 2 = Done adequately and on time
DC maintenance cleaning/de-silting	0 = Done by agency 1 = Done jointly 2 = Done by FO	0 = Done poorly 1 = Done adequately 2 = Done adequately and on time
Structure repairs/ Preventive maintenance	0 = Done by agency 1 = Done jointly 2 = Done by FO	0 = Done poorly 1 = Done adequately 2 = Done adequately and on time
Preventive measures	0 = FO has no rules for preventing cattle or other damage 1 = FO has rules but no enforcement means (relies on agencies) 2 = FO has both rules and enforcement means	0 = Rules not enforced properly 1 = Rules well enforced

Table 4. Farmer organization non-O&M activities indicator.

Activity	Level of Activity	Benefit
Income Generating and Financial Activities		
Input coordination and supply	0 = Not undertaken 1 = Coordination of information on needs 2 = Retail supply undertaken	0 = No income generated 1 = Mostly to those who undertake the activity 2 = Income accrues mostly to the FO funds
Crop storage and trading	0 = No activity 1 = Provide common storage facility 2 = Trade in crops	0 = No income generated 1 = Mostly to those who undertake the activity 2 = Income accrues mostly to the FO funds
Providing credit	0 = No activity 1 = Facilitate institutional credit 2 = Operate credit facility and facilitate institutional credit	0 = No income generated 1 = Mostly to those who undertake the activity 2 = Income accrues mostly to the FO funds
Other income generating activities	0 = No activity(s) 1 = Facilitate individual farmers to undertake activities 2 = Operate additional business(es)	0 = No income generated 1 = Mostly to those who undertake the activity 2 = Income accrues mostly to the FO funds
Non-income Generating Activities		
Sponsor community rituals and activities	0 = No activity 1 = FO activities only 2 = Other community activities as well	0 = None 1 = To FO only 2 = To wider community
Provide community facilities	0 = No activity 1 = Provided community hall only 2 = Provided several facilities	0 = None 1 = To FO only 2 = To wider community
Sponsor activities for special groups (women, youth etc.)	0 = No activity 1 = Activities for one group 2 = Activities for two or more groups	0 = None 1 = To local community only 2 = To wider community

Table 5. Joint management committee performance indicator.

Activity	Performance	Decision-making	Outcome
Seasonal planning	0 = JMC does not undertake seasonal planning 1 = JMC undertakes seasonal planning	0 = One-sided (officer or FR) decisions are taken 1 = Participatory decisions are taken	0 = JMC plans ignored 1 = JMC plans partially implemented 2 = JMC plans implemented without change
Maintenance planning	0 = JMC does not undertake maintenance planning 1 = JMC undertakes maintenance planning	0 = One-sided (officer or FR) decisions are taken 1 = Participatory decisions are taken	0 = JMC plans ignored 1 = JMC plans partially implemented 2 = JMC plans implemented without change
Monitoring of system performance	0 = Progress/performance occasionally discussed at JMC meetings 1 = Progress/performance always discussed at JMC meetings	0 = One-sided (officer or FR) decisions are taken 1 = Participatory decisions are taken	0 = No actions are taken in response to discussion 1 = Actions taken in response to discussions
Problem solving	0 = JMC does not try to solve problems 1 = JMC tries to solve selected problems; others are forwarded to agencies 2 = JMC tries to deal with all problems	0 = Only one party, agency or FRs, tries to solve problems at JMC meeting 1 = Both parties jointly attempt to solve problems	0 = No actions are taken in response to discussion 1 = Actions taken in response to discussions

Table 6. Degree of turnover indicator.

Activity	Planning (decision making)	Implementation
Operations		
On FC	0 = Operation decisions taken by agency 1 = Operation decisions taken jointly 2 = Operation decisions taken by FCGs (FO)	0 = Implemented by agency 1 = Implemented jointly 2 = Implemented by FO
Among FCs	Same scoring as above	Same scoring as above
On BC (DC gates)	Same scoring as above	Same scoring as above
On MC/headwork	Same scoring as above	Same scoring as above
FC Maintenance		
• FC cleaning	0 = Maintenance decisions are taken by agency 1 = Maintenance decisions are taken jointly 2 = Maintenance decisions are taken by FO	0 = Implemented by agency 1 = Implemented jointly 2 = Implemented by FO
• FC de-silting	Same scoring as above	Same scoring as above
• FC structure repairs	Same scoring as above	Same scoring as above
• FC earthwork	Same scoring as above	Same scoring as above
DC Maintenance		
• DC cleaning • DC de-silting • DC structure repairs • DC earthwork	Scoring same as for FC maintenance	Scoring same as for FC maintenance
BC Maintenance		
• BC cleaning	0 = Maintenance decisions are taken by agency 2 = Maintenance decisions are taken jointly 4 = Maintenance decisions are taken by FO	0 = Implemented by agency 2 = Implemented jointly 4 = Implemented by FO
• BC de-silting	Same scoring as above	Same scoring as above
• BC structure repairs	Same scoring as above	Same scoring as above
• BC earthwork	Same scoring as above	Same scoring as above
MC Maintenance		
• MC cleaning • MC de-silting • MC structure repairs • MC earthwork	Scoring same as for BC maintenance	Scoring same as for BC maintenance

Annex 2

Table 1. Indicator values of evaluated FOs.

Programme	Scheme	FO	A	B	C	D	E	F
Maximum possible scores			36	20	19	28	15	48
INMAS	Devahuwe	Peramuna	32	16	12	11	11	15.5
	Devahuwe	Ekamuthu	32	16	12	11	0	15.5
	Kaudulla	CP Pura Perakum	33	18	12	11	11	17.0
	Kaudulla	Eksath	33	18	12	11	0	16.8
	Meeoya	Perakum	24	17	11	6	12	17.0
	Muthukandiya	Village 3	27	10	8	8	9	12.8
	Muthukandiya	Village 6	25	10	8	8	0	12.8
	Muruthawela	Pahala Perakum	23	9	7	6	8	13.2
	Muruthawela	Thisara	23	9	7	6	0	13.2
	Rajangana	Ranketha	35	18	13	11	12	17.2
	Rajangana	Navajeewana	35	18	13	11	0	17.2
	Thabbowa	Perakum	31	15	9	5	10	11.8
	Thabbowa	Thenuwara	31	15	9	5	0	11.8
MANIS	Ambewela	Thennakoonwela	22	10	11	2	6	13.2
	Buththala	Medagamaela	24	9	11	3	6	13.2
	Gampola Rajaela	Kurukude Ekamuthu	8	7	8	0	4	12.8
	Komarikaela	Kanugolla	35	13	14	11	3	17.2
	Maela	Ekamuthu	20	4	7	2	6	13.5
	Mahanneriya	Mahananneriya	16	8	9	0	3	12.5
	Mannankattiya	Siri Parakum	7	6	5	4	6	16.5
	Mediyawa	Mahasen	18	7	8	2	3	11.0
	Murapola	Girambe Kolabissa	19	8	8	2	6	13.8
	Radagalpotha	Radagalpotha	21	8	8	2	0	12.5
	Wennoruwa	Wilgoda	31	11	13	7	9	13.2
Mahaweli	System C	Hungamalagama	24	15	9	13	13	19.0
	System C	Diyaviddagama	21	15	9	13	0	19.0
	System C	Serupitiya	8	13	10	2	0	17.5
	System C	Pahalarathkinda	17	15	10	10	0	18.5
	System H	D3/D4/421	24	13	10	10	12	21.0
	System H	D4/ 204	5	5	5	0	0	15.0
	System H	D1/313	13	13	10	5	0	20.0
	System H	D2/101	15	12	10	1	0	19.0
	System H	D3/305	16	14	8	7	0	17.5

Note: Key – A = FO strength, B = FO water distribution, C = FO maintenance, D = FO non-O&M activities, E = Joint management committee performance, F = Degree of turnover

Irrigation Infrastructure Management by Public Funds: How It Can Be Made Justifiable

Namalee Madawalagama (engineer) and Badra Kamaladasa (engineer)
Irrigation Department, Colombo, Sri Lanka

Introduction

About 80 % of the paddy production is being done under major and medium irrigation schemes in our country. Investment for irrigation development is considered to be the responsibility of the government, especially in a welfare state like Sri Lanka. Once constructed, the responsibility of operation and maintenance (O&M) of these schemes is also shouldered by the government. Subsidies such as fertilizer and seed paddy or a guaranteed price for paddy are arranged by the government from time to time to attract farming communities for agriculture or sometimes to attract votes. But, there is a concealed value in all these subsidies. When also considering the input of other agrarian services, a colossal sum of funds is diverted for the survival of irrigated agriculture.

This paper aims to compare the actual annual fund requirements and the available funds to operate and maintain an irrigation scheme. The Huruluwewa Irrigation Scheme was selected to compare actual requirements and the expenditure within the scheme (Annex 1: Table 1 for details of Huruluwewa Irrigation Scheme). Funds received from various sources and the labor contribution by the beneficiaries to fill the gap between the actual O&M requirement and the funds received is also highlighted in the same scheme. The scheme also compares the financial inputs of the Mahaweli Authority of Sri Lanka (MASL) and the North Central Provincial Council, the other two major institutions responsible for the O&M of irrigation schemes.

Sustainability of an Irrigation Scheme

The medium and major irrigation schemes are operated and maintained by the Irrigation Department, MASL and the nine Provincial Councils. Their approach and financial commitment for O&M activities differs from one to another. The sustainability of an irrigation scheme wholly depends on the degree of maintenance and the nature of operations, especially flood operations attended by the owner and the beneficiaries. To have a properly maintained and correctly operated irrigation scheme, at least the following requirements must be fulfilled.

1. Tested and validated O&M manual
2. Regular inspection and identifying maintenance requirements

3. Identification of best suitable technical solutions as remedial measures
4. Accuracy of methods adopted and implementation
5. Availability of funds for inspection and implementation of remedial measures
6. Beneficiaries sharing the responsibilities of O&M

Factors 1 to 4 as mentioned above normally depend on the management systems adopted by various organizations. The Irrigation Department, MASL and Provincial Councils adopt different strategies. Availability of funds, which is normally channeled through the government budget, also varies from one organization to the other.

Position of Funds and Requirement by the System

The actual requirement, funds provided, subsidiaries and value of crops of the Huruluwewa Irrigation Scheme are discussed in this paper.

Operation and Maintenance (O&M)

The Huruluwewa Irrigation Scheme is located (at the coordinates 325,345 mN, 160,195 mE) in the Anuradhapura District. The irrigation engineer is responsible for the O&M as well as necessary improvements to be carried out in the scheme.

Technical Data of Huruluwewa Scheme (Irrigation Department 2007)

Extent in Acres	
Left bank sluice	3,200 acres
Right bank sluice	7,200 acres
Center sluice	27 acres
Tank Bund Length	2.37 km
Bund lop width	6.7 m
Canals	
Main canal	31.6 km
Branch canal	5.0 km
Distributory canal	38.62 km
Field canal	168.25 km
Agricultural roads	178.8 km

Table 1. Gives the actual fund requirement for the O&M of the Huruluwewa Scheme for 2007.

The present practice adopted in most of the major and medium irrigation schemes under the purview of the Irrigation Department is that funds are provided only for O&M of head-works (bund, land roads and sluice as spill) and main and distributory canals. Operation and

Table 1. Actual requirement of funds for operation and maintenance of the Huruluwewa Scheme (Irrigation Department 2007).

Item	Description	Actual fund requirement (Rs.)
Operations of main system	Purchase of equipment, fuel and allowances for O&M staff	681, 230
Maintenance of main system	Head-works (clearing, removing of ant holes, applying grease to moving parts and painting, etc.)	179, 625
	Main canal and branch canal (clearing, de-silting, improvements to structures, greasing and painting of gates, improvements to agricultural roads)	772, 984
Sub-total	Operation and maintenance cost for head-works, main canal and distributory canal	1,633,839
	Operation and maintenance of downstream system from D-canal (see Table 2 below for details)	3,245,025
Total requirement		4, 878,864

maintenance of field canals and in some cases drainage canals is carried out by the farmer organization (FO) with their funds and labor. Only machinery and equipment required and a part of the funds needed are provided by the government. Table 2 shows the actual requirement and expenditure by various sources for the O&M of the field canal and downstream system in Huruluwewa.

Funds Provided by Government

DCB fund-(Contribution from scheme relevant district)
Rs. 325,000
Irrigation Department/Irrigation Management Division IMD
Rs. 2, 245,872
(Equipment charges are accounted here)
Sub-total = Rs. 2,570,872

Contribution from Farmer Organization and Farmers as Labor Input

Direct funds from farmer organizations	Rs. 1,013,079
Indirect contributions	Rs. 1,328,400
Sub-total	Rs. 2,341,479

This calculation shows that the FO (farmer organization) contribution (labor input and FO funds) in up-keeping the irrigation system is significant (about 72 % of total requirements in field canal (FC) maintenance). Nevertheless, this labor input is frequently ignored in financial analysis, due to difficulties in accounting.

Table 2. Requirement for operation and maintenance of field canals and the funds received from sources (Resident Project Manager – IMD (2007).

FC area and name of farmer organization	Estimate (actual requirement) Rs.	Financial or labor contribution (Rs.)				
		ID funds	IMD	FO funds	Shramadana funds	Provincial council/ District fund (DCB)
Meegahapattiya FO	266,766	Equipment	31,517	166,859	68,800	
Gomarankalla FO	127,621	Equipment	39,667	47,977	48,800	
Yaya 05 FO	144,005	Equipment	42,896	32,100	76,000	
Galenbidunuwewa FO	187,266	Equipment	30,518	81,749	75,000	
Ulpathgama FO	95,000	Equipment	30,140	29,600	41,600	
Yaya 06, 21 Janapada FO	161,685	Equipment	34,770	51,600	80,400	
D11 Dutuwewa FO	136,700	Equipment	44,690	26,600	70,400	
D12/13 FO	177,689	33,818	44,742	81,100	110,800	
Kokawewa FO	410,077	Equipment	42,652	15,400	106,400	250,000
Gettalawa Udara FO	258,284	Equipment	63,999	82,600	127,600	
RB Yaya 06, Ekamuthu FO	141,495	Equipment	15,250	80,600	46,000	
Janasirigama FO	230,982	Equipment	22,509	47,073	86,400	75,000
Huruluwewa Nikawewa FO	202,186	Equipment	48,229	29,600	126,000	
Padikaramaduwa Mahasen FO	94,622		15,378	36,900	40,800	
Padikaramaduwa Gemunu FO	214,841		34,143	91,600	940,00	
Kivulekada FO	250,332		32,012	101,600	120,000	
Aluthdivulwewa FO	87,123		14,252	32,600	42,400	
Total	3,245,023	33,818+ equipment charge	578,544	1,013,079	1,328,400	325,000

Improvements, Repairs and Preventive Maintenance

The above figures give only an idea about the funds required for essential annual O&M required to up-keep the irrigation systems at their minimal service condition as identified in the ‘O&M Plan’. In addition to this, requirements for improvements, modifications, flood-damage repairs and preventive maintenance are also identified by the O&M staff and need to be accounted for. Meeting such requirements is the responsibility of the Irrigation Department.

Estimates thus prepared for improvements and repairs of the Huruluwewa Scheme for 2007 and allocations made available are tabulated in Table 3 below.

These figures show that due to limited availability of funds, general improvements and immediate repairs cannot be attended to, as and when needed. Contribution from farmers for

Table 3. Actual amount needed for improvements and repairs and available funds.

Item	Estimated amount (Rs.)	Funds available(Rs.)
Improvements to the main system	1,315,000	Nil
Preventive maintenance	1,927,000	176,515
Irrigation water management	2,891,700	370,100
Improvements to head works	1,806,500	Nil
Improvements to agricultural roads	1,490,000	Nil
Repairs following flood damage	400,000	Nil
Total	9,830,200	546,615

Source: Irrigation Department 2007

improvements and repairs (for the work beyond FCs) cannot be expected as their income is marginal. Delays in attending to repairs and improvements eventually lead to more damages and an increase in demand for funds for maintenance of the schemes, and ultimately culminate in a need for rehabilitation earlier than the guaranteed life span of the systems. Although these figures only relate to the Huruluwewa Irrigation Scheme, they reflect the real situation of most irrigation systems.

Fertilizer Subsidies

The government provides fertilizer for paddy at a low price (less than one-third of the actual cost) in order to encourage paddy farming. The Agrarian Services Department records indicate that the subsidy provided by the government for fertilizers during 2007 for farmers of the Huruluwewa Irrigation Scheme is as high as Rs.122 million.

Production

The value of production of the Huruluwewa Scheme in 2007 is depicted in Table 4 below.

Table 4. Value of production for two cultivation seasons in the Huruluwewa Scheme.

	Acreage cultivated (ha)	Production (kg)	Gross income (Rs.)
Maha (2006/2007)			
Paddy	4,345	3,059,000	97,900,000
Yala (2007)			
Paddy	745	524,500	16,800,000
Soybean	660	1,185,000	142,000,000
Maize	245	1,168,000	31,500,000
Vegetables	90		21,500,000
Total income			309,700,000

Source: Irrigation Department 2007

The above figures give only the direct income from production. When compared with government expenditure on O&M activities, which amounts to nearly Rs.3 million, the value of production of the scheme is very high. However, if the fertilizer subsidy, introduced recently (amounting to Rs.122 million), is included in the calculation, this picture changes dramatically.

Since the actual requirements of the annual O&M are not fulfilled, frequent rehabilitation requirements can be witnessed. Most of the schemes that have been recently rehabilitated show symptoms of deterioration demanding another round of rehabilitation earlier than the guaranteed life span of the system, while other systems are also in dire need of attention.

Comparison of O&M Costs among the Institutions

Three institutions are mainly responsible for the management of irrigation schemes namely, the Irrigation Department, MASL and Provincial Councils. Table 5 gives the estimated funds utilized for the O&M of irrigation schemes in these organizations where different types of technical and financial approaches are adopted. The summary of the average expenditure on the O&M of irrigation system per acreage by the three institutions are as follows:

Table 5. Average expenditure on O&M and improvement of the irrigation scheme by different organizations.

Institute	Name of scheme	Average expenditure Rs./Ac
Irrigation Department	Huruluwewa (Anuradhapura)	246
	Muruthawela Scheme(Hambantota)	212
Mahaweli Authority	Udawalwe Scheme	208
North Western Provincial Council (NWPC)	Mohariya Scheme	593
	Siyambalankotuwa Scheme	563
	Maha Karukkumaduwa Scheme	725

Sources: Irrigation Department 2007; MASL 2007; NWP 2007

There are several reasons for the high variation between the institutions.

- It can be observed that the NWPC spent a considerably higher amount of funds on the management of irrigation schemes, which included expenditure on improvements.
- Active, well-established and financially sound farmer organizations exist in major and medium irrigation schemes and their active participation in O&M is higher.
- After launching programs to improve system performance through farmer participation, farmers are well aware of their responsibilities for safeguarding schemes for their benefit and, hence, their participation is high. The FOs in major and medium irrigation schemes managed by the ID and MASL are performing better in O&M than the FOs in Provincial Councils.

Conclusions

The contribution to the national economy by an irrigation scheme is much higher than the investment in O&M by the government. Inputs from farmers for O&M are also significant in major and medium irrigation schemes where well organized farmer organizations exist. The pattern of expenditure by various government organizations on O&M does not vary much (except O&M expenditure by Provincial Councils). Frequent rehabilitation requirements arise due to the failure to attend to repairs in a timely manner and inadequate maintenance due to the lack of funds. If the government can increase input for O&M, the rehabilitation costs will become less. It is necessary to review the investment on fertilizer subsidy as it has made a significant change to the cost-benefit balance of irrigation systems.

References

Agrarian Services Department. 2007. Internal Documents.

Assets Management Branch. 2007. Irrigation Department Internal Documents.

Irrigation Engineer's Office (Huruluwewa). 2007. Internal Documents.

North Western Provincial Council. 2007. Internal Documents.

Resident Project Manager's Office. 2007. Report on Operation and Maintenance Program for 2007 – Huruluwewa Irrigation Scheme.

Resident Project Manager's Office, Udawalawe Area. 2007. Internal Documents, Mahaweli Authority of Sri Lanka.

Annex 1

Table 1. Details of three irrigation schemes on O&M

Technical data, allocation requirement and expenditure on operation and maintenance of irrigation schemes by three institutions

	Irrigation Department			Mahaweli Authority	Provincial Council – North-West		
	Huruluwewa	Muruthawela	Uma Ela	Udawalawe	Mohariya	Siyambalan-kotuwa	Mahakumbukkada-wala
Extent (acres)	10,427	4,426	2,004	22,432	270	774	250
Bund							
Bund length (km)	2.37	1.464	0.214	4	2.75	1.5	1.82
Max bund height (m)	37.5	31.5	12.2	36.6			
Canal							
Main canal							2
Nos.	3		1	2	2	3	2.6
Total length (km)	31.6	14	16	125	2.4	6.9	
Field canal			(85 TOO)				
Nos.			Non		7	40	4.94
Total length (km)	211.87	123.6		1,350	2.5	6.78	
Agricultural roads							
Nos.				(data Not	2	4	2
Length (km)	178.8	40	10	available)	1.9	4.0	4.9
Estimate for O&M	4,878,862	1,605,221	1,809,680	13,838,000	200,000	621,467	212,321
Expenditure	2,570,872	939,000	865,485	11,172,000	160,040	435,492	181,418

Policy Alternatives for the Management of Minor and Medium Irrigation Schemes to Develop Groundwater Systems in Restricted Catchments for the Improvement in Food Productivity in the Dry Zone of Sri Lanka

S. S. Sivakumar
Civil and Water Resource Consultant Engineer

Introduction

Agriculture continues to be one of the largest sectors in the economy of Sri Lanka, accounting for 18 % of the gross domestic product (GDP), 35 % of total employment and more than 20 % of exports. It is the main source of livelihoods for the rural population, which accounts for 70 % of the population. Past agricultural policies of the country were directed towards self-sufficiency in rice, and presently production exceeds the requirement and is expected to increase from 2.6 million metric tonnes to about 3.33 million metric tonnes in the next 25 years with the increase of the population (Sivakumar 2002b).

Status of the Agriculture Sector

The important factor to consider in the agriculture sector is the low farm incomes due to low productivity, especially in irrigation schemes. Recent studies reveal that in some irrigation systems, less than 50 % of the family income is derived from irrigated agriculture and a greater part of the family income is derived out of non-agricultural activities. Furthermore, it was revealed that, 10 acres of irrigated agriculture has to ensure at least 250 person-days of employment to be the major source of income of farmers. In order to overcome this situation it is required to improve irrigation water availability economically (Sivakumar 2002a).

Probably the most profound challenge facing world agriculture today and in the foreseeable future is how to produce more food with less water. The primary challenge in the water sector of developing countries is, and will be, how to cope with rising competition for water among multiple stakeholders in ways which are equitable, efficient and sustainable. Recent research in Sri Lanka (Shanmuganathan 2004) has shown that most of the dry-zone districts are also facing serious water scarcity, which will worsen over time. Sri Lanka is already the fourth driest Asian country on a per capita basis, and has very high rainfall variability. Therefore, the global concerns about water scarcity do apply to this country also.

Status of Food Production and Water Resources

Food scarcity is a pressing problem in many countries. The problem, however, is particularly serious in less developed countries with low agricultural production combined with a fast growing population. To meet food requirements, efforts should be made to increase food production at least several times over the present supply. This can be done by the use of better viable and vigorous seeds, development and cultivation of new improved crop varieties, use of proper fertilizers, pesticides, and herbicides, better on-farm water management, better use of agricultural implements, provision of extension services, strengthening of the existing institutions and introduction of new socioeconomic, legal and organizational support to improve productivity. Proper economic management of water, however, is of overriding importance in the production of food. The success and efficiency of most other measures are dependent on the quantity, quality and timing of the irrigation water supply, the way it is used, and the degree of control over it (Sivakumar 2001a). Water is critical to the web of life, but at the same time, it is a limited resource in many areas of the world. Proper economic management of this scarce resource is essential for the improvement and sustainability of food production.

Water Scarcity

The human race through the ages has striven to locate and develop fresh water, being one of the basic necessities for subsistence of life. Over 90 % of liquid fresh water available at any given moment on the earth lies beneath the land surface. Groundwater, unlike surface water, is available in some quantity almost everywhere that man can settle in; is more dependable in periods of drought; and has many other advantages such as the fact that it is directly consumable; that it requires less investment than surface water; and that it has a readily absorbable high nutrition content for crop production.

The need to stabilize agricultural production in Asia, where over 40 % of the area is drought-prone, translates to the need to promote the speedy development of groundwater resources. Even in areas where there are surface water supplies available through major, medium and minor irrigation projects, groundwater is playing an increasingly vital role in supplementing surface water (Nagaraj and Dewan 1972). The importance of the role of groundwater to meet water supply requirements for domestic, rural, urban, industrial and agricultural use needs no emphasis. The increasing demand placed on it has stimulated investigations directed towards the quantification of the resource, which is basic for the formulation of plans for its exploitation, management and conservation (Sivakumar 2001b).

Irrigation holds a special place in the water scarcity debate, as it uses more than 70 % of the world’s total water supply, while in Sri Lanka about 96 % of annual freshwater withdrawal is used for agriculture. Sri Lanka is the world’s second highest user in terms of percentage of population, among others in utilizing fresh water withdrawals for agriculture (Ilampooranan 1993).

The Need for Research

The much-needed water for agriculture sectors in dry and intermediate zones, which covers about two-thirds of Sri Lanka, has to come from water available for irrigation, while meeting the challenge of increasing food production. Opportunities available for further expansion of irrigated lands in the country are very slim (Sivakumar 2009). Introduction of other food crops (OFCs) is economically feasible to overcome this problem. There is a wide gap between OFCs planned and accomplished in completed projects. Where paddy and OFCs are cultivated, the availability is always tied to paddy cultivation and this compels OFC growers to produce to the glut created by rain-fed cultivators thus reducing profits (Sivakumar 2008). The absence of a proper mechanism to compensate those who switch to OFCs compels others to grow paddy. Hence, clear scientific justification is needed to address the problem through an in-depth research supported change of policy to reduce the pumping cost of OFC cultivation by raising the water table. The water table can be raised by foregoing a certain percentage of paddy cultivation and keeping some percentage of water in irrigation schemes exclusively for recharging groundwater.

Research Objective

Research was carried out to address the acute problem of water scarcity and to spell out an operational policy for conserving surface water. The objective was to reduce the use of surface water for paddy cultivation under minor and medium irrigation schemes and to increase the extent of OFC cultivation using groundwater. Also, to create an artificial boundary to lift the water table and reduce the pumping cost of irrigation so that OFC could achieve the optimum crop yield.

Research Methodology

The methodology of this research uses a complete water balance study in a restricted catchment area incorporating a few medium irrigation schemes, several minor irrigation schemes and a large number of dug wells to illustrate the:

a) Development of a model to represent all the relevant variables connected with the movement and utilization of surface and groundwater

b) Usage of the above model to study the viability of conserving surface water by storing groundwater; and reducing the extent of paddy cultivation that relies on surface water; and increasing the extent of OFC cultivation using groundwater to achieve optimum crop yield

c) Economic viability of achieving optimum crop yield as in (b)

d) Creation of an artificial aquifer boundary to optimize the effectiveness of groundwater use to achieve optimum crop yield

e) Economic viability of the creation of a artificial boundary in terms of productivity

f) Increased crop production by combining both (b) and (d)

g) Economic viability of achieving optimum crop yield as in (f)

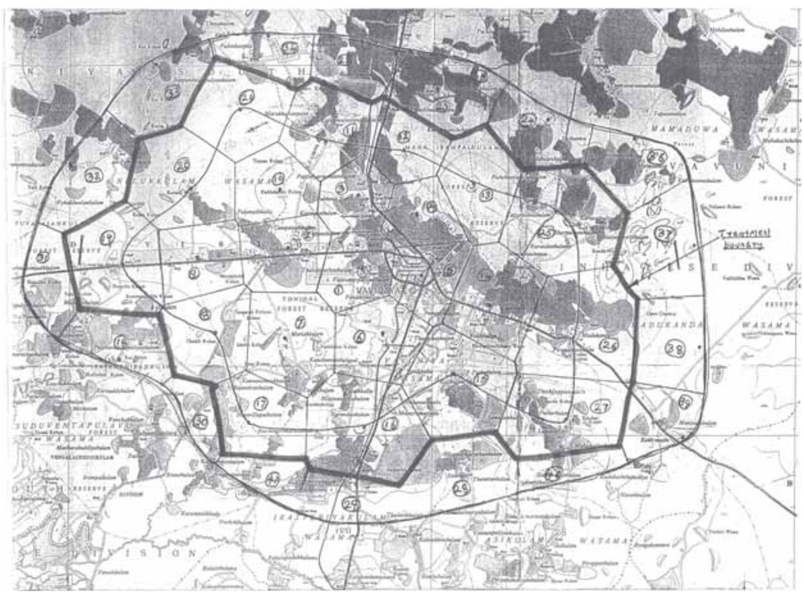
Many field experiments conducted by agronomists reveal that the increase in the yield of a crop depends (in addition to other factors) on dissolved nitrogen in the irrigation water that is supplied (Ferreira and Goncalvesn 2007). More frequent and less intense irrigation tends to give a better crop yield due to reduced moisture stress, requires less water to fill the root zone to field capacity and reduces solute movement. The general relationship between crop yield and water applied to the crop tends to increase linearly up to about 50 % of full irrigation, and then moving in a convex curvature to the optimum yield, followed by a reduced yield with further increases in applied water (Jeffrey and Russel 2003).

Farmers whose sole objective is to get optimum net income tend to irrigate their crop by incurring the minimum cost for their irrigation water and getting optimum productivity for their crop. Hence, the main methodology adopted in this research regarding the optimum crop yield is economizing the cost of the irrigation water and increasing the extent of cultivation per unit of irrigation water.

Study Area Characteristics

The study area as in Figure 1 is located in the northern part of Sri Lanka between 9^{o} 22' and 9^{o} 52' north latitude and between 79^{o} 52' and 80^{o} 49' east longitude. The area covers 6 medium irrigation schemes, 40 minor irrigation schemes, around 2,000 shallow wells, including 41 observation wells in a polygonal network formed by connecting the perpendicular bisectors of adjoining observation wells, covering 185.23 km^2 in both the Vavuniya and Vavuniya South Divisional Secretary's Divisions in the Vavuniya District.

Figure 1. Study area with polygonal network.



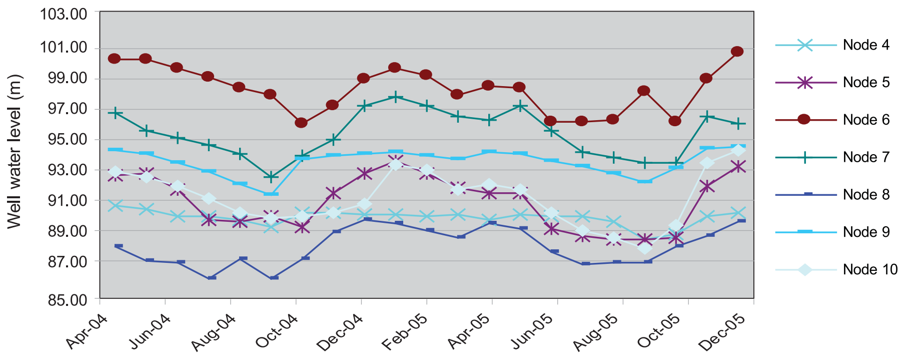
This area falls within the dry zone of Sri Lanka and in the Agro-ecological region of DLI (Ponrajah 1984). The average annual rainfall of the district is around 1,400 mm. The monthly average temperature is around 27.5^{o} C, although it falls below this level during October to January. The main rainy season extends from early October to late January and the sub-rainy season extends from late March to late May.

Soil and Groundwater of the Study Area

The general landscape of this area, with 3 % to 4 % slopes, contains minor and medium watersheds and catchment basins. Reddish brown earth, low humid clays and alluvial soil are the main soil groups, which occupy the concave valleys and bottom lands. Shallowly weathered and rarely fractured crystalline rock with a thin soil mantle and limited groundwater potential determines the substrata of the study area (Cooray 1984).

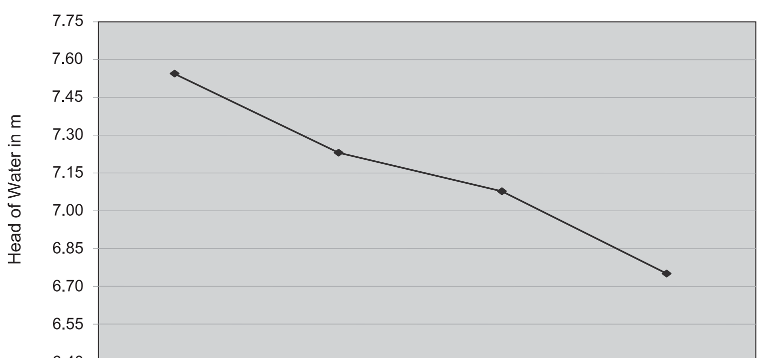
The cultivation of subsidiary food crops of about 0.2 to 1.0 hectare lots derives the needed water mostly from shallow dug wells, which have been constructed with a 4 m to 6 m diameter and a depth of about 9 m (DOA administration report, 1999 to 2003). Water levels of observation wells collected from 1997 to 2004 are given in Figure 2.

Figure 2. Monthly groundwater level fluctuation.



The collected water levels reveal that there is a substantial decline in the groundwater table in this region. Figure 3 clearly illustrates that the groundwater table did not reach its previous year (1991) maximum level during 1992 to 2002. This may be due to the excessive exploitation of groundwater; or due to the reduction in recharge of the aquifer by the speedy filling of minor

Figure 3. Average groundwater level at the end of recharging periods.



	May 1999	May 2000	May 2001	May 2002
Groundwater Level in m	7.60	7.30	7.15	6.81

tanks for domestic consumption; or the combination of both influenced by the influx of displaced populations in this area given the conflict situation that prevailed in the country.

Groundwater Model Formulation

A groundwater model is a system which represents the flow of groundwater in a given aquifer. In general, there are two idealized uses of simulation in groundwater hydrology. The first use is in the prediction of future events based on a calibrated and validated model (Loague et al. 1995); the second use is in the development of concepts for the design of future experiments to improve the understanding of processes (Chawla 1990).

Data Required for Developing a Groundwater Model

All groundwater resource studies are iterative because perfect data are not available and circumstances change over time. Improved assessment becomes possible once more and data are available (Issar and Passchier 1990). The first phase of a study of a groundwater model consists of collecting all existing geological and hydrological data of the groundwater basin in question. This will include information on surface and subsurface geology, water tables, precipitation, evapotranspiration, pumped abstractions, stream flows, soils, land use, vegetation, irrigation, aquifer characteristics and boundaries. Developing and testing the numerical model requires a set of quantitative hydrogeological data that fall into two categories: 1) physical framework such as topography, geology, types of aquifers, aquifer thickness and lateral extent, aquifer boundaries, lithological variations within the aquifer, and aquifer characteristics; and 2) hydrological stress parameters such as water-table elevation, type and extent of recharge areas, rate of recharge, type and extent of discharge areas and rate of discharge.

Model Calibration

Generally, calibration is defined as the adjustment of parameter values within known ranges to simulate the measured state of the flow system (Bair and Roadcap 1992). However, because of the complexity of calibration, most practitioners still rely on ‘trial and error’ methods throughout the world (Olsthoon 1995).

The longer the period used for calibration, the better results such a system will yield. This is particularly so for unconfined aquifers, which have a long natural response time (Chawla 1990). As long-term records are seldom available, the model usually has to be calibrated using data covering only a relatively short period, and the time periods, if possible, should be selected according to where extremes of water table behavior have occurred. The absolute minimum period, however, is data spanning for two full years, the first year being used to adjust the input data and the second year serving as a check to see whether the adjustments were adequate. If not, the process is repeated (Boonstra and Ridder 1981).

Source of Errors

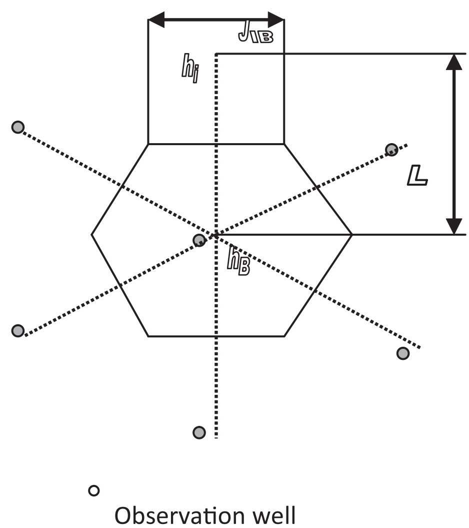
The list below demonstrates that almost all input data are subject to error. The deviation between the calculated and observed water levels will often be the result of a combination of these errors. Of course, errors can also be made in feeding the data in the computer and it is advisable to first check whether any such error had been made. Errors in input data can arise from two categories of sources.

- Errors in the physical properties of the aquifer
  - o Transmissibility 'T'
  - o Specific yield 'Sy'
  - o Water table elevation
  - o Type of aquifer
- Errors in the hydrological stress exerted on the aquifer
  - o Recharge from precipitation
  - o Recharge due to seepage in the conveyance and distribution system and application of irrigation water in fields
  - o Lateral groundwater flow through boundaries
  - o Groundwater abstraction

Calibration Procedure

As deviations between calculated and observed water tables are due to either error in individual input parameters or due to a combination of such errors, and the problem one faces in changing the values, which are not known exactly, is that it can cause errors as well. Values of these parameters lead to residue in the equation. The values of the parameters can be determined so as to minimize the residue. This process is called a 'calibration process'. Figure 4 shows one typical node within the polygonal network to illustrate the water balance of any polygon in the study area.

Figure 4. Typical polygon for node B.



Subsurface flow + vertical flow will be equal to change in storage as given below.

$$\sum_{i=1}^{M}(h_i^{j+1} - h_B^{j+1})Y_{iB}T_{iB} = \frac{S_B}{\Delta t}(h_B^{j+1} - h_B^{j})A_B + A_BQ_B^{j+1}$$

For the calibration periods, the values of h_i^{j+1}, h_B^{j+1}, h_o^{b} and Δt are known. In case the values of T_{ab}, S_B and AQ_B^{j+1} are known, the equation should be exactly satisfied. In case the values of these parameters are not known accurately and due to the error in the assumed values of transmissibility, storage coefficients and recharge coefficients, the equation will not balance. Hence, there will be an error or residue RES_B^{j+1}.

$$RES_B^{j+1} = \sum_{i=1}^{M}(h_i^{j+1} - h_B^{j+1})Y_{iB}T_{iB} - \frac{S_B}{\Delta t}(h_B^{j+1} - h_B^{j})A_B + A_BQ_B^{j+1}$$

The objective of the calibration process is to determine the values of T_{ab}, S_B and recharge coefficients so as to minimize the square of this residue. Squaring is done to avoid the cancellation of positive and negative errors. In each of the error optimization models, four variables for polygonal inputs, one variable for that particular polygonal specific yield, and five to seven variables for transmissibility for every polygonal connection, were formulated with constraints. Constraints were given as practicable ranges for the recharge coefficients, specific yield, and transmissibilities. The objective function together with constraints below, are used as error optimization models for each node.

$$Min\sum_{i=1}^{N}\left[\sum_{i=1}^{M}(h_i^{j+1} - h_B^{j+1})Y_{iB}T_{iB} - \frac{S_B}{\Delta t}(h_B^{j+1} - h_B^{j})A_B + A_BQ_B^{j+1}\right]^2$$

Where,
M - Number of wells surrounding node B, N - Number of seasons for calibration
Subject to:$-0.06 < S_B < 0.15$, $15 < T_{iB} < 25$, $0.075 < a < 0.15$, $0.05 < b < 0.1$, $0.15 < c < 0.25$, $0.9 < d < 1.5$. Where a, b, c are the recharge coefficients of tank storage, field input, and rainfall respectively and d is the withdrawal factor.

For the entire study area, altogether 164 variables for polygonal recharge coefficients, 41 variables for specific yield and 100 variables for transmissibility and 17 variables for the boundary lateral flow were found by error minimization using the non-linear optimizer such as GINO or MATCAD 2000.

First, for each node, models for minimization of the residue can be formulated. Using one of the non-linear optimization packages, all the models can be minimized separately and the values of stress parameters and recharge coefficients can be found. Taking these values of stress parameters and recharge coefficients as initial values to the groundwater model, residue in each node has to be found. Whenever the residue is not within the tolerance level, stress parameters and recharge coefficients have to be adjusted slightly and systematically, so that the residue for the first iteration can be found. By observing the trend of change in residue, within the third or fourth iterations, the residues in all the nodes can be brought to the tolerance level.

This is a trial and error method. However, 'MATCAD2000' (a user-friendly package requiring less computing time), which is superior to GINO, was used in this study to minimize the iteration time. All the 41 polygons were individually minimized using MATCAD2000 and the values of S_B, T_{iB}, a, b, c and d were found. While doing the second node minimization, if it is connected to the first node, the corresponding T_{iB} found from previous minimization was used and that particular constraint was removed from the second optimization model. By this method the entire 41 polygons were optimized and the hydro-geological parameters for each polygon were found.

Prediction of Model

All the work of collecting data, preparing the data and calibrating the model allows us to reconstruct the measured water table elevation. But the true purpose of a model is to indicate what the long-term behavior of the water table would be if certain plans for the use of water are implemented. 'Prediction run' is the term used when the model simulates the future behavior of the groundwater system when a certain development plan is implemented. It also allows us to study the consequences of a number of alternatives within the development plan. Possible situations to consider may include:

- Identifying effective recharge locations
- Whether a change in the cultivation pattern is necessary
- Changing the operational policy
- Whether irrigation canals have to be lined or not
- What the best site for a pumping station is
- What the effect of changes in the relative contribution of surface water and groundwater are
- Whether there is any possibility of raising the water table by reducing the permeability of the peripheral area of a restricted catchment

By simulating such alternatives, one can provide the decision-makers with a sound basis to select the most appropriate plan.

The period over which the model can simulate future conditions in prediction runs depends on several factors, which includes periods for which the model had been calibrated and the pattern of development activities during the calibration as well as during the prediction period. One should not predict for more than about twice the period used for calibration (Boonstra and Ridder 1981). The important data for prediction runs are:

- Data on initial water table elevation
- Data on recharge and abstraction rates
- Data on boundary condition

Prediction Model in Spreadsheet

For prediction, the water balance equation has been re-arranged to have h_B^{j+1} in LHS with RHS as function of h_B^{j+1} as below.

$$h_i^{j+1} = h_B^{j} + \left[. A_B Q_B^{j+1} + \sum_{i=1}^{M} (h_i^{j+1} - h_B^{j+1}) Y_{iB} T_{iB} . \right] \Delta t / S_B A_B$$

As h_B^{j+1} is connected to M surrounding nodes, while finding the h_B^{j+1} the already found h_B^{j+1} will slightly vary. Hence, after completing the first iteration process for all the 41 nodes, the same process has to be repeated five to six times to get accurate results. The function of GOALSEEK in spreadsheet with a small micro was used in this prediction run, and all the iterations were performed in a few key strokes to predict the water level with zero error. Even though the model is formulated season-wise, prediction is possible monthly or even weekly by changing a few cell formulae and adding a few more cell formulae.

Model Validation

Validation efforts are simply a comparison of modeling results against field data. Since the goal of model validation is to ensure that the modeling results provide a good representation of the actual processes in the real system, validation should be applied to every step of the modeling process (Chawla 1990).Validation is the simulation of a different measured state of the flow system using the final parameter values from model calibration (Chawla 1990).There have been a number of definitions of model validation. The International Atomic Energy Agency defines validation as follows: “A conceptual model and the computer code derived from it are validated when it is confirmed that the conceptual model and the computer code provide a good representation of the actual processes occurring in the real system.”

To test the validity of the model using the calibrated parameters and using the eighth season (September 2001), water level as initial water level and the rest of the inputs, the ninth season (May 2002) water level was predicted using the prediction model. Wherever the predicted values were not matching with the observed values, the stress parameters were systematically and slightly adjusted to get a good match. In the same way, using the ninth season (May 2002) water level as the initial water level and the rest of the inputs, the tenth season (Sept. 2002) water level was predicted using the prediction model. In the same way, the water levels of May 2003, September 2003, May 2004 and September 2004 were predicted and compared with observed water levels.

This led to an observed error in depth of the water table in the order of the magnitude ranging from -0.08 % to +2.1 %. For a groundwater simulation model in the integrated finite difference method, an error of this magnitude may be regarded as acceptable depending on the scope and purpose of the project.

Operational Research

Using the calibrated model, several prediction runs were carried out to determine the behavior of water levels to illustrate:

1) The possibility of reducing the extent of cultivation using surface water and increasing the storage of groundwater for economic cultivation

2) The possibility of creating an artificial aquifer boundary to reduce the lateral flow and raise the water table for economic pumping that would reduce the cost of irrigation water and increase productivity

3) The possibility of combining both 1 and 2 to raise the water table by improving the groundwater storage capacity to increase the crop yield and by increasing the extent of economic cultivation per unit of irrigation water

To achieve these, the following steps were carried out;

1. The behavior of the water table of this catchment was analyzed by keeping 10 %, 20 %, 30 %, 40 % and 50 % of the full capacity of the irrigation schemes during the season of June to September. This was done by assuming that, to keep 10 % of the full capacity of a medium and minor irrigation scheme, 12 % of cultivation has to be foregone.
2. The first interior boundary of the study area was selected for the creation of an artificial boundary by using boundary treatment. To create the artificial boundary, the transmissibility values (actually the permeability) were reduced in steps and the behavior of the water table was observed. The ‘T’ values between 17 very extreme peripheral nodes (18, 30, 41, 29, 28, 40, 39, 38, 37, 36, 24, 35, 22, 34, 33, 32, 31) and 14 interior adjoining nodes (8, 17, 16, 15, 27, 26, 25, 13, 23, 12, 11, 21, 20, 19) were reduced in steps of 2 – 3 m^2 /day and the water levels were predicted. There are 30 nodal connectivities. Hence, all the ‘T’ values were changed in five steps.
3. During this analysis, every step of paragraph 1 was carried out for all five steps of paragraph 2. Accordingly 25 trials were carried out. Even though this was a very cumbersome exercise, the outcome produced an interesting shift.

The summary of results of the operational research considering the above three different options are given below.

- Changing the operational policy of minor and medium irrigation schemes by foregoing cultivation by 25 % to 35 % to conserve surface water by storage as groundwater, is giving water table gains in almost all nodes except nodes 37 and 38 by 0.533 m to 0.914 m during discharging season, and by 0.762 m to 1.143 m during recharging season. This is a reduction of almost 45 % to 65 % of water table loss in between two consecutive seasons in 80 % of the area of the catchment under study.

- Creating an artificial aquifer boundary to optimize the effectiveness of groundwater in an elevated water table using peripheral boundary treatment, causes a reduction of 35 % to 45 % in permeability and increases the nodes in the water table to be closer to the treated boundary by 0.457 m to 0.838 m during recharging season.

- Combining peripheral reduction in permeability by 35 % to 45 % and foregoing the cultivation of minor and medium irrigation schemes by 45 % to 55 % result in an average gain of water table during discharging season (June – Sept) by 1,067 m to 1,448 m excluding node 37 and 38. The same trend is observed in recharging season although to a lesser degree. This is a reduction of almost 60 % to 70 % of water table loss in between two consecutive seasons in 95 % of the area of the catchment under study.

Economic Analysis of the Operational Research

Detailed cost benefit analysis for all the three options of the operational research were carried out taking into account the farmers' sole objective of getting maximum net income, and their tendency to irrigate their crop by spending the minimum for their irrigation water and getting the maximum productivity of their crop. Hence, one of the main assumptions adopted in this economic analysis regarding the optimum crop yield is economizing the cost of the irrigation water and increasing the extent of cultivation for every unit of irrigation water, leaving out the physiology of the crop. Foregoing cultivation will be a loss to Gross Domestic Product (GDP) and lead to a loss in Gross National Product (GNP) too. The gain in water table will reduce the cost of energy by way of fuel and electricity. This reduces the cost of irrigation and in turn increases the extent of cultivation per unit of irrigation water and leads to increases in the crop yield. This will indirectly contribute to GDP and GNP.

Economic Analysis for the Change in Operational Policy of Irrigation Schemes

The change in operational policy will reduce the extent of paddy cultivation. This could be taken as the indirect cost and will occur yearly. The return was calculated based on savings in electricity by raising the water table on an average in steps of 0.63 ft., 1.75 ft., 2.41 ft., 2.93 ft. and 3.12 ft. for 1,680,030 m^3 of domestic pumping, 2,281,220 m^3 of agricultural pumping and 160,910 m^3 of production well pumping in season 13; and in steps of 0.96 ft., 2.29 ft., 3.46 ft., 3.92 ft. and 4.05 ft. for the pumping of 1,679,190 m^3 of domestic pumping, 2,149,900 m^3 of agricultural pumping and 80,750 m^3 of production well pumping in season 14. This saving in expenditure in pumping water for domestic agricultural production by raising the water table was taken as the return from the implementation of this policy.

Economic Analysis for Boundary Treatment

The boundary treatment was proposed to reduce the average transmissibility in steps of 79 %, 70 %, 61 %, 53 %, and 44 %. Hence, the cost of cut off was taken as per Irrigation Department data for costing. The present worth factors were taken from relevant tables. This was calculated based on the savings in electricity by way of raised water table for average steps 0.14 ft., 0.46 ft., 0.67 ft. and 0.75 ft. for 1,679,190 m^3 of domestic pumping, 2,149,900 m^3 of agricultural pumping and 80,750 m^3 of production well pumping in season 13.

Economic Analysis for the Change in Operational Policy of Minor/Medium Schemes Together with Boundary Treatment

The 25 combinations for the combined alternatives of one and two were analyzed. The direct cost would be the boundary treatment cost. As the indirect cost and direct benefit are annual in nature, the net values and the present worth of various policy implementation periods (project life period) of 10 years, 15 years, 20 years and 25 years with interest rates of 5 %, 7.5 % and 10 % were calculated and analyzed.

Due to very heavy expenditure on boundary treatment, the present worth of return was less for up to 20 years of project life time, than the present worth of cost up to step three of the boundary treatment. Even though there was a considerable shift in water level gain, with a 60 % to 70 % of water table loss in between two consecutive seasons in 95 % of the catchment under research and the high cost of treatment reduced the benefit up to the last three steps. Normally, for any water resource project, the life period is taken as 30 – 50 years (RBMP 1990). Hence, this option is also economically viable.

Summary of Economic Analysis of the Operational Research

The alternative to the operational policy of minor and medium irrigation schemes by foregoing cultivation by 25 % to 35 % gave the benefit cost ratio based on present worth greater due to considerable rise in the water table. The rise in water table occurred almost above 80 % of the observation wells. The rise in water table was around 45 % to 65 % of the loss in water table between two consecutive seasons. This will reduce the cost of irrigation water and in turn increase the extent of cultivation per unit of irrigation water. This will increase the crop yield per unit of irrigation water and lead to increased productivity in terms of food production. The boundary treatment showed positive results when the lifetime of the project exceeded 20 years and for the interest rate of 7.5 %.

For most of the water resource projects the project life time is more than 30 years and the interest rate can go up to 10 % as per the guidelines for the preparation of ‘River Basin Master Plan 1990’ of the Central Water Commission if India, and the technical guidelines of the Irrigation Department (Ponrajah 1985). This implies that the boundary treatment is also economically feasible with certain limitations such as a minimum project life period of 20 years and maximum borrowing rate of 7.5 %, as assumed in the options considered.

The combination of the above two alternatives yielded further improvement whereby at any time the water table will reduce 60 % to 70 % of the water loss in between two consecutive seasons in 95 % of the catchment under study. This implies that the boundary treatment, combined with changing the operational policy of minor and medium irrigation schemes by foregoing a part of the cultivation, is an economically feasible policy alternative with certain limitations such as a minimum project life period of 20 years and a maximum borrowing rate of 7.5 %.

After completion of the project investment, the average cost of irrigation water will be reduced considerably due to less energy costs, and this in turn will increase the extent of cultivation per unit of irrigation water.

A summary of the economic analysis for all three alternate options of economically feasible steps is given below.

Summary of benefit/cost ratio greater than unity option and steps.

Option	Steps for each season	Benefit cost ratio							
		Discharging season				Recharging season			
Operational policy change	2	14.52				1.59			
	3	14.63				1.46			
	4	12.43				1.33			
	5	10.27				1.13			
Boundary treatment	Year of implementation					20		25	
	Interest rate					7.5 %	10 %	7.5 %	10 %
	3					0.73	0.97	1.15	1.66
	4					0.88	1.17	1.39	2.01
	5					0.83	1.10	1.30	1.88
Combination of policy change and creation of artificial boundary	Year of implementation	20		25		20		25	
	Interest rate	7.5 %	10 %	7.5 %	10 %	7.5 %	10 %	7.5 %	10 %
	3	0.97	1.13	1.28	1.78	0.82	1.09	1.17	1.75
	4	1.09	1.19	1.49	2.23	1.01	1.13	1.44	2.18
	5	1.04	1.13	1.42	2.22	0.97	1.15	1.37	2.02

Conclusion

Minor / medium irrigation schemes conserve surface run off and convey most of it to recharge groundwater, and as such serves as a recharge shed for the wells situated in the zone of influence. It is an insurance against water scarcity as the yield increases considerably for every unit of rainfall. The minor / medium irrigation schemes prevent soil erosion and depletion of soil fertility. In the context of impending water deficiency, the construction of minor/medium irrigation schemes will be a dependable infrastructure in the development of water potential in any catchment. Acknowledgement of the remarkable role played by the minor/medium irrigation schemes on replenishment of groundwater and its spread over a large area would be a great asset in the planning and execution of settlement and crop production projects.

This research leads to the conclusion that a change in operational policy for minor/medium irrigation schemes by foregoing one-third of the cultivation under minor/medium irrigation schemes; or keeping one-fourth of the storage of these irrigation schemes at any time, will gain an average of 45 % to 65 % in the loss of water table in any consecutive season in almost 80 % to 90 % of the catchment area under consideration.

Recommendations

It is recommended to construct new irrigation schemes or re-construct the abundance of minor /medium irrigation schemes with 25 % of storage exclusively for recharging groundwater. In the existing minor/medium irrigation schemes the sluice to be raised to store 25 % of the total capacity of the schemes to recharge groundwater and to store 25 % as dead storage. This change in operational policy will lower energy costs and reduce considerably the average cost of irrigation water for OFC cultivation, and this in turn will increase the extent of cultivation per unit of irrigation water and lead to an increase in productivity.

Hence, it is recommended new irrigation schemes be constructed with dead storage at 25 % of full capacity, and the sluice to be raised (during any re-construction of existing sluices) to retain 25 % of storage as dead storage in the future.

References

Bair, S. E.; Roadcap, G. S. 1992. Comparison of Flow Models Used to Delineate Capture Zones of Wells: 1. Leaky-confined Fractured-carbonate Aquifer. *Groundwater* - Vol. 30, April 1992, 199-211.

Boonstra, J.; De-Ridder, N. A. 1981. Numerical Modelling of Groundwater Basins. 29 ILRI, Wageningen, ILRI Publication, 1981.

Chawla, A. S. 1990. Groundwater Hydrology and Conjunctive Use. WRDTC University of Rookee.

Cooray, P. G. 1984. An Introduction to the Geology of Sri Lanka, National Museum of Sri Lanka, Colombo, 1984.

Ferreira, T. C.; Goncalves, D.A. 2007. Crop Yield / Water Use Production Fluctuation of Crops Grown Under Differential Nitrogen and Irrigation Treatments in a Hot, Dry Climate. www.sciencedirect.com.

Ilampooranan, K. 1993. Conjunctive Use Management Model. A Case Study. Unpublished Dissertation of MSc (WRD) of WRDIC University of Roorkee, Roorkee, India.

Issar, A.; Passchier, R. 1990. Regional Hydro Geological Concepts, International Contributions to Hydrogeology. *Groundwater Recharge* Vol. 8, 1990, 23-94.

Jeffrey, S.; Russell, A. M. 2003, Perspectives in Civil Engineering Commemorating the 150th Anniversary of American Society of Civil Engineers-2003-Technology, pp 401.

Nagaraj, .B. S.; Dewan, R. L. 1972. Theoretical and Experimental Aspects of the Rice of Groundwater due to Canal Irrigation. *Proceedings of symposium of waterlogging*. Central Board of Irrigation and Power New Delhi, India, Publication No.118, P.69-78.

Olsthoorn, T. N. 1995. Effective Parameter Optimization for Groundwater Model Calibration. *Groundwater*-Vol. 33, February 1995, 42-57.

Ponrajah, A. P. 1984. Design of Irrigation Head-works for Small Catchments, 2nd edition. Colombo, Sri Lanka: Irrigation Department, 1984.

Shanmuganathan, S. 2004. Development of a Comprehensive gGoundwater Model to Analysis the Management Options for Vavuniya region, MSc. Thesis, University of Moratuwa, Sri Lanka, 2004.

Sivakumar, S. S. 2001(a). Groundwater Balance Study in a Restricted Catchment in Vavuniya to Find Effective Recharge Location by Introducing New Operational Policy on Minor and Medium Irrigation Scheme. Seminar on Irrigation for the Centenary Programme of the Irrigation Department held on February 15 and 16, 2001 at the BMICH, Colombo, Sri Lanka.

Sivakumar, S.S. 2001(b). Formulation of Groundwater Simulation Model in Restricted Area and Calibrating the Model Using Optimization Technique with Particular Reference to Vavuniya. The 58th Annual Sessions of SLAAS held from December 2-5, 2002 at the University of Colombo, Sri Lanka.

Sivakumar, S.S. 2002a. Water Resource and Agriculture Development Strategy for North East with Special Reference to Water Availability Study for Northern River Basins. A post conflict needs assessment.

Sivakumar, S.S. 2002b. Application of Regional Aquifer Simulation Model in a Restricted Catchment to Find Effective Recharge Location by Introducing New Operational Policy of Minor and Medium Irrigation. IWMI/Colombo Plan Seminar on “Forward Thinking Policies for Groundwater Management. Energy, Water Resource and Economic Approaches,” held from September 2-7, 2002, in New Delhi, India

Sivakumar, S.S. 2008. Water Balance Study to Develop a Technique to Improve Groundwater System in Vavuniya. A popular presentation at the annual research session 2008, Vavuniya Campus of the University of Jaffna, Sri Lanka.

Sivakumar, S.S, 2009. Water Resource and Agriculture Development Strategy and Food for Thought for the Re-emerging Development of Conflict Affected North East Region. A special presentation. Northern Provincial Council, Trincomalee, Sri Lanka, 2009.

Economic Valuation of Irrigation Water under a Major Irrigation Scheme (Gal Oya) in Eastern Sri Lanka

P. Sivarajah and A. N. Ahamad
Dept. of Agricultural Economics, Eastern University,
Chenkalady-30350 (EP)

Introduction

About three-fourths of Sri Lanka comes is within the dry-zone, in which water becomes a particularly limited resource during the dry '*yala*' season. Therefore, it is very important that a farmer in the dry zone uses water at an optimum level. Even though up to now irrigation water in Sri Lanka is unpriced, views have emerged that it has to be priced due to its scarcity and increasing demand for both farming and residential use. The Government of Sri Lanka has been investing large amounts of money in irrigation development and subsequent supply of water to farmers since national independence. The lack of participation of water users in system management and inadequate funds for operation and maintenance (O&M) activities have resulted in the inefficient use of water on the one hand, and the excess use of water on the other. As a result, farmers use water until the marginal productivity of water reaches zero (Seagraves and Easter1983) and overall water usage has become inefficient.

One way to achieve an efficient allocation of water is to price its consumption correctly. Pricing of water affects allocation considerations by various users. The prevailing pricing methods for irrigation water include volumetric pricing, non-volumetric pricing methods, and market-based methods. Volumetric pricing mechanisms charge for irrigation water based on the consumption of actual quantities of water (Easter and Welsch 1986; Small and Carruthers 1991; Bandaragoda 1998). Non-volumetric methods charge for irrigation water based on a per output basis, a per input basis, a per area basis, or based on land values (Easter and Welsch 1986; Easter et al. 1997).

Market-based mechanisms have recently arisen as a need to address water-pricing inefficiencies inherent in existing irrigation institutions. These mechanisms rely on market pressures and well-defined water rights to determine the irrigation water price. Area pricing is the most common method used for irrigation water pricing (Bos and Walters 1990). The rotational method combines elements of volumetric pricing with area pricing, for equitable allocation of irrigation water fixes flows by day, time, and duration of supply, proportionate to irrigated area (Bandaragoda 1998; Perry and Narayanamurthy 1998). Tiered pricing for irrigation water is common in the State of Israel (Yaron 1997b).

In Sri Lanka, the charges for irrigation water are not based on the amount of water used, but on the basis of the operation and maintenance value of irrigation water. There have been many studies in Sri Lanka to value irrigation water for agriculture. Upasena and Abeygunawardena (1993) estimated the value of irrigation water as Rs.750 per acre per rotation (season), using the productivity change method. They also identified that farmers were willing to pay Rs. 560 per acre/year for O&M with an expectation to receive an effective water supply to their land plots, and that that supply will be higher than the O & M costs of irrigation (Rs. 370 / acre/year). Piyasena (2000) estimated the value of irrigation water supplied under the Mahaweli Irrigation System using a Linear Programming model, and found that the value of water was Rs. 2,030/acre-feet in the '*yala'* season. Later, Renwick (2000), using a residual approach, found that the value of water under the Kirinda Oya Irrigation System was Rs.16,748 per hectare (Rs. 6,699.2 per acre) for paddy cultivation during the '*maha*' season. Whereas, Bandara and Weerahewa (2003) estimated the value of irrigation water used for paddy cultivation in five districts to be Rs. 5,727.63 acre^{-1} season^{-1} or Rs.1,272.8 per acre-feet. Meanwhile, Herath and Gichuki (2006) conducted a field study in the Lunuwewa in 'Mahaweli H' area to value irrigation water by using the 'Willingness-To-Pay' method, and found that the majority of farmers were willing to pay Rs. 300 per hectare/year for irrigation water.

The objective of this study was to estimate the economic value of irrigation water used in a crop farm (paddy and chilies) using a Linear Programming approach in the Senanayake Samudra (Gal-Oya Irrigation Scheme) Right Bank System area in the Ampara District.

Methodology

The Linear Programming approach is used to identify the optimal farm plan for the farmer in the Gal Oya Irrigation Scheme, given the limited (constraints) land, labor, water and capital available for cultivation of crops in the '*yala*' season. A farmer needs two pieces of information in deciding whether he should add a little more input to his crop or not. First, he needs to know the cost associated with adding one extra unit of the input and second, he needs to estimate how much more income his crop would generate as a result of the added input. Hence, if the added income to the crop is larger than the added cost, a farmer interested in increasing profits will add more of the input for production activity. At the point of profit maximization, the Marginal Value of Product (MVP) is equal to the price of the productive input used. Therefore, the farmer can use water until the point is reached whereby the last Rupee spent on water, returns exactly its incremental cost.

It is assumed that farmers tend to maximize profits from each activity (production) on the farm land owned. Thus, the maximization model of LP is used to identify the maximum profits attainable and the shadow prices of inputs used in production.

The maximization model used in this study is as follows:

Maximize: $N = PI * X + Py * Y$

Where X and Y are two different commodities (Example: paddy and chilies)

PI - Price of paddy per unit of X

Py - Price of chilies per unit of Y

N - Net profit from all activities

The LINDO (2002) software package was used to solve the linear programming problem. By using the LINDO program the shadow price of the constraints (resources) of the optimal farm plan can be found. The LINDO solution report also gives a 'Dual Price' figure for each constraint. The 'Dual Price' (Shadow Price) can be interpreted as the amount by which the objective would improve given a unit of increase in the right-hand side of the constraint. Dual Prices/ Shadow Prices indicate how much a person should be willing to pay for additional units of a resource.

The crops cultivated (paddy and chilies), duration of crops and their net returns per acre, on an average 2-acre farm are shown in Table 1. The net returns were estimated from survey data collected.

Table 1. Crops and net returns (1 acre).

Crops	Abbreviations	Net Return (Rs./Acre)
1. Paddy (4.5 months)	P1	37,080
2. Paddy (3.5 months)	P2	26,380
3. Chilies	C	68,550

Technical crop water requirements for paddy 1 (4.5 months), paddy 2 (3.5 months) and chilies were found by using the software package CROPWAT. CROPWAT is a computer program used to calculate the crop water requirement and irrigation requirements from crop and climate data. The output, which is the crop water requirement for one acre land crop cultivation, is used for modeling the matrix formulation of linear programming. The CROPWAT program also generated the water co-efficient (irrigation requirement).

Constraints and co-efficients for the model were estimated from data collected through the survey (net returns from selected crops are shown in Table 1). Water constraint was identified through the information obtained from District Irrigation Engineers. Water co-efficient was identified through secondary information collected and with the help of the CROPWAT program. Taking into consideration the land (2 acres), labor (50 man-days), water (4.1 acre-feet) and capital (Rs. 50,000) constraints, the matrix was formulated to solve the problem of profit-maximization by linear programming (Table 2).

Table 2. LP Matrix formulated for profit maximization.

Limit			Paddy 1 (P)	Paddy 2 (S)	Chilies (C)
Objective	N	-	37.08	26.38	68.55
Land	L	2.00	1.00	1.00	1.00
Labor	L	50.00	15.00	15.00	70.00
Water	L	4.10	4.37	3.54	3.43
Cash Rs.	L	50,000	31.8	35.6	45.9

LP Model formulated and used is as follows:

Maximize N = 37.08P + 26.38S + 68.55C

Subject to;

1. Land: $P + S + C <= 2$,
2. Labor: $15P + 15S + 70C <= 50$,
3. Water: $4.7P + 3.54S + 3.43C <= 4.1$;
4. Cash: $31.8P + 35.6S + 45.9C <= 50$.

Where P, S, C and N => 0.

Method of Data Collection and Analysis

Data needed for this study were collected from three sources: 1) sample farm survey; 2) secondary data from records; and 3) publications and reports, along with use of the CROPWAT Program (FAO1998) to estimate the crop water requirements for the crops.

The survey was carried out at the Right Bank System in the Gal Oya Irrigation Project. The sample consisted of 30 farmers. These farmers were selected using the 'Multiple Stage Sampling' technique. The area of the Right Bank System of the Gal Oya Project was selected as a cluster of the Senanayake Samudra, and a few distributory channels in the 'Right Bank System' were selected randomly. Data was collected through a sample survey using a pre-tested questionnaire from farmers residing along three irrigation channel (Distributory Channel) areas. For the analysis, climatic data such as mean monthly temperature ranges, type of soil, elevation, average rainfall, rainfall pattern, rainfall distribution, and crop pattern, were collected from the Meteorological Department Sub-station at Ampara, and the Land and Water Management Centre of the Department of Agriculture. Data on water issues from the Right Bank system of the Senanayake Samudra for each month in the '*yala*' season were also obtained from the Irrigation Engineer's Office, Ampara.

Results and Discussion

The results indicated the objective function value and the Dual or Shadow Prices, along with the slack or surplus of the inputs used on the 2-acre farm. It was found that the farmer can obtain a maximum profit of Rs. 59,127.88 per season by cultivating paddy and chilies on 2 acres of land. The output also indicated that paddy 1 (4.5 months) and chilies had zero Reduced/ Shadow Costs, while paddy 2 (3.5 months) had a Shadow Cost greater than zero. This implies that it is not economical to include paddy 1 in the farm plan activity.

The results also showed that the farmer could cultivate 0.4539 acres of long-aged paddy (4.5 months), and chilies on 0.617 acres of land, while short-aged paddy (3.5 months) is not selected to be cultivated (Table 3).

Shadow or Dual Price is the maximum price that management is willing to pay for an extra unit of a given limited resource. Shadow prices, which reflect the social value of goods, replace the market prices that are used in private calculation. In a perfectly competitive economy,

Table 3. Level of activities and reduced cost.

Variable	Value	Reduced Cost
1. Paddy 1 (P)	0.453920	0.000000
2. Paddy 2 (S)	0.000000	5.587403
3. Chilies (C)	0.617017	0.000000

market prices and shadow prices will coincide (Smith 1985). As shown in Table 4, the water constraint has a Dual/Shadow Price of Rs. 6,159.76, which implies that the farmer can increase his net profits by this amount by using additional acre-feet of irrigation water in his optimal farm plan. Water has such a high Shadow/Dual Price due to its limited availability. Therefore, it's profitable for the farmer in the area to purchase water at a price close to or less than Rs. 6,159.75 per two acre-feet. These results are close to the findings of Renwick (2000), who valued irrigation water as Rs. 6,699.2 per acre-feet, and that of the figure projected by Bandara and Weerahewa (2003) at Rs. 5,727.6 per acre.

Table 4. Slack and dual prices of constraints/inputs.

Row	Slack or Surplus	Dual Prices
2) Land	0.929063	0.000000
3) Labor	0.000000	0.677458
4) Water	0.000000	6.159756
5) Capital	7.244252	0.000000

Conclusions and Policy Implications

The study estimated the value of irrigation water using the principle of Marginal Value Product in a Linear Programming approach that maximizes net returns for a specific farm plan. The Shadow or Dual Price of water was used to estimate the economic value of irrigation water. The results indicated that the economic value of irrigation water was Rs. 6,699.2; the amount by which the net returns could be increased by its additional usage. This indicates the likely importance of water in crop cultivation under irrigation schemes. Thus, it is economically rational for the farmer to pay at least Rs. 6,699.2 for acre-feet of irrigation water, as long as its benefits (returns) are also more.

However, the water management and cost recovery mechanisms should be developed according to the farm size and season of cultivation, as both have significant impacts on farmers in irrigation schemes. The productivity of land, cropping intensity, water availability, and market prices should be considered in recommending a price for irrigation water. It is also important to communicate the need to, and encourage the farmers in the irrigation scheme to contribute to the development and maintenance of existing irrigation systems in a sustainable manner.

References

Bandara, H. M. S. J. H.; Weerahewa, J. 2003. Economic Value of Irrigation Water in Paddy Cultivation in Sri Lanka. *Tropical Agricultural Research* Vol. 10, 2003; Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.

Bandaragoda, D. J. 1998. *Need for institutional impact assessment in planning irrigation system modernization.* IIMI Research Report 21. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI).

Bos, M. G.; Walters, W. 1990. Water Charges and Irrigation Efficiencies. *Irrigation and Drainage Systems* Vol.4: 267-278.

Easter, K.W.; Welsch, D. E. 1986. Implementing Irrigation Projects: Operational and Institutional Problems. In *Irrigation Investment, Technology, and Management Strategies for Development,* ed. K. W. Easter. Boulder, Westview Press.

Easter, K. W.; Becker, N.; Tsur, Y. 1997. Economic Mechanisms for Managing Water Resources: Pricing, Permits, and Markets. In *Water Resources: Environmental Planning, Management and Development*, ed. A. K. Biswas. McGraw-Hill, New York.

FAO (Food and Agriculture Organization). 1998. CROPWAT for Windows –User Guide. Food and Agriculture Organization, United Nations, Rome.

Herath, C. P.; Gichuki, F. N. 2006. Willingness to Pay for Irrigation Water for Paddy Farming: A Case Study in Lunuwewa in Mahaweli System H". Proceedings of Water Professionals day Symposium on Water Resources Research in Sri Lanka, Geo-Informatics Society of Sri Lanka, University of Peradeniya, Peradeniya, October 1, 2006.

LINDO. 2002.. LINDO PC, ver.6.1; LINDO Systems Inc., North Dayton St., Chicago, Ilinois -60622, USA.

Perry, C. J.; Narayanamurthy, S.G. 1998. *Farmer response to rationed and uncertain irrigation supplies.* IIMI Research Report 24. Colombo, Sri Lanka: International Irrigation Management Institute, Colombo, Sri Lanka.

Piyasena, H.D.R.N. 2000. Determination of the Economic value of Mahaweli Irrigation Water. A research report submitted for the B.Sc degree in Agriculture, University of Peradeniya, Peradeniya.

Renwick, M. E. 2000. *Valuing water in irrigated agriculture and reservoir fisheries: A multiple use irrigation system in Sri Lanka*. IWMI Research Report 51, Colombo, Sri Lanka: International Water Management Institute (IWMI).

Seagraves, J. A.; Easter, K.W. 1983. Pricing of Irrigation Water in Developing Countries. *Water Resources Bulletin* 19 (4): 663-672. American Water Resources Association.

Small, L. E.; Carruthers, I. 1991. *Farmer Financed Irrigation*. Cambridge University Press, Cambridge, UK.

Smith, A. 1985. *Public sector shadow prices in distorted general equilibrium models.* Discussion Paper No. 41. January 1985 (IT), Centre for Economic Policy Research, London, UK.

Upasena,W. I. J.; Abeygunawardena, P. 1993. Economic Value of Irrigation Water in Devahuwa Irrigation Scheme. *Tropical Agricultura Research*, Postgraduate Institute of Agricultura, University of Peradeniya, Peradeniya.

Yaron, D. 1997. The Israel Water Economy: An Overview. In *Decentralization and Coordination of Water Resource Management,* eds. D.D. Parker and Y. Tsur. Boston, KluwerAcademic Publishers.

Development of a Water Resources Assessment and Audit Framework for Sri Lanka

M. Matin, V. Smakhtin, M.Palliyaguruge, S. Mohideen, N. Yapa, A. Ranjith, S. Gunasinghe and P.Jayakody
International Water Management Institute (IWMI), Colombo, Sri Lanka

Abstract

The demand and use of water resources is permanently increasing, while the quality of water is dropping and the availability of water in the context of climate change is becoming uncertain. To meet these growing problems it is necessary to carefully assess the existing water stocks and future trends in a country. The accuracy of such an assessment highly depends on the quality of data and information used. In other words – we cannot manage what we do not measure. In most developing countries, the lack of readily accessible and quality controlled data is the major obstacle for scientifically-based assessments on water resources, water development planning and evaluating the status and trends of water resources. Sri Lanka too faces similar obstacles.

Recently IWMI initiated the development of a prototype system for managing national water resources data and information, which can be accessed online by various users and interested stakeholders. The data and information in the system is being organized in modules to provide user-friendly access. The 'overview' module includes information on topography, soil, land use, land cover, river network and settlement patterns. The 'water availability' module contains data on various components of the hydrological cycle, including rainfall, runoff, evaporation, ground- water, river basin characteristics, per capita water availability and trends, and water scarcity. The 'Demand and use' module focuses on the factors that affect demand, such as population growth, sectoral demand, irrigation requirements and withdrawals. The 'water quality' module provides information on salinity, water quality constituents and water-related diseases. The 'governance and management' module contains information on institutions, legislation and finances in the Sri Lankan water sector. The 'disaster and risk' module focuses on the characteristics of floods, land slides, tsunami etc. Finally, the 'climate change' module covers the impacts of climate change on rainfall, salinity and sea level rise to guide adaptation planning.

The system is designed with a view to facilitate assessments of water resources at various administrative (e.g., province, district) and hydrological (e.g., river basin) units. The map-based interface ensures quick access to available data and allows the date to be downloaded and

displayed. The system is currently a 'work in progress' and only an illustration of what can be achieved. It is envisaged that by cooperating with national agencies, the system will be enhanced into a unified platform for maintaining and sharing data by various participating agencies and will be used to conduct a systematic assessment of water resources in Sri Lanka. By developing a comprehensive and national water audit, Sri Lanka may provide as an example to other developing countries too.

Introduction

The demand and use of water resources is permanently increasing, while the quality and availability of water is declining. According to the Comprehensive Assessment (Molden 2007), about 2.8 billion people in the world live in areas facing water scarcity. By 2025, one-third of the population of the developing world will face severe water shortages (Keller et al. 2000). Climate change can affect the quantitative and qualitative status of water resources by altering hydrological cycles and systems which in turn, will increase temperature and shift precipitation patterns (EEA 2007). To meet these growing problems it is necessary to carefully assess the existing water stocks and future trends in a country. The accuracy of such an assessment is highly dependent on the quality of data and information used. In other words – we cannot manage what we do not measure. In most developing countries, the lack of readily accessible and quality- controlled data is the major obstacle to scientifically-based assessments of water resources, water development planning and evaluating the status and trends of water resources.

Most of the studies on water scarcity assessment rank Sri Lanka as a country with either little or no water scarcity or moderate water-scarcity conditions, but they do not consider the spatial and temporal variation of water availability in the country (Amarasinghe et al. 1999). Sri Lanka experiences high seasonal and spatial variations in rainfall due to the bi-monsoonal climatic pattern (northeast monsoon from October to March and southwest monsoon from April to September)—(Amarasinghe et al. 1999). Large tracks of the country are drought prone. Droughts occur in both semi-arid and humid zones – in different degrees (Imbulana et al. 2006).

At present in Sri Lanka, water resources data and information are hosted by multiple government agencies, and there is a need to integrate such data into a coherent water resources information system (Imbulana et al. 2006). Recently IWMI initiated the development of a prototype system for managing national water resources data and information, which can be accessed online by various users and interested stakeholders. The present paper describes different modules of the system.

Methodology

The heart of the system is the data base, which targets various user groups and provides useful information to assist in their management decisions. Information is retrieved from the platform, through web interface enabling subject-wise access. The system includes the following data and information types:

- Spatial data in GIS format (e.g., administrative boundaries, transportation, river basins, land use, etc.)
- Attribute data: data linked to some spatial unit (e.g., population, irrigation)
- Time series data (e.g., rainfall, runoff)
- Descriptive information (e.g., policy documents)

The data and information are categorized into several topics:

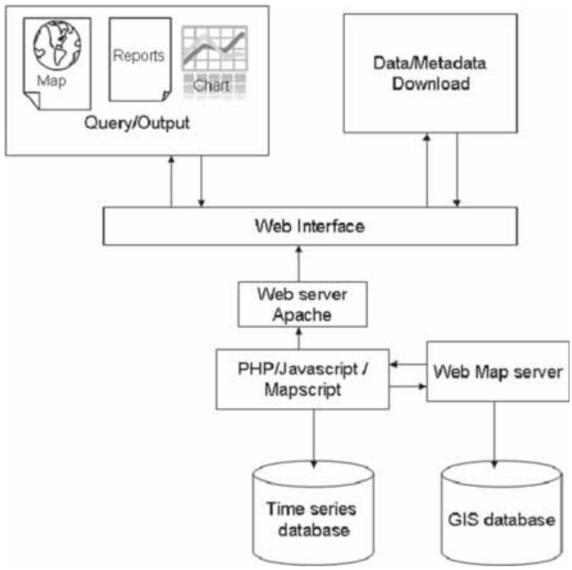
- Data and information that help users to understand the physical settings of the country
- Water availability, including current status and future trends
- Water demand and use
- Water quality
- Water governance, including institutional and legislative information
- Water-related disasters and risks
- Climate change impacts on water resources

Data from different agencies, stored in heterogeneous formats, are harmonized to enable comparison and presentation.

System Architecture

The system is developed with an open source technology to minimize the cost of implementation and replication. The architecture of the system is shown in Figure 1. The user interface is coded with PHP/Java script to provide web-based access for queries, outputs and data download. Apache web server version 2.2 (http://httpd.apache.org/) is used for hosting the system. Minnesota web map server (http://mapserver.org/) is used with PHP map script (http://www.maptools.org/php_mapscript/) to develop the mapping interface. The attribute and time series data are stored in an open source PostGRESQL database.

Figure 1. System diagram.



System Modules

The system currently contains seven information modules mentioned in the ‘Methodology’ section .The detailed descriptions of each module are given below.

Overview

The overview module contains base data to provide an overall picture of the geo-physical conditions of the country. It includes the following data sets:

Administrative Boundaries: Many of the statistical and census data are aggregated by different administrative levels. There are four levels of administrative boundaries in Sri Lanka namely: Provinces, Districts, DS Divisions and GN Divisions. The present system includes administrative boundaries up to DS divisions (Figure 2).

Topography: The system contains 90 m SRTM digital elevation model to represent the topography of the country (Figure 3).

Soil, Land Cover and Agro-ecological Zones: Agro-ecological zones are land resource mapping units, defined in terms of climate, landform and soils, and/or land cover, and having a specific range of potentials and constraints for land use (FAO-AEZ website). Sri Lanka is divided mainly into two major agro-ecological zones, namely the dry zone and the wet zone (Figure 4). A transitional intermediate zone was recognized in 1956-1961 during the study conducted by the Canada-Ceylon Colombo Plan Survey (Somasekaram et al. 1997). The soil map mainly shows the great soil groups. The maps on land expanse show the major areas of land cover including forests, paddy, tea, rubber and coconut cultivation areas.

Figure 2. Administrative boundaries.

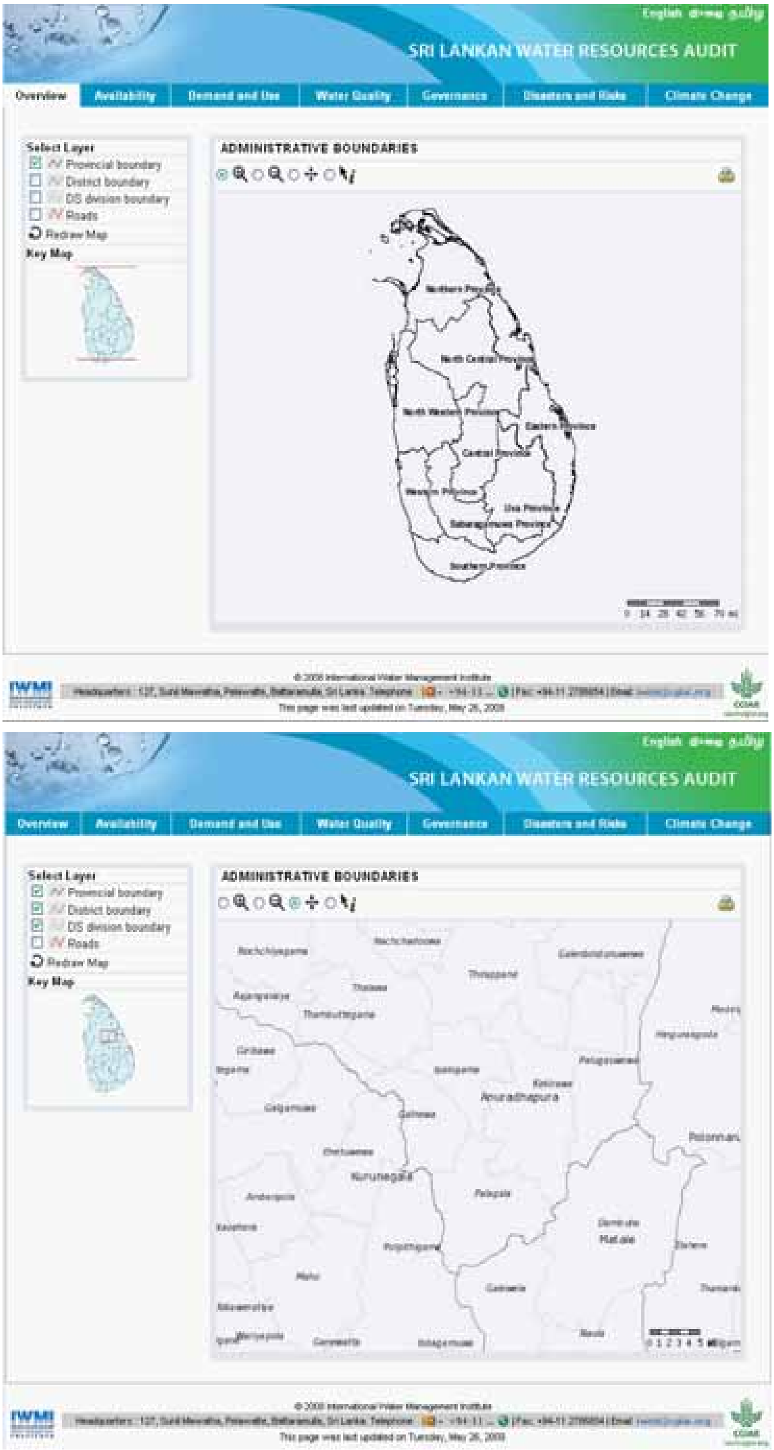


Figure 3. Topography.

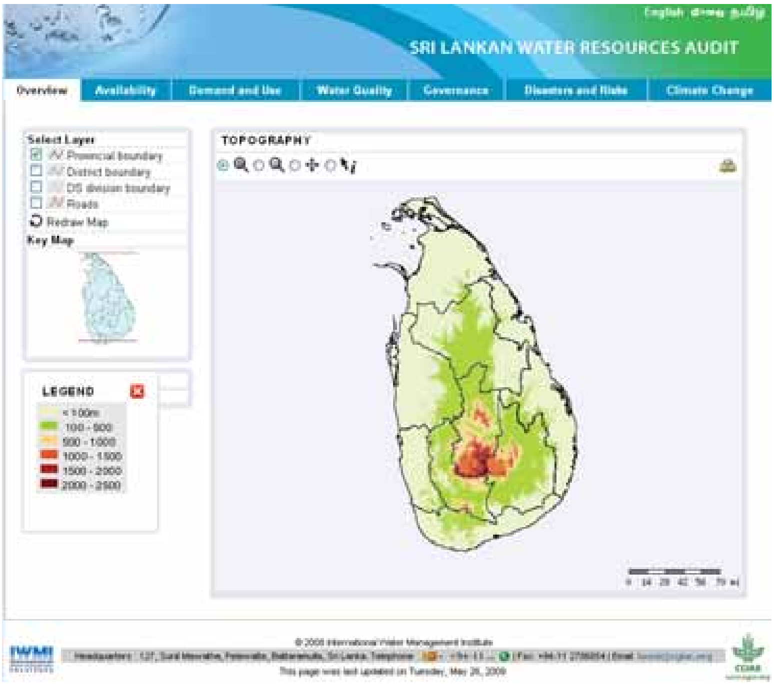
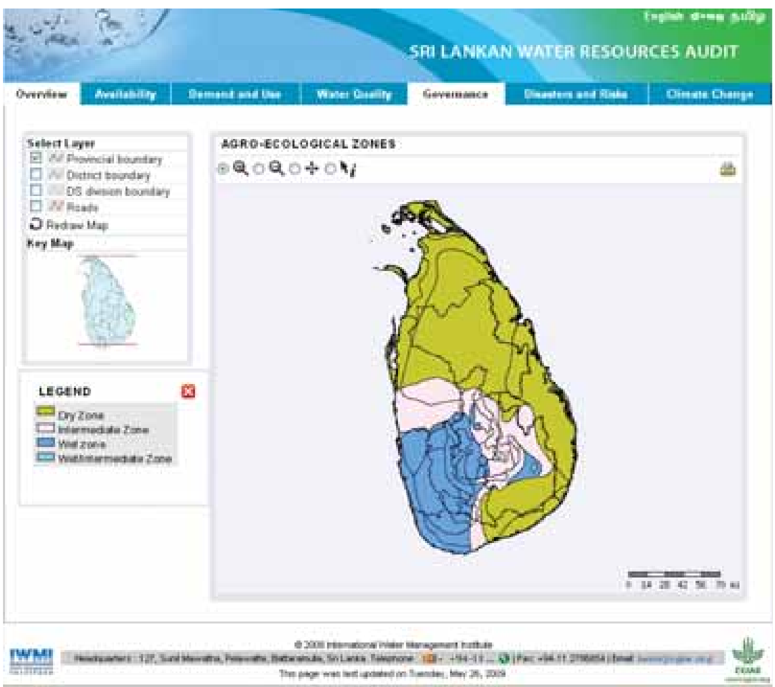


Figure 4. Agro-ecological zones of Sri Lanka.



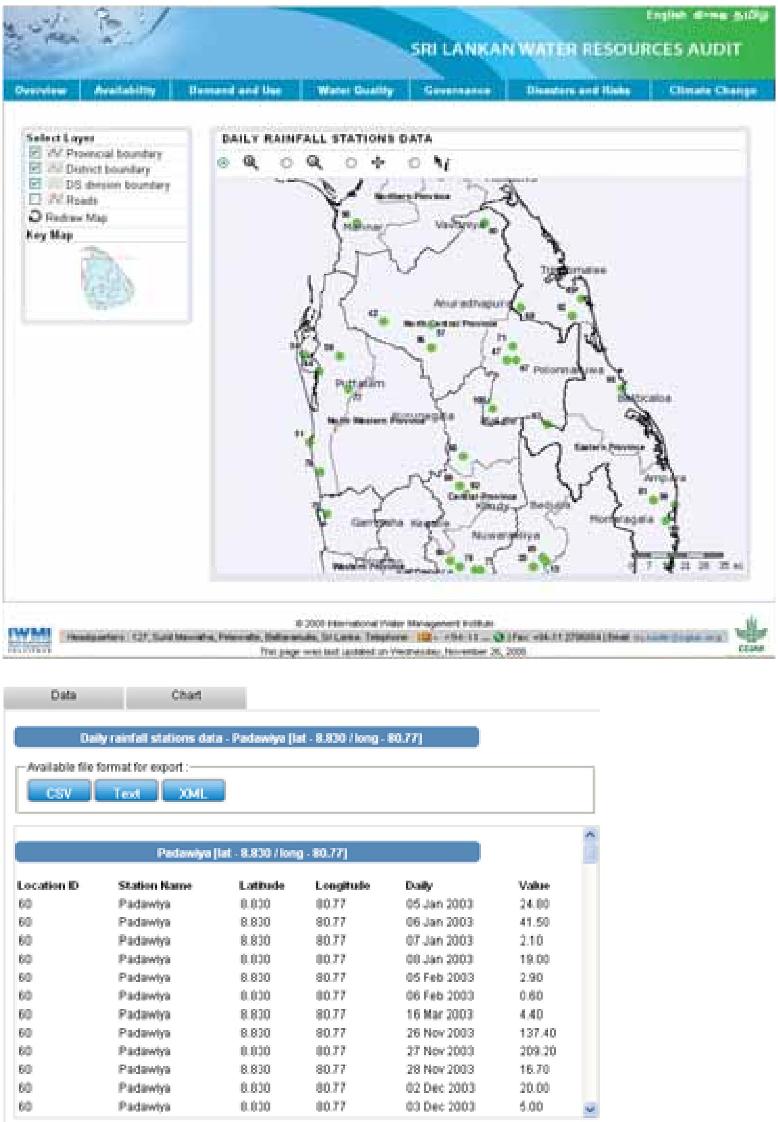
Water Availability

The 'water availability' module contains data on various components of the hydrological cycle, including rainfall, runoff, evaporation, groundwater, river basin characteristics, per capita water availability and trends, and water scarcity.

Time Series Data

The system provides a map-based interface to display rainfall, runoff and evaporation station locations and retrieve daily and monthly station data (Figure 5). The data are displayed in tables and charts with an option for downloading in text or XML format.

Figure 5. Location of rainfall station and data.

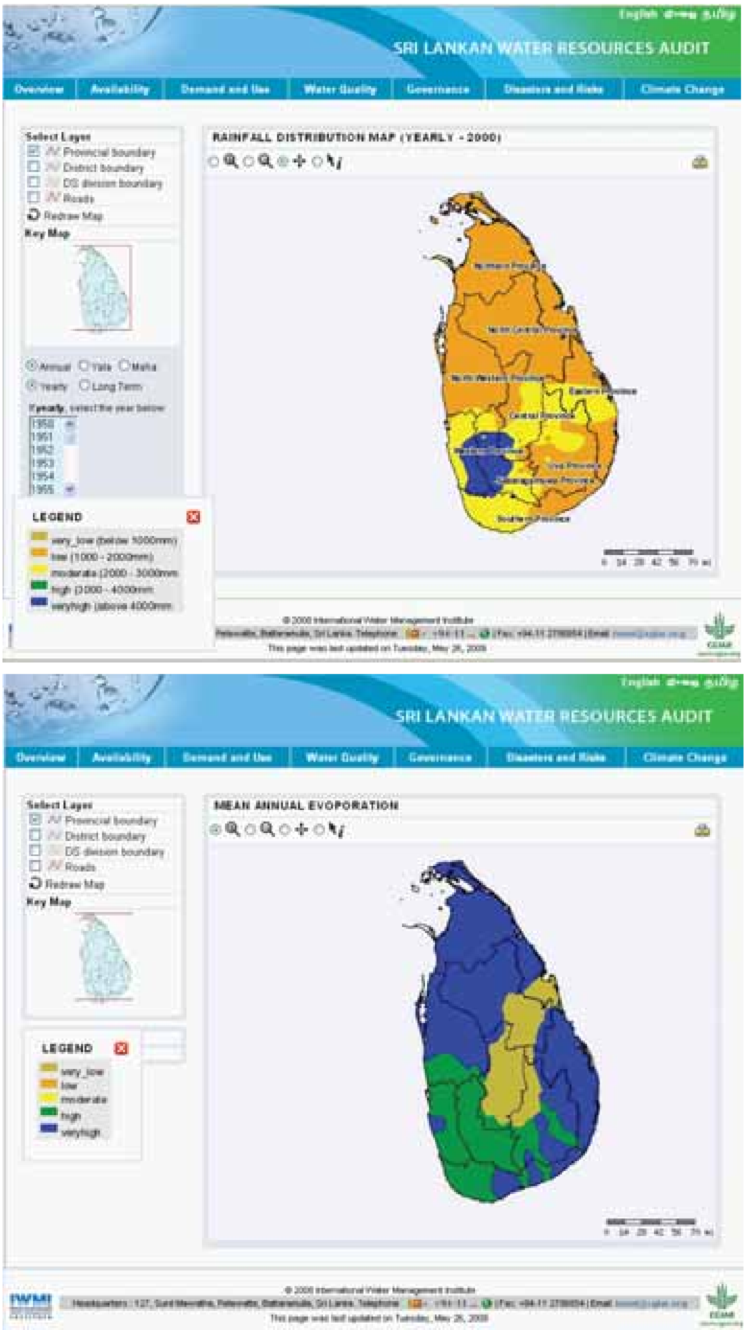


Location ID	Station Name	Latitude	Longitude	Daily	Value
60	Padawiya	8.830	80.77	05 Jan 2003	24.00
60	Padawiya	8.830	80.77	06 Jan 2003	41.50
60	Padawiya	8.830	80.77	07 Jan 2003	2.10
60	Padawiya	8.830	80.77	08 Jan 2003	19.00
60	Padawiya	8.830	80.77	05 Feb 2003	2.90
60	Padawiya	8.830	80.77	06 Feb 2003	0.60
60	Padawiya	8.830	80.77	16 Mar 2003	4.40
60	Padawiya	8.830	80.77	26 Nov 2003	137.40
60	Padawiya	8.830	80.77	27 Nov 2003	209.20
60	Padawiya	8.830	80.77	28 Nov 2003	16.70
60	Padawiya	8.830	80.77	02 Dec 2003	20.00
60	Padawiya	8.830	80.77	03 Dec 2003	5.00

Time Series Grid

Interpolated time series data are useful to visualize the spatial distribution of hydro meteorological variables. The system includes annual and seasonal rainfall distribution for 1950 – 2005 (Figure 6). Similar data could also be generated for other variables.

Figure 6. Distribution of mean annual rainfall, 2000, distribution of mean annual evaporation.



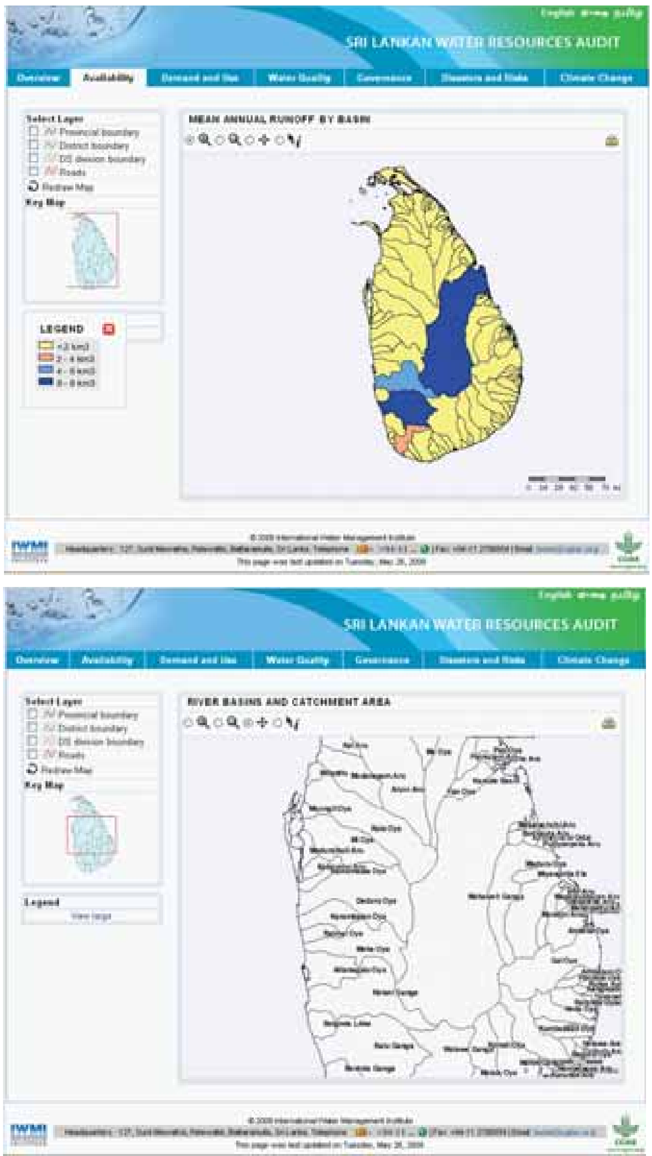
Long-term Averages of Hydro-meteorological Variables

These provide an overall picture of variation in hydro-meteorological variables across the country. The system includes the distribution of annual and seasonal long-term mean rainfall and evaporation.

Summary of Statistics

This is a summary of hydro-meteorological variables in terms of their administrative and hydrological units, which data is useful for planning at those levels. The system includes rainfall and runoff data summarized according to districts and basins (Figure 7).

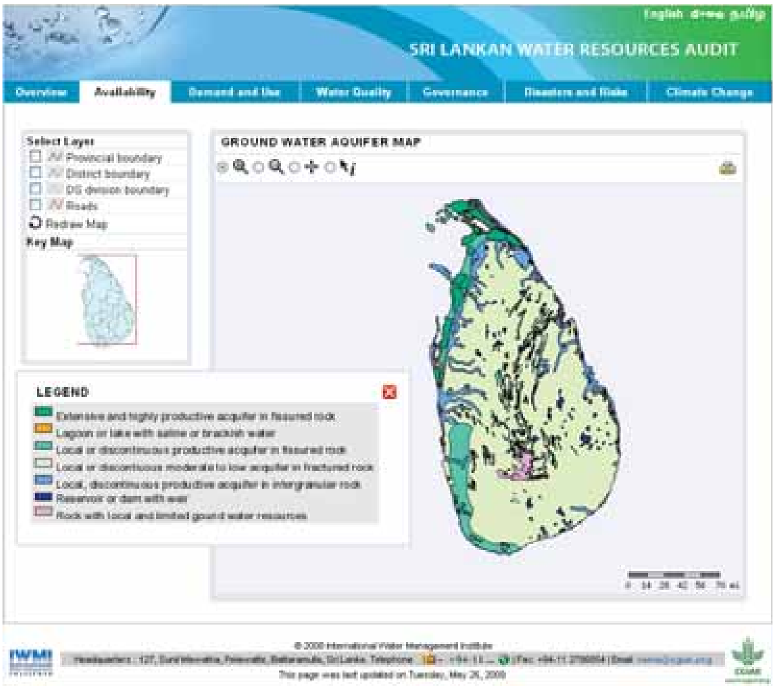
Figure 7. Annual total runoff for basins.



Groundwater

There is no baseline groundwater quantity or quality monitoring system in Sri Lanka (Imbulana et al. 2006). A groundwater aquifer map is included to better depict the groundwater condition (Figure 8).

Figure 8. Groundwater aquifer map.



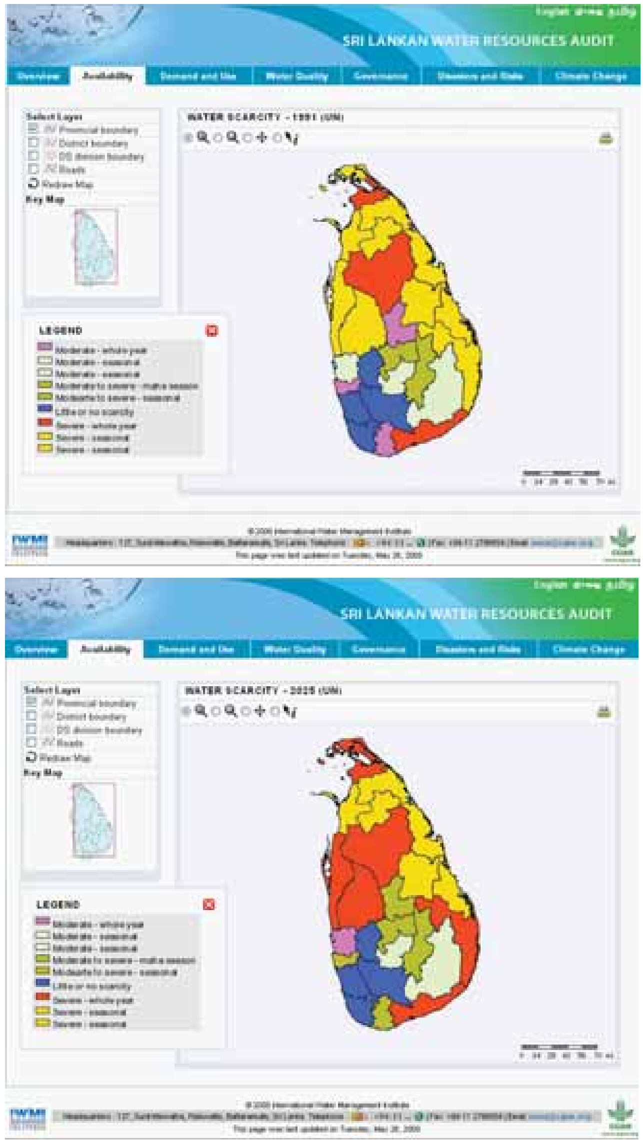
Per Capita Water Resources

The system includes an analysis of district-wise per capita water resources and water scarcity maps (Figure 9). These are helpful to identify resource-scarce areas.

Storage Capacity

Given that about 34 % of the net inflow of water in Sri Lanka is drained to the Indian Ocean, there appears to be some scope for further water resources development (Bastiaansen et al. 2003). Because of the sporadic spatial and temporal distribution of precipitation, the only way water supply can be controlled to match demand is through storage. (Keller et al. 2000). A map is included in the system to show the storage capacities of different districts.

Figure 9. Water scarcity map.

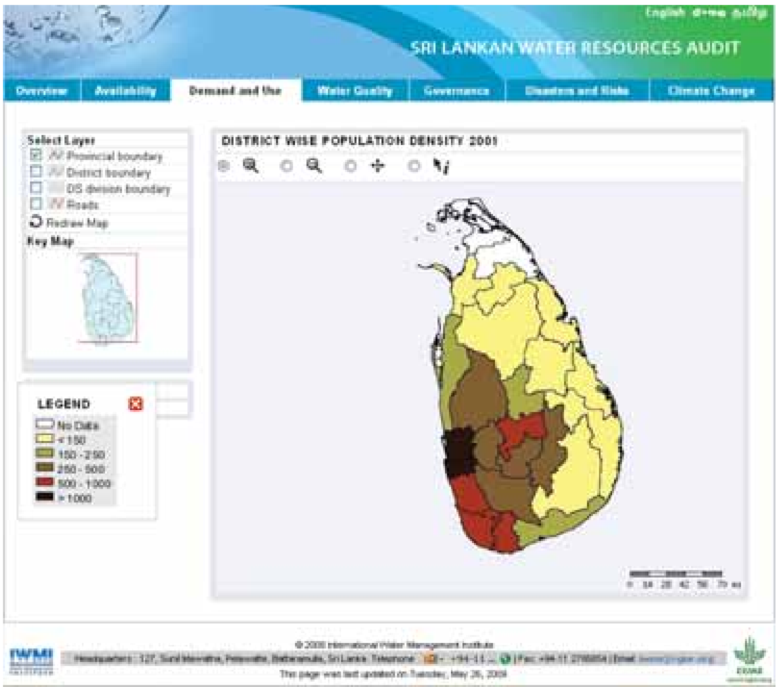


Water Demand and Use

The major driving forces behind the increase in water demand are population growth, urbanization, industrialization, increases in food demand and consumption patterns. The system at present includes several indicators of water use including the below mentioned.

Demography: Understanding population growth and spatial distribution is important when estimating current requirements and when forecasting future needs for water resources. Water use also varies according to different livelihood practices. Analysing changes in livelihoods, including consumption patterns in different areas, is also important in order to understand the potential demand that may arise from such changes. Demographic data are mainly collected and aggregated according to administrative boundaries. The current system includes district-wise data on population density and water consumption (Figure 10).

Figure 10. Population density 2001.

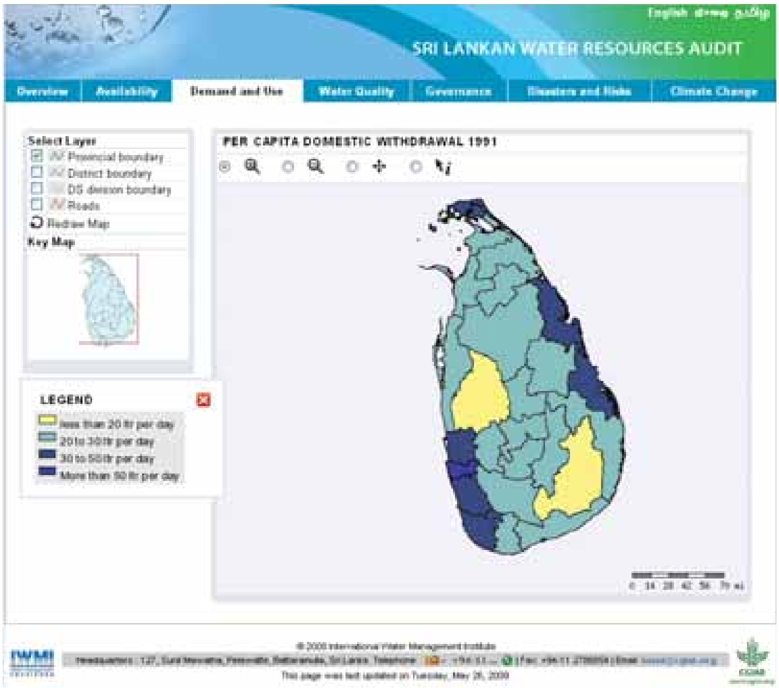


Water Withdrawal: Water withdrawal data is important to understand the exploitation of available water resources in different areas, which in turn can be used to identify areas of scarcity. The system also includes data on a sector basis of per capita withdrawal and the percentage of seasonal withdrawal from available water resources (Figure 11).

Water Quality

Water pollution is a major public health concern in Sri Lanka. There is a limited availability of water quality information in Sri Lanka. The Central Environmental Authority (CEA) undertakes water quality assessments in specific areas to address local needs and regulate local

Figure 11. Per capita domestic water withdrawal 1991.



development projects (Imbulana et al. 2006). The system is designed to incorporate data for monitoring water quality, and data on salinity and water-related diseases. None of the data mentioned in this module is currently included in this model.

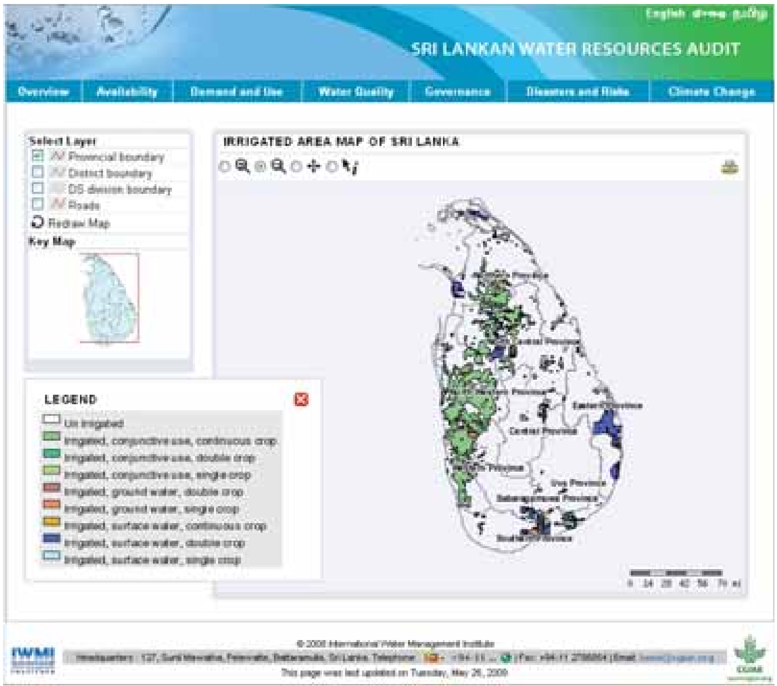
Governance

Governance includes implementing better planning and management in order to improve the availability of water resources and measures such as increasing efficiency in usage of water to cater future demand. Data and information in this module at present includes: irrigation and drainage development, institutions, legislation and finance.

Irrigation and Drainage Development

Irrigation activities in Sri Lanka date back 2,500 years (FAO 2008). The Mahaweli Development Program is the largest multipurpose national development program (Somasekaram et al. 1997). Besides this, there are 535 major irrigation schemes in the country. The system includes maps of irrigation schemes and the Mahaweli system. A map of the irrigated area, generated from satellite remote sensing, is also included (Figure 12).

Figure 12. Irrigated area map.



Institutions

There are about 30 government institutions contributing to water resources development in Sri Lanka (Imbulana et al. 2006). Coordination among these agencies is important to pursue good governance in water management. The system is aimed at obtaining information on these agencies, including contacts of key people, roles and niches of institutions etc. Therefore, the proposed data and information sharing strategy will address and remedy, at least to some extent, the major challenge of overlaps and contradictions in some development programs adopted by institutions to manage water resources.

Legislation

There are over 43 Acts of Parliament concerning the water sector. These laws have been enacted over time to meet specific needs (FAO 2008). A compilation of these laws to provide one-stop access would be useful to identify overlaps, gaps and conflicts. The system aims to include all the water-related laws in the country in the on-line database. Creating a common point of access to existing studies that analyze the laws and institutional jurisdictions regarding this area would be useful in this respect. Another useful feature may be to provide a list of the various provisions dealing with specific topics, e.g., groundwater, farmer organizations and their functions, etc.

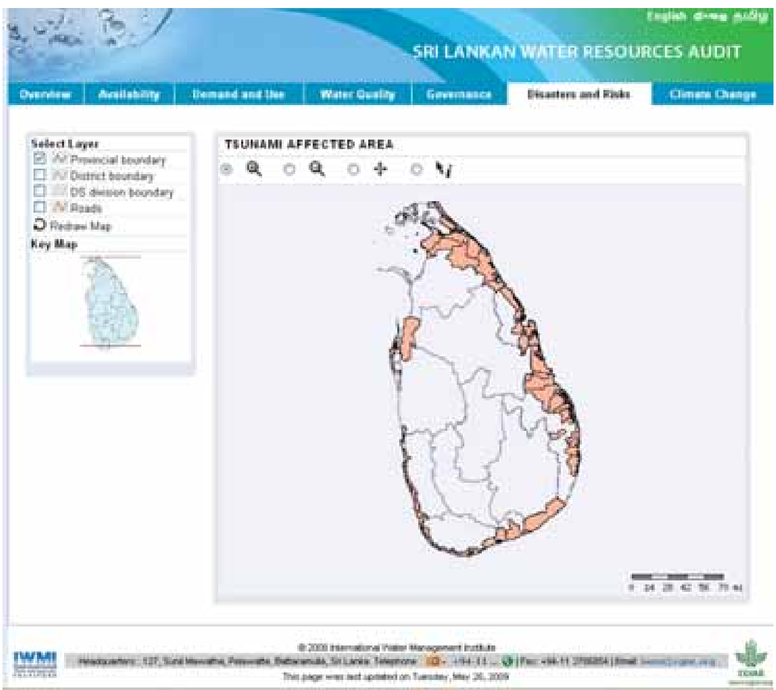
Finances

Investment in water resources has varied from 8 % a decade ago, to around 2 % of total capital investment of the country (Imbulana et al. 2006). Information on tariff structures for the domestic water supply, funding of irrigation development and financing irrigation water resources management will be captured in this section of the on-line 'water audit'.

Disaster and Risks

Major water-related disasters in Sri Lanka include floods, droughts, landslides and tsunamis (Figure 13). Cyclonic storms and gale-force winds are also frequent with monsoon activity or as a result of severe weather changes in the Bay of Bengal (Imbulana et al. 2006). Fifty-eight percent of the country falls under the dry zone, which is frequently subjected to droughts. Occasional droughts also occur in the wet zone. Floods are usually associated with monsoon rainfall. The Kalu, Kelani, Nilwala, Gin and Mahaweli rivers, originating from the wet zone, are the major flood- prone rivers in Sri Lanka (Imbulana et al. 2006). Eight districts in the central highlands are at risk of land slides (Ralapanawe – website). Though tsunamis are not a frequent disaster in Sri Lanka, in 2004 most of the coastal districts were hit by a tsunami, which caused severe damage. Information of water-related disasters would be useful to plan for prevention, mitigation and rehabilitation.

Figure 13. Tsunami affected areas.



Climate Change

The change in precipitation patterns, caused by climate change, might have a high impact on the availability and distribution of water resources in Sri Lanka. Climate change may also impact the rise in sea level and saline water intrusion in the rivers. Information on these subjects would be useful for adaptation planning.

Multi-lingual Features

The interface of the system will be translated into the Sinhala and Tamil languages to promote the use of the system at local level (Figure 14).

Figure 14. Sinhala interface of the system.

Conclusions and Recommendations

The present system for water resources audit is to demonstrate a prototype framework for organizing, accessing and sharing water resources related data and information. The system is currently a ‘work in progress’ and only an illustration of what can be achieved. It is envisaged that through cooperation with national agencies, the system will be enhanced into a unified platform for maintaining and sharing data by various participating agencies and will be used to conduct a systematic assessment of water resources in Sri Lanka. By developing the concept of a comprehensive and national water audit, Sri Lanka may provide as an example to other developing countries too.

References

Amarasinghe, U.; Mutuwatta, L.; Sakthivadivel, R. 1999. *Water scarcity variations within a country: A case study of Sri Lanka.* IWMI Research Report 32. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Amarasinghe, U.; Samad, M.; Anputhas, M. 2005. *Locating the poor: Spatially disaggregated poverty maps for Sri Lanka.* IWMI Research Report 96. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Australia 2000. Australian Water Resources Assessment 2000.

Bastiaansen, W.G.M.; Chandrapala, L. 2003. Water Balance Variability across Sri Lanka for Assessing Agriculture and Environmental Water Use. *Agricultural Water Management* Vol. 58, p 171-192.

EEA. 2007. Climate Change and Water Adaptation Issues. EEA technical report, 2007.

FAO (content source); Panikkar, A. K. (Topic Editor). 2008. 'Water Profile of Sri Lanka'. In: *Encyclopedia of Earth,* ed. J. Cutler. Cleveland, (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth April 7, 2007; Last revised August 24, 2008; Retrieved November 20, 2008]. <www.eoearth.org/article/Water_profile_of_Sri_Lanka>

FAO-AEZ : Agro ecological zones information portal (www.fao.org/ag/agl/agll/prtaez.stm)

Imbulana, K. A. U. S.; Wijesekera, N.T.S.; Neupane, B. R. 2006. 'Sri Lanka National Water Development Report'. Prepared for the 2nd UN World Water Development Report, 2006.

Keller, A.; Sakthivadivel, R.; Seckler, D. 2000. *Water scarcity and the role of storage in development.* IWMI Research Report 39. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Molden, D. 2007. Water for food, water for life: A comprehensive assessment of water management in agriculture. International Water Management Institute, 2007

Ralapanawe, V. www.recoverlanka.net/background/hazards.html#landslide

Somasekaram, T.; Perera, M. P.; Godellawatta, H. 1997. Atlas of Sri Lanka, Published and distributed by Arjuna Consulting Co Ltd., ISBN 955-9276-04-02.

Sri Lanka's Water Policy: Themes and Issues

V.K. Nanayakkara
Director, Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI) and former Chairman, Water Resources Council, Sri Lanka

Abstract

Fresh water resources in Sri Lanka remain a free public good with the State acting as the trustee and custodian of the resource. Although the country is blessed with a seemingly plentiful supply of water, it encounters severe problems of temporal and spatial scarcity. Nearly five decades of efforts at formulating a national water policy with a view to introducing a bulk water allocation system have failed mainly due to a lack of understanding of the basic issues confronting certain elements that constitute the basic policy. This paper presents selected key themes and issues which help stimulate the formulation and adoption of an improved water resource policy statement.

The author argues that what is important in the case of water is not the question of 'ownership' of water but regulating the user rights of this common property resource, particularly since such use is always in a state of flux. In the course of its movement in the hydrological cycle, it can only be owned when it is captured in a receptacle or in an impounding tank or as treated water in a reservoir and water conveyed in an irrigation channel. But, it is this very right to abstraction of bulk water from its natural state that is not defined and left to the will of individuals and agencies – virtually resulting in the creation of a 'free for all' situation. While the domain of water is characterized by over 50 legislative enactments and a plethora of agencies numbering over 40, there isn't a single neutral agency to determine the appropriate balance between the demands for off stream consumption and the volume of water flows needed by the river system.

The objectives of this paper are: to clarify the meaning of the terms 'ownership', 'user-rights', 'common property rights', and 'right to water'; to analyze and suggest refinements to several water policy themes and issues such as 'bulk water entitlements', 'groundwater management' and 'user conflicts'; to outline the roles of institutions for clarity in implementation; to suggest elements that should constitute a future water policy. A better understanding of the issues relating to this finite and vulnerable resource will help clarify the policy concerns that are constantly overlooked – intentionally or unintentionally - in the domain of water.

Does Sri Lanka have the right water resource policies for the twenty-first century? Such concerns prompted policymakers to attempt several policy reforms in Sri Lanka's water domain during the last five decades. Several United State Agency for International Development

(USAID) and Asian Development Bank (ADB) efforts culminated in producing a 'national water resources policy and institutional arrangement' document with a water policy approved by the Cabinet of the Government of Sri Lanka in March 2000. Yet, public concerns expressed on certain sensitive issues, and the lack of consensus due to the changing hands of the subject of policy development among various successor ministries, resulted in the demise of this water policy formulation effort.

Ownership or User Rights

One of the most contentious issues in the national water resource policy process was the question of ownership. Skeptics alleged that ownership would pave the way for the sale of the water resource, which should be freely available to the people as a human right. Can water be owned? Ownership connotes a right to prevent others from using a 'resource'. Yet water is a common property resource that is always in a state of flux. In the course of its movement in the hydrological cycle it can only be owned when captured in a receptacle. It is best defined as a common property resource, not a state or a private property and, as such, incapable of being owned. What is the value of expressing ownership for a fugitive and constantly changing asset? What is relevant is the right to use and acknowledging a human right to a basic water requirement. Under the Roman Law, the air, the rivers, the sea and the seashore were incapable of private ownership. This concept of common property, called, the Public Trust Doctrine maintains that the state holds navigable waters and certain other water resources as common heritage for the benefit of the people.[1] The doctrine can prevent the continued destruction of public waters (Stevens 2003).

Water rights are linked to land ownership. In Sri Lanka, a landowner is regarded as owning the water underneath his land and consequently has a right to pump all the water from the common aquifer, thereby lowering the water table. Furthermore, he may use or abuse all the rain which falls on his land. In Sri Lanka, all the streams that flow across a private land fall within the public domain. Right to abstract and use surface and underground water should be subject to a right of reasonable use without a permit. Extraction of water by mechanized means may not be a reasonable use, for which, a permit requirement should be recognized. A water right entitles a holder of the right to exclusive use of surface or subsurface (underground) water for a specified purpose. It does not, however, endorse a right to own the river or underground water. Consequently, a water right only permits the use of water up to the permitted quantity. Being a property right, its infringement by external parties can be prevented.

People may have an exclusive right to the use of water, but it can never be 'owned' as it passes through a particular point on its continuous journey through the water cycle. The government is the custodian of the island's water resources, as an indivisible national asset

[1] Issuing its landmark judgment on the Water's Edge Golf Course Case, in the matter of an application under Article 126 of the Constitution in S.C. (F.R) No. 352/2007, the Supreme Court declared that the sovereign lands of a state are held in trust by the state for the benefit of all the people of the country and ruled that the tract of land acquired for the public purpose of providing water retention as a low lying area has "to serve needs of the general public as distinct from the elitist requirements of the relatively small segment of society in Sri Lanka."

and has ultimate responsibility for and authority over water resources management, the equitable allocation and usage of water and the transfer of water between catchments. This principle recognizes that where resources are limited and the competition is increasing, some party has to have oversight and custodianship over those resources. This means that the government is not the legal owner of water but the overall manager of water. Ownership is a difficult legal concept. Property rights can vary significantly in nature and degree. There is a difference between right to access / right to use and the ownership of water.

Water rights can be broadly categorized into public, common or private property on the basis of the decision-making rights of allocation. In public water rights, the government asserts its rights over water by controlling the allocation directly through government agencies. People obtain water rights by acquiring water permits, which allow them to use but not own water. In common water rights, people can use water in ways that are specified by the given community as seen in many farmer-managed irrigation systems in Asia. Private property rights are those held by an individual or legal personality such as a corporate body. In some cases, private rights go beyond mere user rights to include a sale or lease to others as in Chile's tradable water rights systems (Ruth Meinzen-Dick et al. 2007).

Is there a human right to water? In 1948, when the Universal Declaration of Human Rights was adopted, but no explicit recognition of a right to water was made as water like air is so fundamental to preserve life. The International Covenant on Economic, Social and Cultural Rights (1966) recognized this right under two articles, namely, article 11 - the right to an adequate standard of living and article 12 - the right to health. The Committee on Economic Social and Cultural Rights adopted general comment No.15 in November 2002 in which water is recognized, not only as a limited natural resource and a public good, but also as a human right.[2] Although not legally binding, the right to water requires governments to increase progressively the number of people with safe, affordable and convenient access to drinking water. Access to basic sanitation is also included in the right to water. It is noteworthy that the right to water does not mean water is free, but rather that it be affordable and accessible to all.

Bulk Water Abstraction

Water has to satisfy multiple needs as it flows through a catchment. Currently, there is no proper bulk allocation system in Sri Lanka. Some large consumptive users allocate water to themselves. In the current situation, the agency that operates the structures also controls the water allocation. For example, in the upper reaches of the Kelani River, hydro-electricity producers control the water releases. At the lower reaches at Ambatale, the National Water Supply and Drainage Board (NWSDB), which controls the intake structures, decides water allocation and consequently determines the balance flow for ecological purposes. Wherever irrigation structures are found, the Department of Irrigation controls the quantity for diversion.

[2] The comment provides guidelines for State Parties on the interpretation of the right to water and that it emanated from and was indispensable for an adequate standard of living as it is one of the most fundamental conditions for survival. The right to health entails the underlying determinants of health, inter alia, access to safe and potable water. http://www.unhchr.ch/html/menu3/b/a-cesr.htm.

The most serious deficiency observed in water allocation has been the tendency by large water users to allocate water to themselves regardless of the needs of others.

Often, there are inter-agency conflicts, particularly during times of low flow. When consumptive users such as irrigators, urban water providers, industrial and commercial users appropriate the scarce surface water, who will ensure the minimum environmental flow for the preservation of river ecology, fishing and a host of other in-stream uses? The reasons for a neutral' State Authority' involvement in managing water resources are to coordinate the sharing of water for the benefit of all existing and potential users, whether they obtain their water from watercourses, underground water or overland flow, and to protect the environment. The challenge for the proposed authority is to establish a set of allocation principles that are rational and can accommodate long-term demands.

Do we need to establish a formal water allocation system? Can we meet all our water needs in the domestic, irrigation, hydropower generation, recreation, navigation and fishery development sectors? Can we guarantee a basic water requirement to all the people for all the above competing needs without managing the resource? The dilemma we face as a nation is how to manage our water bodies in a sustainable manner, so that future generations too will inherit a healthy river system with the capacity to provide our drinking water needs, capacity to support productive agriculture and preserve an ecosystem with a diverse range of flora and fauna.

When deciding water allocations, responsible agencies now have to take into account many more competing demands than in the past. And to this day, about 4.6 million out of the 20 million inhabitants in the country, predominantly those living in the rural areas, do not have access to safe drinking water (Wickramage 2008). They have to meet their water requirements from wells and rivers, the quality of which water is questionable. How can universal access to safe drinking water be ensured unless the freshwater sources are protected from ad hoc withdrawals by powerful vested interests?

Water use consists of three types: (a) intake uses (b) on-site uses and (c) flow uses. Intake uses for domestic, agricultural and industrial purposes, actually remove water from its source. On-site uses include water consumed by the wetlands, swamps, evaporation from surface water bodies, natural vegetation and wildlife. Flow uses include water for estuaries, navigation, waste dilution, hydro-electricity, fish and recreational uses. What is important is to determine whether the allocation for such uses has to be permitted as a 'free-for-all' or whether guidelines should be enforced by a neutral agency. The use of water for primary needs, like domestic use, and watering of plants and livestock, should be free without the need for a permit. However, any system of bulk water entitlements is likely to fail if the 'reasonable user' categories are not clearly specified in legislation. (Nanayakkara 2003).

User Conflicts

With less water available, the resource harbors a considerable potential for conflict, which may occur among individuals or community groups who require water for drinking or for cultivation or for commercial/industrial purposes. While the irrigation sector's head-end-tail-end problems are well known, and such conflicts are resolved at cultivation ('Kanna') meetings, there is no arbitrator for water conflicts between drinking or cultivation purposes. Furthermore, the urban population in Sri Lanka is projected to increase to 45 % by 2015 and 65 % by 2030

(Presidential Task Force on Housing and Urban Development, 1988, p.4). The expanding water requirements of growing urban populations are worsening the scarcity of water and seriously encroaching onto the water resources that were previously devoted to agricultural use, particularly in the dry zone. A case in point is the Anuradhapura Water Supply Scheme, which competes with irrigation requirements of the Thuruwila farmers. (Aheeyar et.al. 2008). With economic growth, new appropriation of water for commercial, agriculture, industrial or hotel use would disturb the earlier appropriations.

The water crisis in Sri Lanka's south-eastern arid zone has resulted in communities fighting with one another for their dwindling water supplies. A recent HARTI (Hector Kobbekaduwa Agrarian Research and Training Institute) study shows that the water sharing arrangement practiced in the Kirindi Oya Irrigation and Settlement Project (KOISP) between the 'old system farmers' and the 'new system farmers' is a clear example of inequity, where the old system farmers are provided with 70 % with only the balance for the new system users. While a large number of small tanks used by the farmers in the new system area were demolished for the KOISP, the farmers were denied equitable use since a 'prior appropriation' right taking precedence over 'riparian' rights (Aheeyar et al. 2008). Furthermore, it is observed that customary cattle watering places were not recognized in the development of the Kirindi Oya system (Ruth Meinzen-Dick, 2001). Farmers and pastoral groups in the Kirindi Oya area have different perceptions on water.

The dry zone is historically a water-stressed region. But what is the situation in the water-rich wet zone? The following case illustrates an instance of conflict among the farmers depending on small tank/anicut systems and the beneficiaries of rural village water supply schemes, for which water is drawn from the same supply source upstream of the small tank. The townships of Galaha and Deltota in the Kandy District suffer from a severe water shortage for domestic purposes. The rural water supply schemes are unable to cater to this fast developing area where human settlements have increased. In order to meet this demand for domestic water, extraction from Loolkandura Oya has been mooted. However, the farmers in the Gabadagama area object to any diversion of water from Loolkandura Oya as water from this stream has been used to cultivate paddy in Gabadagama north and south. In addition the villagers in Gabadagama obtain their drinking water requirements from this source.[3]

The absence of any principles for sharing water between upper and lower riparians as well as between drinking and irrigation purposes has hindered the development planning efforts of both the Irrigation Department and the NWSDB. Should the 'prior appropriation' doctrine prevent any beneficial use by later water users? Clearly, the rapidly growing populations in Galaha and Deltota townships foster fierce competition for the use of scarce water of the Loolkandura Oya placing a strain on a fragile and finite resource. Who should get priority of use during times of shortage? Where, in the balance of competing interests, does natural justice lie? Climate change and population growth may exacerbate the ever more complex problems of water abstraction.

[3] Information obtained as per interview on May 25, 2009 with Ms. Illangasinghe, Project Director, Towns South of Kandy Water Supply Project, National Water Supply and Drainage Board.

There is no mechanism or institutional arrangement for decision making with regard to bulk water allocation as the above case illustrates. The absence of such a bulk water allocation policy compels ad-hoc decision-making by reference to political authorities who are dictated to by pressure groups rather than by any consensus among the stakeholders. It is essential to develop principles for equitable sharing of water between the upper and lower riparians.

Groundwater Management

A vastly under-valued resource, groundwater, is one of the keys to solving the water crisis, but lies hidden out-of-public-sight. It represents 97 % of the planet's accessible freshwater reserves, and currently supplies innumerable farmers, many industries and 2 billion people with their daily water needs, and is also an essential source of water for countless springs and wetlands, for dry-weather flow in the upper reaches of most rivers, and contributes significantly to species diversity in coastal estuaries. Yet in many nations, unsustainable groundwater practices are contributing to significant and irreversible damage to the resource base. Groundwater extraction can be traced in great part to the use of flood irrigation to mass produce food – the driving factor behind the Green Revolution. Since 1950, the global acreage of land under irrigation has tripled (Maude Barlow 2007).

A water policy should address not only surface water but also the groundwater resource. Currently, a doctrine of territorial sovereignty is applied in groundwater extraction, which means that "what is beneath our feet is ours to use." Groundwater, though not as visible as surface water, is ubiquitous in the island's land mass and its use is rapidly increasing in Sri Lanka, intensifying smallholder cultivation and improving the standards of living of poor farmers in the dry zone. The dry-zone farmers lament the lack of water for their crops at the end of the growing season, because over extraction has dried out aquifers. In some areas, like Kalpitiya Peninsula, high concentrations of nitrates and agro-chemicals are already being found in the groundwater (IWMI Water Policy Briefing, Issue 14, p.2). Despite the intense use of agro wells during the last couple of decades, groundwater use has so far been unregulated. Ownership of the overlying land should not permit the occupier to pump underground water through mechanical means. Guidelines should be established prescribing the spacing norms for pumps and wells.

The groundwater management necessitates proactive intervention because high abstraction rates and uncontrolled developments require management policies, which strive to balance the needs and interests of all water users and affected stakeholders in a particular region. A survey conducted by IWMI revealed that "…in Sri Lanka, some aquifers are already being pumped dry by the end of the dry season, and some communities have been left without drinking water." Furthermore, farmers in the lower reaches of the Hakwatuna scheme in the Deduru Oya basin, for example, are lamenting that heavy pumping upstream has reduced the availability of both groundwater and surface water in their area (IWMI, Water Policy Briefing, Issue 14, p.4). Water rights may offer a way for poor irrigators to protect their river water from being stealthily stolen by wealthy and powerful investors through induced seepage and reduced base flow caused by heavy pumping.

Over-extraction also has far-reaching economic and environmental effects. Aquifers are naturally discharged into rivers and other water bodies during dry periods, thereby sustaining important wetlands and native vegetation. Because Sri Lanka's aquifers are shallow, they are particularly vulnerable to pollution. Safeguarding water quality is vital, especially as 66 % of rural drinking water comes from open dug-wells (DCS 2008). Additionally, other pollution problems have also emerged. Several deep tubewells constructed recently to provide drinking water in the dry zone have been abandoned because of high iron and fluoride concentrations.

The Water Resources Board is mandated to collect, collate, analyze, interpret and disseminate groundwater-related data in Sri Lanka. All groundwater sources used for domestic and livestock purposes should be subjected to a detailed water quality analysis at the implementation of the scheme. The microbiological, physical and chemical parameters should be included in such a water quality surveillance programme. All wells need to be registered to monitor trends in groundwater development and its use. Agro-chemical pollution of aquifers and soil salinization also need to be monitored, particularly in areas where groundwater is used for drinking and where there is not enough rainfall to flush out salts and other contaminants (ibid, p.2).

The implications of stream-aquifer connectivity and the need for a conjunctive management approach are the most under appreciated issues in Sri Lanka. A management policy should clearly stipulate that groundwater should not be regarded as a resource separate from surface water. The policy should recognize that both surface and groundwater are hydrologically connected and are complementary components of a larger single system.

Governance and Institutions

The complexities of water use require that all the players – water users, policymakers and planners at all levels be actively involved in decision-making, planning and implementation of water management. Centralized and sectoral approaches to water resource development and management are insufficient to solve local management problems. The role of government needs to change to ensure a more active participation from people, local institutions, NGOs and Community Based Organizations (CBOs). The management of a resource at the lowest appropriate level requires the fundamental principal of a decentralized approach. Yet, such an approach would fail if it were to operate in an institutional vacuum. Figure 1 depicts the sectoral and non-sectoral players at national and sub-national levels that handle various aspects of the management of water resources.

The quasi-federal character of the Sri Lankan polity after the enactment of the Thirteenth Amendment to the Constitution has some particular implications for water management. The confusion governing the allocation of the subject of irrigation within the provincial, central and concurrent jurisdictions is illustrated in Table 1 by juxtaposing the subjects and functions assigned to the Central Government and the Provinces. The Provincial Council list empowers the centre to handle inter-provincial irrigation and land development projects, which utilize water from rivers flowing through more than one province. It also empowers the centre to handle all schemes where the command area falls within several provinces, such as the Mahaweli Development Project.

There is a need for an institutional arrangement at the national level, such as a proposed National Water Resources Authority (NWRA) capable of defining the overall water policy directions and adjudicating disputes. The complex functions of a national authority lie in the establishment of effective integration of the overall socioeconomic and environmental decision -making process. Figure 2 depicts the sectoral and sub-sectoral areas dispersed in the domain of water with a need for a central apex body to provide a system of linkages between existing organizations, including basin authorities for harmonizing policy approaches.

Figure 1. Institutional setting.

National Level	
Non-sectoral Players	
• WRC (Proposed)	Policy formulating body for Water Resource Allocation
• NWRA (Proposed)	Water Rights, Bulk Entitlements
• CEA	Environmental Quality Standards, EIA Procedure (Tolerance limits for discharge of effluents into inland waters)
Sectoral Players	
• Irrigation Department	Irrigation development and maintenance
• CEB	Power generation, transmission and distribution
• Mahaweli Authority	Water and related infrastructure development in designated basins; Water panel
• NWSDB	(1) Regulator for drinking water : (2) Operator of integrated urban schemes, small town schemes
• Department of Agrarian Development	- Village irrigation
• Department of Fisheries	Aquaculture, fisheries management
• NARA*	Aquaculture and fisheries research
• Water Resources Board	Hydro-geological investigations into groundwater
• NAQDA** Development of aquaculture and inland fisheries	
Provincial Level	
Provincial Ministry of Irrigation	
Provincial Ministry of Local Government	
Divisional Level	
• Divisional Secretary	Divisional Agricultural Committee, Kanna meetings
• Farmer Organizations	O&M of field channels, and distributory channels, Village irrigation
• Local Government Level	
Municipal Councils	Urban water supply systems
Urban Councils	Unintegrated urban systems, small towns water supply schemes,
Pradeshiya Sabha	Rural water supply schemes
Village level	
CBOs/NGOs	Community water supply schemes (piped, gravity schemes, rainwater harvesting schemes.)

* National Aquatic Research Agency

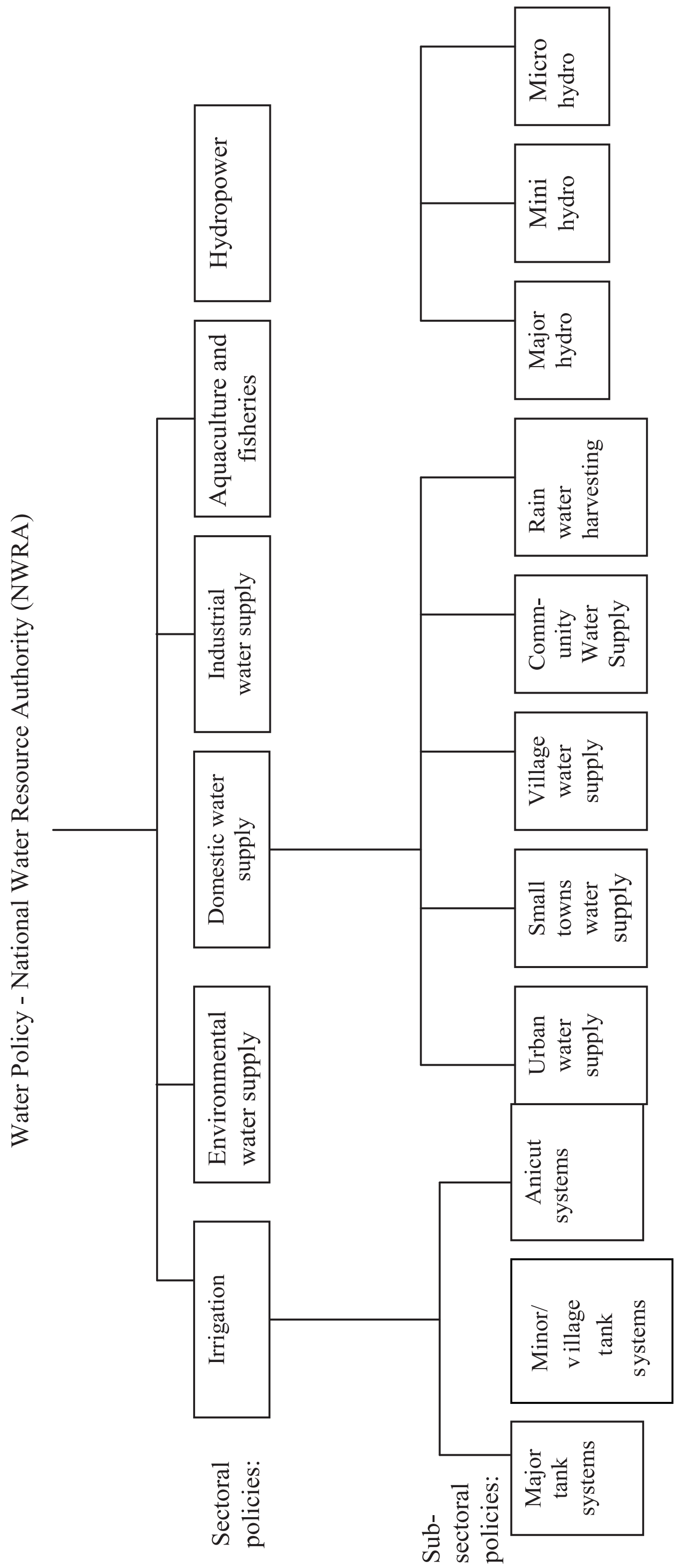
** National Aquaculture Development Authority

Table 1. Competence jurisdiction relating to irrigation in the Thirteenth Amendment.

List 1 - Provincial	List 2 – Reserved	List 3 - Concurrent
9.2 Rehabilitation and maintenance of minor irrigation works 19. Irrigation – Planning, designing, implementation, supervision and maintenance of all irrigation works, other than irrigation schemes relating to rivers running through more than one province or inter provincial irrigation and land development schemes.	National Policy on Irrigation Rivers and waterways; shipping and navigation: maritime zones including historical waters, territorial waters, Exclusive Economic Zone and continental shelf and internal waters; state lands and foreshore, except to the extent specified in item 18 of List 1. Inter-provincial irrigation and land development projects 2.1 Such projects would comprise irrigation and land development schemes- (a) within the province initiated by the State and which utilize water from rivers flowing through more than one province: a Provincial Council however, may also initiate irrigation and land development schemes within its province utilizing water from such rivers; (b) within the province which utilize water diverted from water systems located outside the province; and (c) all schemes where the command area falls within two or more provinces such as the Mahaweli Development Project. 2.2 These projects will be the responsibility of the Government of Sri Lanka. 2.3 The Government of Sri Lanka will be responsible for the administration and management of such projects.	17. Irrigation - 17.1 Water storage and management, drainage and embankments, flood protection, planning of water resources. 17.2 Services provided for inter-provincial land and irrigation schemes, such as those relating to rural development, health, education, vocational training, co-operatives and other facilities.

Source: Damayanthi and Nanayakkara (2008), Impact of the Provincial Council System on the Smallholder Agriculture in Sri Lanka, Colombo HARTI, p. 21

Figure 2. Policy areas in the domain of water use.



Unfortunately Sri Lanka does not have a single water administration, which is responsible for the freshwater resource, as a whole. But, it does have multiple authorities for the sectoral aspects of water administration. Where traditions of inter-jurisdictional jealousy and distrust preclude opportunities for coordination of the economy, fragmentation remains an impediment to productivity gains. Consequently, the responsibility for the development, apportionment and management of the freshwater resource is ad-hoc, tentative and confusing.

What does the sectoral organization of society imply with regard to demands on water? The health authorities are interested in water supply and sanitation to protect against water-related diseases, high morbidity and mortality. To date, around 6 million inhabitants in the country have to meet their drinking water requirements from wells and streams, the water quality of which is questionable. How can universal access to safe drinking water be assured unless the freshwater resources are protected from ad hoc withdrawals by powerful vested interests?

The agricultural authorities are responsible for crop production, in ensuring food security, excessive increasing of water requirements for intensive land use, often leading to land degradation. Irrigated agriculture claims the lion's share of the island's water use, accounting for over 70 % of total withdrawals. The Central Environmental Authority is responsible for habitat protection to avoid ecosystem degradation and maintenance of water quality. The economic development authority is responsible for industrial production, thereby increasing water requirements, may also leads for generating pollution loads.

In-stream use of water also serves fisheries, transportation and recreation needs. Although hydro-power is a non-consumptive use, it requires public water allocation through decisions to build dams and the operating rules that change the flow pattern of rivers. Public allocations to fisheries, wildlife and navigation are embodied in the restrictions on the development or withdrawal of water for other uses. The primary challenge in Sri Lanka is, and will be, how to cope with the rising competition for water between multiple kinds of users in ways which are equitable, efficient and sustainable.

At the national level, a large number of ministries, departments and public corporations have responsibilities impinging on water resource management. These institutions, numbering over 30, perform various functions such as irrigation, drainage, water supply, hydropower and ecological purposes (Imbulana et al. 2006). Central agencies are categorized according to water use (irrigation, drinking water, hydro-electricity, forest, land), and each is vested with multiple functions (policy, regulatory, commercial and conservation). It is easy for an agency to compromise one function in favor of another. The tunnel-view tendency in each of these sectoral bodies introduces incoherence in decision-making that explains many of the difficulties in coping with emerging problems.

Responsibilities for management of the water resources are scattered over different agencies within provincial, district and divisional administration. The management of some of the major and medium sized irrigation reservoirs and minor tanks/anicut schemes has been entrusted to the Project Management Committees/Farmer Organizations with shared responsibilities. Some of the large reservoirs serving multi-purpose objectives are also managed by agencies such as the Ceylon Electricity Board, Irrigation Department, National Water Supply and Drainage Board and the Mahaweli Authority of Sri Lanka. A multiplicity of institutions is sometimes unavoidable. Water resource, by its very nature is cross sectoral, whereas administrative arrangements of the government are based on the sectoral approach.

The above institutions also fall into the category of water users when they function as service delivery agencies, playing a dual role at the same time. There isn't an integrated approach to water resources management or a system that separates development and service delivery functions of an authority responsible for the management of the resource. There is also a lack of a legally empowered authority or agency to allocate water for different water users although the Irrigation Department in certain critical situations assumes such a responsibility.

Future Directions

As a growing population will increase needs and expectations for water use, and as supplies become further stressed and polluted, the government needs to refocus its approaches to water management. What could be the elements of such a comprehensive, integrated and sustainable countrywide water policy? The ensuing policy directions present a number of principles that can be applied at all levels in the polity. We must acknowledge the doctrine of reasonable and beneficial use to mean that water must be allocated fairly and used efficiently. All users should avoid actions that impair the quantity and quality of water available for other users. This public resource must continue to be managed by the State to further the benefit of all who live in the country.

Despite public ownership, there isn't a single custodian for the natural resource. A neutral agency should determine the appropriate balance between the demands for water for off-stream consumption and the volume of water flows needed by the river system. The growing competition for water between irrigation use for food production and domestic use by both urban and rural dwellers needs to be resolved by a nonpartisan body at the apex, such as the earlier proposed National Water Resources Authority (Bandaragoda 2006). It should determine the sharing and allocation of water between multiple kinds of users in ways which are equitable, efficient and sustainable. Currently, there is no administrator for the water rights system. Like air, water is a resource that transcends society's boundaries. Watersheds and aquifers cross private property borders as well as national, sub-national and local government boundaries.

At the national level, a dilemma has arisen concerning appropriate degrees of centralization and decentralization of water planning and administration. Water resources planning and management frequently fail to use the river basin as the natural unit for hydrologic management, resulting in the inefficient use of water and inadequate concern for in-stream and ecosystem values. Therefore, it is imperative to recognize the environment as a legitimate user of water. The maintenance of stream flows in keeping with minimum water levels for in-stream uses has never been implemented in Sri Lanka. Consequently, environmental concerns such as the loss of biodiversity, salinity intrusion and seasonal drying up of wetlands have arisen. A percentage of the flowing water in streams must be dedicated to the environment for fish and stream reservations.

Many water problems stem from a failure to take an adequately large 'systems viewpoint' (like upstream-downstream relationships on major rivers), while day-to-day administration and public participation call for a more localized approach. The appropriate resolution of this issue requires delineation of administrative boundaries to conform to river basins. This is a complex issue that can retard the progress in the implementation of devolved responsibilities as set out in the Thirteenth Amendment of the Constitution.

Apart from the creation of a single new institution at the apex, the mandates of existing sectoral agencies need to be re-examined in order to sharpen the regulatory role of the government. Furthermore, the roles and responsibilities of the existing water agencies would have to be re-oriented to reflect their revised mandates of service delivery and to keep such functions separated from resource management functions, given the unclear and overlapping nature of institutional roles and responsibilities. The need to separate the policymaking and regulatory roles from the implementation, operation and service management functions of institutions is paramount. The mandates of sectoral agencies as structured currently do not address some important issues such as water sharing, conjunctive use and basin management.

Can our land stewardship be separated from water stewardship? Since the mode of land use also helps determine the water balance, an integrated view of land and water use must be taken into account for water management planning. Such planning must presuppose that a watershed-based approach is adopted, which often cuts across administrative boundaries. Improved water governance will thus require a revision of the present system, which is a 'free for all' system, through the development and enunciation of a shared, comprehensive vision of water resources. Integrated Water Resources Management (IWRM) assists communities to improve the ways they share, manage and protect water resources. Groundwater is inextricably linked and physically connected to surface water and must be managed conjunctively and sustainably. There is a need to legally recognize the principle that the overlaying property owner is not vested with a right to private ownership of the groundwater beneath his feet except to the extent of a reasonable user right.

Because of a general perception of water abundance, Sri Lanka's laws from colonial times never reflected any urgency for conservation. Hence, the policy has evolved over the last two centuries as if water had no cost and there were no limits to its availability. It is an axiom that there is not enough water in the island to permit every user to do with the resource as he or she pleases. Like other laws governing scarce things, a water law must encourage desirable activities and prevent or discourage undesirable conduct. There is an urgent need for a comprehensive water resources legislation to fill this void of legal regulation.

It is important to recognize that water is not simply a free 'gift of nature'. In all its competing uses, water has an economic value. Some form of cost recovery is evident in the domestic water supply sector, which includes the recovery of operation and maintenance costs plus the greater part of debt service or depreciation of revenues derived from tariffs. Managing water as an economic good (certainly not as a commercial good to be traded in the market) is an important way of achieving equitable and efficient use and encouraging conservation.

References

Aheeyar, M. M. M.; Nanayakkara, V. K.; Bandara, M. A. C. S. 2008. Allocation of Water among Different Water-use Sectors in Sri Lanka: Lessons of Experience. Research Study No: 128, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka.

Bandaragoda, D. J. 2006. *Status of institutional reforms for integrated water resources management in Asia: Indication from policy reviews in five locations.* Working Paper No. 108. Colombo, Sri Lanka: International Water Management Institute.

Barlow, M. 2007. Blue Covenant: The Global Water Crisis and the Coming Battle for the Right to Water**.** Canada. McClelland and Stewart

Damayanthi, M. K. N.; Nanayakkara, V. K. 2008. Impact of the Provincial Council System on the Smallholder Agriculture in Sri Lanka. Research Study No: 126, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka.

Department of Census and Statistics. 2008. Household Income and Expenditure Survey – 2006/2007. Available at http://www.statistics.gov.lk/HIES2006_07Website/Tabulation.asp accessed on 29th May 2009.

Government of Sri Lanka. 1978. 'Thirteenth Amendment to the Constitution'**,** Democratic Socialist Republic of Sri Lanka- 1978.

Government of Sri Lanka. 1988. Presidential Task Force on Housing and Urban Development**,** May 15, Battaramulla, Sri Lanka.

Imbulana, K. A. U. S. ; Wijesekera, N. T. S.; Neupane, B. R. 2006. 'Sri Lanka National Water Development Report', UNESCO and Ministry of Agriculture, Irrigation and Mahaweli Development.

IWMI (International Water Management Institute). 2005. 'Planning Groundwater Use for Sustainable Rural Development'**.** Water Policy Briefing, issue 14.

Meinzen-Dick, R. ; Bakker, M. 2001. Water Rights and Multiple Water Uses: Issues and Examples from Kirindi Oya, Sri Lanka. *Irrigation and Drainage Systems* 15: (2)129-148, the Netherlands: Kluwer Academy Publishers.

Meinzen-Dick, R. ; Nkonya, L. 2007. 'Understanding Legal Pluralism in Water and Land Rights: Lessons from Africa and Asia'. In*, Community-based Water Law and Water Resource Management Reform in Developing Countries,* eds. B. van Koppen, M.Giordano and J. Butterworth. CAB International, 2007.

Nanayakkara, V. K. 2003. 'Sri Lanka's Efforts in Introducing Water Sector Policies and Initiating Related Institutional Development'**.** Project Final Report, Vol. 5, Appendix III. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Stevens, J. S. 2003. The Public Trust and In-stream Uses: Issues in Legal Scholarship. Joseph Sax and the Public Trust Article 9. Available at http:/www.bepress.com/ils/oss4/art9 accessed on???

United Nations.1966. The International Covenant on Economic, Social and Cultural Rights, 1966.

Wickramage, M. 2008. 'Water for Human Use'. Paper presented at the Consultative Workshop on Updating Sri Lanka's Water Development Report, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka. March, 18, 2008.

සාධනීය හා ඵලදායි ජල කළමණාකරණ ක්‍රියාවලියක් සඳහා ප්‍රාදේශීය ආණ්ඩුකරණ ක්‍රියාවලිය - පානීය ජල කළමනාකරණ වැඩ සටහන, බණ්ඩාරවෙල නගර සභාව

සිසිර සද්ධාමංගල විතානාච්චි
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ප්‍රාදේශීය ආණ්ඩුකරණය නව අදහසක් නොවන අතර එය විද්‍යාර්ථීන් අතර සාකාච්ඡාවට බඳුන් වන්නේ තිරසාර හා ප්‍රජාතන්ත්‍රීය ආර්ථික සංවර්ධනය පිළිබඳ අදහස ඉස්මතු වීමත් සමහයග යහ ආණ්ඩුකරණයක පැවැත්ම උදෙසා මධ්‍යගත පාලන ක්‍රමයකට වඩා විමධ්‍යගතවූ ප්‍රජාතන්ත්‍රවාදි ව්‍යූහයන් ගේ අවශ්‍යතාව අවධාරණය වියග ප්‍රාදේශීය ආණ්ඩුකරණයල පුරවැසියන් හා රාජ්‍ය අතර සබඳතා ගොඩනගන ක්‍රමවේදයක් ලෙස පමණක් නොව ප්‍රතිපත්ති සම්පාදනයේදී හා වගකීම් බෙදීයාමේ දී ආණ්ඩුකරණයේ පහළ ආයතන වලට වැඩි බලයක් ලබා දෙන ක්‍රමවේදයක් ද වී ඇතග ශ්‍රී ලංකාව තුළ මෙම ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන පළාත් පාලන ආයතනය ලෙස හඳුන්වයිග

ප්‍රජාපාදක ජල සම්පත භාවිතය මූලික වශයෙන්ම පළාත් පාලන ආයතන සමග බැඳී ඇත. පසුගිය කාල වකවානුව තුළ සිදුකළ බලතල පවරා ගැනීම් තුළ ජල සම්පත බෙදාහැරීම හා ජලාපවාහන කටයුතු මධ්‍යම රජය වෙත පවරා ගත්තේය. ඇතැම් පළාත් පාලන ආයතන මෙම ජල කළමණාකරන ක්‍රියාවලිය හා ජල සම්පත බෙදා හැරීමේ ක්‍රියාවලිය තම ආයතනය වෙත පැවරිය යුතු බව තර්ක කරයි. ඇතැම් පළාත් පාලන ආයතන ප්‍රදේශයේ විභව ජල උල්පත් භාවිතයෙන් ප්‍රජාවට ජල සම්පත ලබාදේ. මෙම පර්යේෂණ පත්‍රිකාව තුළින් බණ්ඩාරවෙල නගර සභාව සිදු කරන ජල කළමණාකරණ වැඩ සටහන පිළිබඳ අධ්‍යයනයක් සිදු කර ඇත.

මූලික වදන් : ප්‍රාදේශීය ආණ්ඩුකරණය (Local Governance), යහ ආණ්ඩුකරණය (Good Governance), ජනතා සහභාගීත්ව ප්‍රවේශය (people’s participation) ප්‍රජාපාදක ජල සම්පත් භාවිතය (Community Based Water Resource Usage & ජල කළමණාකරනය (Water Management)

1.0 හැඳින්වීම

ජලය, අසීමිත මානව අවශ්‍යතා ඉටුකර ගැනීම ගැනීම සඳහා යොදා ගන්නා සීමිත සම්පතක. මානව අවශ්‍යතා අතර, අති මූලික අවශ්‍යතාවය වන පානය කිරීම ස¨දහා ජල භාවිතාවේ සිට ආර්ථික නිෂ්පාදනයට දායක වන ස්වාභාවික සම්පතක් ලෙස ජල භාවිතාව තෙක් එම අවශ්‍යතා විශාල පරාසයකට විහිදී ඇත. 1970 දශකයේ සිට ස්වාභාවික ඉන්ධන ගෝලීය දේශපාලනයේ තිරණාත්මක සාධකයක් බවට පත් වෙමින් සංකීර්ණ ජාත්‍යන්තර මෙන්ම දේශීය දේශපාලන හා ආර්ථික සංසිද්ධී ගණනාවක් ඇති විමට හේතු විය. ඒ මත ගොඩ නැගුණු දේශපාලනය තෙල් දේශපාලනය (Oil Politics) ලෙස වත්මනයේදී භාවිතාවට ගැනෙන විපයීය පදයක් වී ඇත.

එසේම අද වන විට ගෝලීය දේශපාලනය තුළ ජලය ද දේශපාලන ප්‍රපංචයක් බවට පත් වෙමින් ඒ මත ජල දේශපාලනය (Water Politics) නම් භාවිතාවද ඉදිරියට පැමිණෙමින් ඇත (Iyer,2003:p197-199). ජෝන් ආර් වුඩ් (John R Wood) දක්වන ආකාරයට ජල දේශපාලනය ජාත්‍යන්තර ගැටුම් නිර්මාණය වීමේ සිට රාජ්‍ය ප්‍රතිපත්ති සම්පාදන දක්වා පුළුල් පරාසයක විහිදී ඇති බලපෑම් සාධකයක් වී ඇති බවයි (Wood,2007:pp36-38), ඒ අනුව භාවිතාවට ගත හැකි ජල සම්පත කළමණාකරණයකට ලක් කරමින් නිසි භාවිතාවක් වෙත ගෝලීය ප්‍රජාවම යොමු කිරීමට අවධානය යොමු වෙමින් පවතී. භූතලය මත ඇති ජල ප්‍රමාණයෙන් භාවිතාවට ගත හැකි 0.0007 % ප්‍රමාණය ද රටවල් සහ කලාප මට්ටමින් ගත් කළ විහිදී ඇත්තේ විෂම ආකාරයකටය. නමුත් ජල භාවිතාව වෙනස් වන්නේ සියුම් ප්‍රතිශතයකින් වන නිසා එම සීමිත ජල මූලාශ්‍ර සුරක්ෂිත කරමින් ජලය භාවිතා කිරීමේ ක්‍රියාවලියකට යොමු වීම, අද දේශපාලනමය මෙන්ම මූලෝපායික උපක්‍රමයක් හා ප්‍රතිපත්තියක් බවට පරිවර්ථනය වෙමින් පවතී.

ජාතික පදනමින් ජල සම්පත භාවිතා කිරීම හා කළමණාකරණය කිරීම ප්‍රතිපත්තියක් බවට පත් වෙමින් ඇති අවස්ථාවක ප්‍රාදේශීයව එම කළමණාකරණය කිරීමේ ප්‍රතිපත්තියක් වෙත යොමු වීමේ අවශ්‍යතාවය ආණ්ඩුකරණ ක්‍රියාවලියේ ඉස්මතු වෙමින් පවතී. මන්ද යත් සංවර්ධනය අත්පත් කර ගැනීමේ මූලෝපායක් ලෙසද අද බොහෝ රාජ්‍යය භාවිතාවට ගැනෙන විමධ්‍යගතකරණ ක්‍රියාවලිය තුළ ප්‍රාදේශීය ආණ්ඩුකරණය බලාත්මක කළ යුතුය යන අදහස අවධාරණය වෙමින් පවතී. ඒ අනුව මෙම පර්යේෂණය තුලින් අධ්‍යයනයට ලක් කරන්නේ ප්‍රාදේශීය ආණ්ඩුකරණ ක්‍රියාවලිය සහ ජල භාවිතා හා කළමණාකරණ ක්‍රියාවලිය අතර ඇති සහසම්බන්ධතාවයයි. එමෙන් ප්‍රදේශයේ ආණ්ඩුකරණය සාර්ථක/ප්‍රතිඵලදායී සරල කළමනාකරණයක් සඳහා කෙසේ යොදාගත හැකිදැයි ප්‍රශ්නයටද පිළිතුරු සැපයීමට මෙම කෙටි වාර්තාව තුලින් උත්සාහ ගනු ලැබේ.

2.0 ප්‍රාදේශීය ආණ්ඩුකරණය සහ ප්‍රාදේශීය ආණ්ඩුමය ආයතන

ආණ්ඩුකරණය තුළ ප්‍රජාව සඳහා පුළුල් නියෝජනයක් හා පුළුල් සහභාගීත්වයක් ලැබීම හරහා ප්‍රජාතන්ත්‍රවාදී අරමුණු සාධනය වන්නේ ද යන්න විද්‍යාර්ථීන් අතර ප්‍රබල ව සාකච්ඡා වන විවාදයක් බවට පත්වී ඇති. ආණ්ඩුකරණය නිශ්චිත සංකල්පයක් ලෙස විද්‍යාර්ථීන් අතර සාකාච්ඡාවට බඳුන් වීම ආරම්භ වන්නේ 1980 දශකයේ සිට ය (Weiss, Thomas,2000, p795). ඉන් පසු එහි ඇති සුවිශේෂිතාල වෙනස්කම් හා නූතන ප්‍රවණතා පිළිබඳ පුළුල් ලෙස විග්‍රහ වීම සිදු විය. 1989 දී ලෝක බැංකුව (IBRD) එළි දැක්වූ උප- සහරානු වාර්තාව (Sub Sahara Report) හරහා, යහ ආණ්ඩුකරණය, සංකල්පය ඉස්මතු වීමත් සමඟ ආණ්ඩුකරණය පිළිබඳ විද්වත් කථිකාව පුළුල් විය (Jayal,2001:p14).

1980 හා 1990 දශක තුළ දේශපාලන ආර්ථික විද්‍යා විෂය ක්ෂේත්‍රය තුළ ද, ආණ්ඩුකරණය, ක්‍රියාවලිය සාකච්ඡාවට බඳුන් වන්නේ ආර්ථික ක්‍රියාවලිය හා ප්‍රතිපත්ති සම්පාදනය අතර ඇති සබඳතා ව විග්‍රහ කිරීමට ය. රාජ්‍යය තුළ සංවර්ධනය වේගවත් කිරීමේ ක්‍රියාවලිය ක් ලෙස 1990 දශකය මැද භාගයේ සිට ඒ හා සම්බන්ධව ප්‍රාදේශීය ආණ්ඩුකරණය පිළිබඳ සංකල්පය විග්‍රහ වන්නට විය. ජීවත් වන ජනතාවගේ අනන්‍යතා හා අවශ්‍යතා ජාතික ආණ්ඩුකරණය තුළ යටපත් වීම තුළ ප්‍රාදේශීය ආණ්ඩුකරණ න්‍යායේ භාවිතායේ වැදගත්කම තහවුරු වීමට අද හේතු වී තිබේ (Weiss,2000:pp798-802).

ජනතාවට සමීපතම දේශපාලන තලය වන නිසා වෙන්ම ප්‍රාදේශීය ආණ්ඩුකරණය වර්තමානය වන විට ප්‍රාදේශීය සංවර්ධනය අත් පත් කර දෙනු ලබන ආණ්ඩුකරණ ආකෘතිය බවට පත් වී ඇත. එක්සත් ජාතීන්ගේ සංවර්ධන සැලැසුම් වාර්තාව මගින්, යහ ආණ්ඩුකරණයක් රටක පැවතීම උදෙසා ප්‍රාදේශීය තලයෙන් සම්පත් බෙදා දිය යුතු බව දක්වයි. එසේම තීන්දු තීරණ ගැනීමේ අවකාශය ද එම ප්‍රාදේශීය ඒකක වලට ලබා දිය යුතු බව දක්වයි. ඒ හරහා

ජනතාව ට අර්ථවත් ආකාරයෙන් ප්‍රජාත්‍රන්තවාදය භුක්ති විඳිය හැකි බව එක්සත් ජාතීන්ගේ සංවර්ධන වාර්තාව අවධාරණය කරයි. එක්සත් ජාතීන්ගේ සංවර්ධන සැලසුම් වාර්තාව දක්වන ආකාරයට යහ ආණ්ඩුකරණයක් පැවැතීම උදෙසා ප්‍රජා සහභාගීත්වය සහ රට තුළ වාසය කරන සියලුම ජන වර්ග හා ස්ත්‍රී, පුරුෂ සැම කොට්ඨාශයකම අභිලාෂ ඉෂ්ඨ වීම සහ නියෝජනය සාධාරණ ආකාරයෙන් සිදු විය යුතුය (UNDP, 1997: pp2-3).

ඉහත අර්ථ දැක්වීම් දෙකින්ම පැහැදිලි වන ප්‍රධාන කරුණ වන්නේ යහ ආණ්ඩුකරණයේ පැවැත්ම උදෙසා බලය විමධ්‍යගතකරණය කරන ලද පුළුල් ජනතා සහභාගීත්වයක් තුළින් ප්‍රාදේශීය ආණ්ඩුකරණය ක්‍රියාත්මක විය යුතු බවයි.

3.0 ජල සම්පත භාවිතාව සහ ජල කළමණාකරණය

ජලය සීමිත සම්පතක් බවට පරිවර්ථනය වීමත් සමඟ එය ආර්ථික භාණ්ඩයක් වීමේ ප්‍රවණතාව තීව්‍ර වෙයි. නිදහසේ පානය කිරීමට තිබූ ජලය වුවද සීමිත බව හේතුවෙන්ම අනාගතයේදී මිලක් නියම වූ භාණ්ඩයක් බවට පත්වීම සිදු වනු ඇත. නමුත් ජලය මානවයාට පමණක් නොව සමස්ථ ජීවී වර්ගයාටම ජීවත් වීමේ මූලාශ්‍රයක් වීම හේතුවෙන් ජලය ලබා ගැනීමේ අයිතිවාසිකමක් මානවයාට ඇත. ගෝලීය වශයෙන් 70% ප්‍රජාවක් ගෘහීය ප්‍රයෝජනයට හා වාසස්ථානවලින් බැහැර පුද්ගල භාවිතාවට ජලය ඍජුව භාවිතා කරයි.

සාරා ඕහාරා දක්වන ආකාරයට දරිද්‍රතාවය වර්ධන වීම කෙරෙහි ජල සම්පත බෙදී යාමේ විෂමතාවය ද මූලිකවම හේතුවේ (O'Hara,2003;p 13). තම දෛනික අවශ්‍යතා ඉටු කර ගැනීමට ජල ප්‍රමාණවත් නොවීම හා භාවිතා කරන ජලයේ අපවිත්‍රාව හේතුවෙන් රෝගාබාධ ඇති වීම මෙම දරිද්‍රතාවය වර්ධනය වීම කෙරෙහි ජලයේ ඇති ඍජු සම්බන්ධයක් නිරූපණය කරය. ඒ අනුව සීමිතව ඇති ජල සම්පත කළමනාකරණයකට ලක් විය යුතුය යන අදහස ඉස්මතු විය. ලාංකීය සමාජ සහ දේශපාලන කතිකාවත තුළ ජල කළමණාකරණය යන භාවිතාව සමඟ පැමිණි සමාජ ගීතිකාව වූයේ පෞද්ගලීකරණය යි. නමුත් ලෝකය හමුවේ ඇති සහශ්‍රක අභියෝග අතර ප්‍රමුඛස්ථානයක් ගන්නා ජල සම්පත සීමිත වීම අභිමුඛව ජල සම්පත නිසි කළමණාකරණයකට ලක් නොවුවහොත් ජලය ඉන්ධන මෙන් දෘඪ ආර්ථික භාණ්ඩයක්ම වනු ඇත. ඒ නිසා ජල කළමණාකරණය පිළිබඳ විද්‍යානුකූල අවබෝධයක අවශ්‍යතාවය තහවුරු වී ඇත.

ජල කළමණාකරණය යනු ආණ්ඩුකරණ ව්‍යුහය මගින් ගනු ලබන තීරණ මත පදනම් වූ මානව ක්‍රියාකාරීත්වයකි (Lindh , 1979 21). සමාජ භූගෝල විද්‍යාඥ ගිල්බර්ට් වයිට් දක්වන ආකාරයට ජල සම්පත් හිමිවීමේ මට්ටම අනුව සංස්කෘතික පදනමක් සමාජයේ ගොඩ නැඟෙයි. විශේෂයෙන්ම ජනතාව අතර සංකීර්ණ සමාජ පූර්ණත්වය තුළ සමාජීය ගෞරවය (Social Honor) වෙනස් වීම කෙරෙහි පිරිසිදු ජල සම්පතේ හිමිකම බලපායි. භූමියක මිල ඉහළ යාම, සමාජ සබඳතා හි හරයාත්මක බව තීරණය කිරීම, පුද්ගල හා කුටුම්භ ආර්ථික පදනම ශක්තිමතක් වීම කෙරෙහි ද ජල පහසුකම ඍජුව බල පාන බව වොල්ටර් ආර් බුචර් (Walter R Butcher) දක්වයි. එය ජල සම්පත් කළමණාකරණයේ සමාජීය අර්ථය (Social meaning of Water management) බව හෙතෙම දක්වයි.

මේ අනුව පැහැදිලි වන්නේ ජල සම්පත් කළමණාකරණයේ දී

1. ජල මූලාශ්‍ර ගවේෂණය
2. ජල මූලාශ්‍ර සංරක්ෂණය
3. ජලය බෙදා හැරීම විධිමත් කිරීම
4. ජලය භාවිතාවේදී සිදුවන ඍජු හා වක්‍ර නාස්තිය වැළැක්වීම

5. ප්‍රජා අවශ්‍යතා පූර්ණය කිරීම සඳහා ඇති ශක්‍යතාව

6. තිරසාර ජල භාවිතාව යන

බහු විධ අභිලාප මුදුන් පත් විය යුතුය. මෙම අභිලාප අතරින් ජල මූලාශ්‍ර ගවේෂණය හා ජලය බෙදා හැරීම විධිමත් කිරීම තාක්ෂණික කරුණු වේ.

විශෙෂයෙන්ම භූතලය මත ඇති ගංගා හා ඇළ මාර්ග ආදී ගලා යන මූලාශ්‍රඅ උල්පත් ජලය මෙන්ම වැසි ජලය හා භූමිය අභ්‍යන්තරයේ පිහිටි ජලය ද භාවිතයට ගත හැක. නමුත් තිරසාර ජල භාවිතයේදි අනාගත පරම්පරාව වෙත ද සම්පත් සංරක්ෂණය කරමින් භාවිතයට ගත යුතුය යන ප්‍රතිපත්තියට අනුව ජල මූලාශ්‍ර සියල්ල ප්‍රයෝජනයට නොගත යුතු බව අවධාරණය වේ (Kirkby..*et al*, 1995; p 1). භූ තලය අභ්‍යන්තරයේ පිහිටි ජලය භාවිතා කිරීම සීමා කළ යුත්තේ එය දීර්ඝ කාලීන ජල හිඟයකදි ප්‍රයෝජනයට ගත හැකි මූලාශ්‍රයක් වන බැවිනි. බොහෝ අවස්ථා හිදී විවිධ ගෝලීය කලාපවල එම ජලය අධිකව පොම්ප කිරීම නිසා බොහෝ විට තිරසර ජල භාවිතාව බිඳ වැටමින් ඇත. (Gleick,1998:pp575-576). මන්ද යත් එය ස්වාභාවිකව ගබඩා වී ඇති ජල නිධියක් වන බැවිනි. ලංකාවේ බොහෝ ජලය සීමිත ප්‍රදේශවල පෞද්ගලිකව හෝ ප්‍රජා ව්‍යාපෘති මගින් නළ ලිං ඉදි කරමින් එම අභ්‍යන්තර ජලය භාවිතා කරනු නිරීක්ෂණය කළ හැක. නමුත් එම කලාපවල මතු පිට ඇති ජල මූලාශ්‍ර නිසි භාවිතයක් දක්නට නොහැක. භූ තලය මත පිහිටි ජල මූලාශ්‍ර සංරක්ෂණය කරමින් භාවිතයට ගැනීම තිරසාර ජල භාවිතාවේ වැදගත් අරමුණක් වේ.

ජලය බෙදීමේදී නිසි නඩත්තුවක් නොවීමත් එය උපයෝගීතාවට අනුව සකස් නොවීමත් මතද ජල නාස්තිය විය හැක. ජල කළමණාකරණයේදි ප්‍රජා අවශ්‍යතා පූර්ණය කිරීමට ඇති ශක්‍යතාවයද වැදගත්වේ. ජලය තම අවශ්‍යතාවය අනුව භාවිතා කිරීමට අවස්ථාව හිමි වීම ද ඒ අනුව ප්‍රජාවට තිබිය යුතුය. නමුත් එම කළමණාකරණ ක්‍රියාවලිය සම්පූර්ණ වීමට නම් නිසි දේශපාලන හා පරිපාලන යාන්ත්‍රණයක් සහිත ආණ්ඩුකරණයක් අවශ්‍ය ය.

4.0 සම්පත් කළමණාකරණය සහ ප්‍රාදේශීය ආණ්ඩුකරණය අතර ඇති සහ සම්බන්ධතාව

භෞතික හා මානව සම්පත් භාවිතාව තුළ එය නිසි පරිදි කළමණාකරණය කරණයකට ලක් විය යුතුය. එය සිමාරහිත ස්වාභාවික සම්පත් වන ජලය, ඛනිජ හා ඉන්ධන ආදි සම්පත් කෙරහි සෘජුව බලපෑම් එල්ල කරයි. රජනි කොතාරි දක්වන ආකාරයට ප්‍රාදේශීය සම්පත් කළමණාකරණයේදී එය කේන්ද්‍රයෙන් දුරස්ථ දේශපාලන ආයතන මගින් නොව කේන්ද්‍රයට සමිප ආණ්ඩුකරණ ආයතන සමඟ ක්‍රියතේමක විය යුතු යග මෙහිදී භූගෝලීය ලෙස ප්‍රාදේශීය ආණ්ඩුකරණ ඒකක වෙත බලය බෙදා දීම සහ නිලධාරීන් හරහා විවිධ කාර්යයන් අනුව බලය බෙදා දීම හරහා ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන බලාත්මක කළ හැක. මිනාක්පිසුන්දරම් (Minakshisundaram) දක්වන්නේ අධිකාරී බලය, නීති හා ප්‍රතිපත්ති සම්පාදනය, පරිපාලන බලය ආණ්ඩුකරණයේ ඉහළතම ආයතන වල සිට පහළතම ආණ්ඩුකරණ ආයතන වෙත ලබා දිය යුතු බවයි. ඒ අනුව පහළ තලයේ ආයතන වලට තීන්දු තීරණ ගැනීමේ ස්වායත්තතාවයක් ලබා දීම, ඒ අනුව සිදුවේ (Jha, S.N et al ,1999:p55).

ඉහත අවධාරණය අනුව පැහැදිලි වන්නේ ප්‍රාදේශීය ආණ්ඩුමය ආයතන බලාත්මක කළ යුතු බවයි. ප්‍රාදේශීයව ස්ථාන ගත වී ඇති භෞතික සහ මානව සම්පත් හඳුනා ගැනීමේ හැකියාව පහසුවෙන් එම ප්‍රාදේශීය ඒකක වෙත ඇත. එසේම ප්‍රාදේශීය සංවර්ධන ක්‍රියාවලිය සඳහා ඇති බාධා සුවිශෙෂිතා හා ප්‍රවණතා හඳුනා ගැනීමේ හැකියාව ද ඇත්තේ එම ප්‍රාදේශිය ආණ්ඩුකරණ ආයතනවලටය.

ටැන්සානියාවේ ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන වඩාත් කාර්යක්ෂම සහ ඵලදායී සේවාවක් සැපයෙන ආයතන බවට පත් කිරීමට ගෙන ආ ජාතික සමළුවේදී මතු වූ ප්‍රධාන කරුණු කිහිපයකි. එයින් වඩාත් වැදගත් මූලෝපාය වූයේ ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන ප්‍රාදේශීයව ජීවත් වන මානව ප්‍රජාවගේ අවශ්‍යතා ඉටු කරන සාකල්‍යමය (Holistic) ආණ්ඩුකරණ ආයතනයක් විය යුතු බවයි. එහිදී මහජන සේවා සැපයීමේ වගකීම එම ආයතන වෙත මධ්‍යම ආණ්ඩුවෙන් විතැන් කොට ලබා දිය යුතු බව ටැන්සානියාවේ රජය ගත් තීරණයට අනුව පොදු සේවා අතරින් ජලය සැපයීම හා අධ්‍යාපන පහසුකම් සැපයීමට බලතල සපයා දෙනු ලැබිය (Chale,G,1996;pp1-3). ඒකීය ආණ්ඩුකරණයක් සහිත ටැන්සානියාව තුළ මහජන සේවා කාර්යක්ෂමව සපයමින් මනා පාලනයක් පවත්වා ගැනීම සඳහා ශක්තිමත් ප්‍රාදේශීය ආණ්ඩු පද්ධතියක් ක්‍රියාත්මක වේ. ඒ සඳහා දේශපාලන බලය, මූල්‍ය සම්පත් සහ පරිපාලන හැකියාව විමධ්‍යගතකරණය කර ඇත. එහි ඇති විශේෂත්වය වන්නේ සෑම ප්‍රාදේශීය ආණ්ඩු ආයතන අතර සබඳතා ජාලයක් ගොඩ නගා තිබීමයි.

දකුණු අප්‍රිකා දේශපාලන සැකැස්මේ ඇති සාධනීය ලක්ෂණයක් වන්නේ එරට ආණ්ඩුකරණ තල තුනම අවධාරණය කර තිබීමයි. එනම් මධ්‍යම රජය, පළාත් ආණ්ඩු සහ ප්‍රාදේශීය ආණ්ඩුකරණය වේ. දකුණු අප්‍රිකාව තුළ ප්‍රාදේශීය ජනතාව උදෙසා සේවය සැපයීම ආණ්ඩුක්‍රම ව්‍යවස්ථාවේ **152** වගන්තිය මගින් ලබා දී ඇත්තේ ප්‍රාදේශීය ආණ්ඩු ආයතන වෙතය. එමෙන්ම **1997** දී දකුණු අප්‍රිකානු රජය ගෙන එන ජාතික ජල ප්‍රතිපත්තිය තුළ ජල භාවිතාවේ ප්‍රධාන ප්‍රමුඛතා තුනක් ලෙස මූලික අවශ්‍යතාවයක් වීම, පාරිසරික අවශ්‍යතාවක් වීම හා ජාත්‍යන්තර බැඳීමක් වීම දැක්විය හැක. එයින් ජාතික ජල ප්‍රතිපත්තිය අවධාරණය කරන වැදගත්ම කරුණ වන්නේ සියලු පුරවැසියන්ගේ මූලික ජල අවශ්‍යතාව ප්‍රාදේශීය ආණ්ඩු ආයතන මගින් ලබා දිය යුතු බවයි. ප්‍රාදේශීය ජල මූලාශ්‍ර සුරක්ෂිත කර ගැනීමේ වගකීම, ජලය බෙදා හැරීම කළමණාකරණය හා තිරසාර ජල භාවිතාවක් වෙත ප්‍රජාව හුරු කිරීමේ වගකීම ප්‍රාදේශීය ආණ්ඩු ආයතන වෙත **1998** අංක **36** දරණ ජල පනත තුළින් දකුණු අප්‍රිකා රජය තහවුරු කර ඇත. (Dlamini , 2007;pp 8-13)

තිරසාර ප්‍රතිපත්තිය මත පිහිටා ප්‍රජාව උදෙසා පොදු සේවා සැපයිය යුතුය. එහි ප්‍රධාන අරමුණු අතර ජනතාවගේ සමාජ හා ආර්ථික සංවර්ධනයඅ ප්‍රජාවගේ සහභාගීත්වය දිරි ගැන්වීම හා ප්‍රාදේශීය ආණ්ඩු ආයතන හා ප්‍රජා පාදක සංවිධාන ඒකාබද්ධ කිරීම වේ. විශේෂයෙන්ම ජනතාවගේ මූලික අවශ්‍යතා දෙස පූර්ණ වශයෙන් අවධානය කොට ඒවා ප්‍රවර්ධනය කිරීම ප්‍රාදේශීය ආණ්ඩු ආයතනවල ව්‍යවස්ථාපිතවම වගකීමක් බවට දක්වා ඇත.

ලෙලිට් මෙලික්යාන් (Lilit Melikyan) දක්වන්නේ ආර්මේනියාව ඇතුළු මධ්‍යම ආසියාතික රටවල ඇති ජල හි`ග කමට පිළියමක් ලෙස අදාල ඒ ඒ ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන ප්‍රජා ජල ව්‍යාපෘති ආරම්භ කොට පුරවැසි සක්‍රිය සහභාගීත්වය ප්‍රාදේශිය ආණ්ඩුකරණ ආයතන හා සමිප කර ඇති බවයි. ආර්මේනියාව විසින් **1999** සිට ක්‍රියත්මක කරන ආකලන ජල සම්පත් කළමණාකරණ වැඩසටහන ඔස්සේ (Integrated Water Resource Management (IWRM)) තිරසාර ජල භාවිතාව සහිතව ජල සම්පත් කළමණාකරණය ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන වෙත පැවරීම සිදු කොට ඇත (O'Hara,2003;pp 40-41).

2002 වසරේ දී සිට ක්‍රියාත්මක ජල සංග්‍රහය අනුව පානීය ජල අවශ්‍යතාව සඳහා ජල සම්පත සංරක්ෂණ වැඩ පිළිවෙලක් සැකසීම හා අයබදු අය කර ගැනීමේ ක්‍රියාවලියක් සංවිධානය කිරීම ප්‍රාදේශිය ආණ්ඩුකරණ ආයතන වෙත පවරා දී ඇත. එහිදී අදාල ප්‍රාදේශිය ඒකකයන් හි වගකීම් දරන්නෝ, සිවිල් සංවිධාන ඒකාබද්ධව තිරණ ගැනීමේ ප්‍රාදේශීය ආණ්ඩුකරණ ස්වායත්තතාව ආර්මේනියානු රජය පිළි ගන්නා ලදි. ජල පහසුකම් සම්පාදන ක්‍රියාවලියේදී ජල මූලාශ්‍ර ගවේෂණය, ඒවා සංරක්ෂණය, ජල නිධියේ හෝ මූලාශ්‍රයේ ජල ප්‍රමාණය ගණනය හා උසස් තාක්ෂණිකව ජලයේ ගුණාත්මක බව මැන බැලීම ආදිය ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන වෙත පවරා ඇත.

ජාත්‍යන්තරව ඇති එම උදාහරණ මගින් තහවුරු වන්නේ ජල සම්පත් කළමණාකරණය කරමින් ප්‍රජාවට ජල පහසුකම් සපයමින් ප්‍රාදේශීය ආණ්ඩුකරණය වඩාත් ප්‍රජාතන්ත්‍රානුකූලවත්, ධරණීය සංවර්ධනය හා තිරසාර සංවර්ධනය දිශානුගත කරගත් ආණ්ඩුකරණයක් කරා යොමු වී

ඇති බවයි. විවධ මට්ටම් වලින් ක්‍රියාත්මක වූ ප්‍රාදේශීය ආණ්ඩුකරණ ක්‍රියාවලියක් පශ්චාත් නිදහස් සමය දෙස පමණක් අවධානය යොමු කරද්දී පැවතුණු ශ්‍රී ලංකාවේ ජල සම්පත් කළමණාකරණය හා භාවිතා විමසා බැලිය යුතුය.

5.0 ලංකාවේ ප්‍රාදේශීය ආණඩුකරණ ක්‍රියාවලිය තුළ ජල සම්පත් කළමණාකරණය

බ්‍රිතාන්‍ය තුළ 11 වන සියවසේ දී ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන පද්ධතියක් නිර්මාණය වන්නේ අය බදු අය කර ගැනීමේ ආයතන පද්ධතියක් ලෙස යි. (Travers,2003p:18). නමුත් ගෝලීය වශයෙන්ම අද වන විට ප්‍රාදේශීය සම්පත් කළමණාකරණය කරමින් දිළිඳුකම පිටු දැකීම හා මධ්‍යගත පාලනයට දායක වන ආයතන ව්‍යුහයක් වශයෙන් ප්‍රාදේශීය ආණඩුකරණ ආයතන පද්ධතිය විකාශනය වී ඇත. ලංකාවේ තත්කාලීනව දේශපාලන ක්‍රියාවලිය තුළ ස්ථාපනය වී ඇති ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන පදධතිය වන්නේ පළාත් පාලන ආයතනයි. ලංකාවේ පළාත් පාලන ආයතන ක්‍රියාත්මක වන්නේ මධ්‍යම ආණ්ඩුවේ හා පළාත් සභාවල පැවරුම් හා සේවා බෙදුම් කාර්යය (service delivery function) ඉටු කරන ආයතන පද්ධතියක් ලෙසයි. පනත් මගින් නිශ්චිතව පවරා ඇති කාර්යය පද්ධතියක් පමණක් පළාත් පාලන අයතන ක්‍රියාවේ යොදවයි.

ජල සම්පත් හා විදුලි බලය අදාළ පළාත් පාලන ඒකක අභ්‍යන්තරයේ බෙදීමේ වගකීම මුල් කාලීනව පැවතියේ පළාත් පාලන ආයතන වෙතය. නමුත් 1992 වසරේ හඳුන්වා දුන් ජාතික ජල සම්පාදන සහ ජලාපවහන මණ්ඩල සංශෝධන පනත මගින් (1992 වසරේ පනත් අංක 13) ගෙන ආ අදහසට අනුව පළාත් පාලන අමාත්‍යාංශය හරහා ලංකාවේ බොහෝ පළාත් පාලන ආයතන සතුව තිබූ ජලය බෙදීමේ වගකීම ජාතික ජල සම්පාදන සහ ජලාපවහන මණ්ඩලයට පවරා ගත්තේය. ඒ අනුව අද වන විට බොහෝ පළාත් පාලන ආයතන අභ්‍යන්තරයේ පානීය ජල අවශ්‍යතාවයේ සිට කාර්මික ජල අවශ්‍යතාවය දක්වා ජලය බෙදීම සිදු කරන්නේ ජාතික ජල සම්පාදන හා ජලාපවහන මණ්ඩලයයි. නමුත් තවමත් බණ්ඩාරවෙල නගර සභාව, මහනුවර මහ නගර සභාව සහ කොළඹ මහ නගර සභාව යන ප්‍රාදේශීය ආණ්ඩුකරණ ආයතන ත්‍රිත්වයෙහි ජල සම්පත් බෙදීම අදාළ පළාත් පාලන ආයතන මගින් සිදු කරයි. මේ පර්යේෂණයේදී ක්ෂෙත්‍ර අධ්‍යයන ලෙස තෝරා ගත් බණ්ඩාරවෙල නගර සභාව සාර්ථක ජල සම්පත් බෙදා හැරීමක් සිදු කරයි.

6.0 බණ්ඩාරවෙල නගර සභවේ ජල සම්පත් කළමණාකරණ ක්‍රියාවලිය

ඌව පළාතේ බදුල්ල දිස්ත්‍රික්කයට අයත් බණ්ඩාරවෙල ප්‍රදේශය දේශීය සහ විදේශීය සංචාරකයින්ගේ සොඳුරු නවාතැම් පොළකි. ශීත දේශගුණයක් ඇති බණ්ඩාරවෙල නගරය බ්‍රිතාන්‍ය පාලන සමයේ සිට සංචාරයට සුදුසු ලෙස මනාව සැලසුම් කළ නගරයක් විය. වර්ග කිලෝමීටර් 2¨3 ප්‍රදේශයක ව්‍යාප්ත වී ඇති නාගරික බල සීමාවක් ඇති මෙහි මුළු භූමි ප්‍රමාණය අක්කර 490 රූට් 3 කි.

බණ්ඩාරවෙල නගර සභා බල ප්‍රදේශයේ වාසය කරන මුළු ජනගහනය 13000 වන අතර නිවාස ගණන 1158 කි. ලියාපදිංචි ඡන්ද සංඛ්‍යාව 4515 කි. (2006 අයවැය වාර්තාව). බණ්ඩාරවෙල නාගරික ප්‍රදේශයේ ජල සම්පත් භාවිතයේ ඉතිහාසය 1923 දක්වා දිව යයි. එවකට බ්‍රිතාන්‍ය පරිපාලක ග්‍රෙන්ස් විසින් නායබැද්ද ශාන්ත කැතරින් තේ වතු ප්‍රදේශයේ පිහිටි ජල උල්පත් 8ක් භාවිතා කොට නගර ප්‍රදේශයට ජලය සපයන ලදී. නිදහසින් පසු ස්ථාපිත ලාංකිය පළාත් පාලන ව්‍යුහය තුළ බණ්ඩාරවෙල ජල සම්පාදන ක්‍රමවේදය නගර සභාව වෙතින් ඉටු වන්නට විය. ඒ සඳහා ප්‍රධාන ජල මූලාශ්‍ර ලෙස යොදා ගත්තේ 1923 බ්‍රිතාන්‍ය පාලකයින් හඳුනාගත් ස්වාභාවික උල්පත්ය.

1992 වසරේ පනත් අංක 13 යටතේ බණ්ඩාරවෙල නගර සභාව පවත්වාගෙන ගිය ජල සම්පත ද ජල සම්පාදන මණ්ඩලයට පවරා ගත්තේ ය. නමුත් එහිදී ජනතාවට ප්‍රමාණවත් හා තරගකාරී සේවාවක් පවත්වා ගෙන යාමට නොහැකි වීම හේතුවෙන් නැවත නගර සභාව වෙත ජලය බෙදීමේ බලතලය පවරා ගන්නා ලදී. එතැන් පටන් බණ්ඩාරවෙල නගර සභාව මූලිකව ජල සම්පාදන මණ්ඩලයේ ද්විතික සහයෝගය ලබා ගනිමින් ජල සම්පාදනය හා අපවහනය නගර සභාව විසින් සිදු කරයි.

6.1 ජල මූලාශ්‍ර ගවේෂණය, සංරක්ෂණය හා තිරසර ජල භාවිතාව

නගර සභාව මගින් භාවිතයට ගනු ලබන්නේ 1923 ඉදි කළ නායබැද්ද ශාන්ත කැතරින් වත්තේ පිහිටි උල්පත් 3 ත් උද්‍යාන පාර හා බදුල්ල පාර පොම්ප ලිං 2 ත් හා ඇල්ලතොට ඇළත්ය. නාය බැද්ද ජල උල්පත් ආශ්‍රිත ජල ටැංකි 4ක් ඉදි කර ඇති අතර එයින් පැය 24ක් ඇතුළත ජල ලීටර් ලක්ෂ 3ක් නිකුත් කරයි. නමුත් නගරයේ ජල භාවිතාව සම්පූර්ණ කිරීම සඳහා ජල ඒකක දළ වශයෙන් 20000 ක් ජල සම්පාදන මණ්ඩලයෙන් ලබා ගැනීම සිදු වේ. මෙම ලබා ගැනීම නතර කිරීමේ අරමුණින් භූගත ජලය ලබා ගැනීමට පර්යේෂණ ආරම්භ කිරීමට නගර සභාව කටයුතු කරමින් පවතී. නගර සභා සීමාව තුළ හා සීමාවෙන් පිටතට ද ජලය බෙදීමේ කටයුතු සිදු කරයි. එය වගු අංක 1 සඳහන් වේ.

වගු අංක 1. නගර සභාව ජල සපයන පොදු ස්ථාන

	නාගරික සීමා තුළ	නාගරික සීමාවෙන් පිටත	එකතුව
ප්‍රජා ස්ථාන	19	02	21
පාසල්	04	01	05
නිවාස	1158	240	1398
ව්‍යාපාර ස්ථාන	194	01	195
හෝටල	74	00	74
විශාල ප්‍රමාණයේ සංචාර නිකේතන	16	01	17
රජයේ ආයතන	24	01	25

මූලාශ්‍ර :- බණ්ඩාරවෙල නගර සභා නාගරික වාර්තා

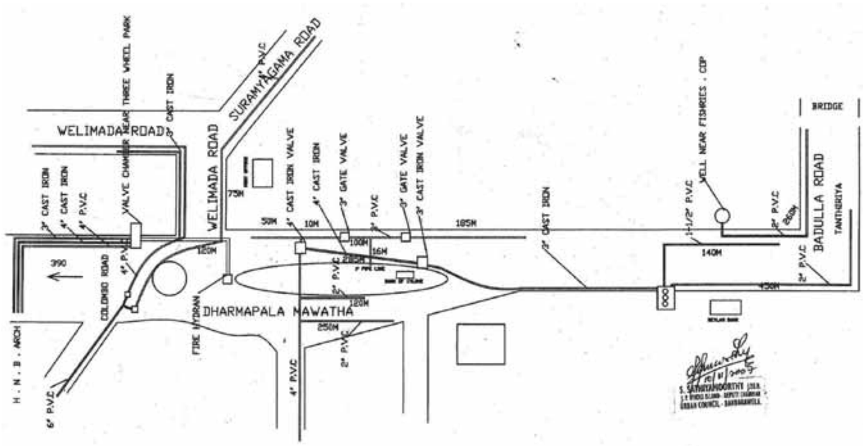
6.2 ජල නල පද්ධතිය, බෙදීම හා නඩත්තු සේවාව

නායබැද්ද ජල උල්පත් වල සිට කි.මී. 7 ක් දුර එලා ඇති අඟල් 3 ක නලයක් මගින් ජලාශ කන්ද ජල පවිත්‍රාගාරයට පොම්ප කරයි. නගර සභාව සඳහා ප්‍රමාණවත් ජල පවිත්‍රකරණ තාක්ෂණයක් නොමැති බැවින් ලිං ජලය මූලාශ්‍රයේ හැර සෙසු මූලාශ්‍ර ජලය ජලාශ කන්ද ජල පවිත්‍රාගාරයට පොම්ප කර පවිත්‍ර කරනු ලැබේ. එය ජල සම්පාදන මණ්ඩලය මගින් සිදු කරයි.

ජලය බෙදීමේ කටයුතු ප්‍රධාන මධ්‍යස්ථාන තුනක් මගින් සිදු කරයි. එනම් ධර්මපාල මාවත, තානායම පාර, සේනානායක පාර, ඉතිකම් බැද්ද සහ පූනාගල පාරේ ඇති බෙදුම් මධ්‍යස්ථාන තුලිනි. මෙම මධ්‍යස්ථාන වෙත අනුයුක්ත කර ඇති බෙදීම් කම්කරුවන් ගණන 14 කි. එයින් කම්කරුවන් බෙදා ඇත්තේ ශ්‍රම අතිරික්තයක් ඇති නොවෙන ආකාරයටය. එයින් නගර සභාව වියදම පාලනය කර ඇත. උදාහරණයක් වශයෙන් ගතහොත්, බදුල්ල පාර උප ජල බෙදීමේ ස්ථානයේ ස්ථාපිත බෙදීම් කම්කරු විසින් පන්සල පාර, වලස්බැද්ද හා තන්තිරිය ප්‍රදේශවලට ජලය බෙදීම සිදුකරයි. නායබැද්ද උල්පත් මගින් සැපයෙන ජලය ගබඩා කෙරෙන ධර්මපාල මාවත

ජල සංචිතයේ ජලය පිටාර ගැලීම සිදුවීම වැලැක්වීමට දිවා හා රාත්‍රී කම්කරුවකු අනුයුක්ත කර ඇත. එයට නගර අභ්‍යන්තරයේ ජල නල පද්ධතිය ප්‍රධාන මාර්ග හා අතුරු මාර්ග පදනම් කර ගෙන සවිකර ඇත. නාගරික ජල නල පද්ධතියේ ස්වභාවය රූප 1න් දක්වා ඇත.

රූප 1. නාගරික ජලනළ පද්ධතිය.



නගරය පුරා ජලය බෙදීම සිදුකරන ජලනල පද්ධතිය දෛනිකව උදෑසන වරුවේ ජල වැද්දුම් ශිල්පියකු හා කම්කරුවකු සමග පරීක්ෂාවේ යෙදෙනු ලැබේ. එසේම පෙරදිනයේදී ජල සැපයුම පිලිබඳව පැමිණිලි පරීක්ෂා කිරීමට තාක්ෂණ නිලධාරී කටයුතු කරයි. මෙම ජල බෙදීමේ ක්‍රියාවලිය දෛනික සුපරීක්ෂාව යටතේ සිදුකරන බැවින් ජලනල පිපිරීමෙන් සිදුවන ජලය අපතේ යාම අවම වී ඇත.

6.3 ජල ගාස්තු හා ජල ආදායම්

ජලය භාවිතා කරන පාරිභෝගිකයන්ගෙන් වැඩිවන ඒකක අනුපාත ක්‍රමයට අනුව ජල සැපයුම් ගාස්තු අයකරනු ලැබේ. ගෘහ හා වාණිජ වශයෙන් එය ප්‍රධාන වශයෙන් වර්ගීකරණය වන අතර, නගර සභා සීමාව තුළ හා සීමාවෙන් බැහැර යනුවෙන් ද ගාස්තු වර්ගීකරණයක් සිදුවේ. නමුත් මෙහි විශේෂත්වයක් වන්නේ ජල සම්පාදන හා ජලාපවාහන මණ්ඩලයේ ජල ගාස්තු වලට වඩා සාපේක්ෂව අඩු අගයක් ගැනීමයි. එය පාරිභෝගිකයාගේ තෘප්තියට ද හේතුවේ. මෙයින් නගර සභාව පාඩුවක් නො ලබන අතර, මනා කළමනාකරණයකින් යුතුව ජල සම්පත බෙදාහැරීම සිදුකරන බැවින් අනවශ්‍ය වියදම් අවම වී ඇත. පසුගිය වසර **5** තුළ බණ්ඩාරවෙල නගර සභාව උපයාගත් සමස්ථ ආදායම් ප්‍රමාණයට **35%-40%** අතර ආදායම් ප්‍රමාණයක් ජල ගාස්තු මගින් ලැබී ඇත. එය වගු අංක 2න් පැහැදිලි වේ.

6.4 පරිපාලන ව්‍යුහය හා පුරවැසි කමිටු ක්‍රියාකාරීත්වය

ජලය බෙදීමේ ක්‍රියාවලිය පවත්වාගෙන යාමට නගර සභාව විධිමත් පරිපාලන ව්‍යුහයක් හා පුරවැසියන්ගේ සහභාගීත්වය ලබාගැනීමට පුරවැසි කමිටුවක් ස්ථාපනය කර ඇත. උප නගරාධිපති එස්. සත්‍යමූර්ති ජල සම්පාදන ක්‍රියාවලියේ ප්‍රමුඛත්වය ගන්නා අතර, තාක්ෂණ නිලධාරීන් දෙදෙනෙක, ජල වැද්දුම්කරුවකු හා ජල කම්කරුවන් 14 දෙනකුගෙන් සෙසු කාර්ය මණ්ඩලයක් සැකසී ඇත.

වගු අංක 2. බණ්ඩාරවෙල නගර සභාවේ ජල ගාස්තු ආදායම්.

ශීර්ෂය	2004 රුපියල්	2005 රුපියල්	2006රුපියල්	2007රුපියල්	2008රුපියල්
ජල ගාස්තු ලෙස ආදායම	2,432,848.04	2,238,021.90	3,496,436.84	3,766,370.23	3,680,930.65
බවුසර් මගින් ජලය විකිණීම්	56,539.13	50,250.00	3,550.00	8,053.00	-
නගර සභාවේ මුළු ආදායම	5,284,231.38	5,466,401.33	11,348,219.06	8,931,719.83	9,967,758.63
නගර සභාවේ මුළු ආදායම ජල ශීර්ෂය යටතේ ආදායමේ ප්‍රතිශතයක් ලෙස	47.10%	41.8%	31.12%	42.1%	36.9%

මූලාශ්‍ර :- බණ්ඩාරවෙල නගර සභා නාගරික වාර්තා

මොවුන්ට ඇති ප්‍රධාන අභියෝගය වන්නේ ජල තාක්ෂණය පිළිබඳ පුහුණුව ලත් තාක්ෂණ නිලධාරීන් නොසිටීමයි. මෙතෙක් කල් වසර 17 ක කාලයක් එස්. සත්‍යමූර්ති උප නගරාධිපතිගේ ප්‍රායෝගික දැනුම හා කැපකිරීම මෙම ජල සම්පාදන ක්‍රියාවලිය සාර්ථක වීමට හේතු වී ඇත.

ඉහත කාර්ය මණ්ඩලය සමග කටයුතු කිරීමට ස්වේච්ඡා පුරවැසි කමිටුවක් ක්‍රියාත්මක වේ. ප්‍රදේශයේ ජල සම්පාදනය පිළිබඳ මහජන අදහස් හා යෝජනා මෙම කමිටුව විසින් පරිපාලන යාන්ත්‍රණය දැනුවත් කරයි. අධ්‍යයන ක්ෂේත්‍රයේ අහඹු ලෙස ගත් නියැදියකින් තෝරාගත් පුද්ගලයින් සමග පැවැත්වූ සම්මුඛ සාකච්ඡා කිහිපයක් පහත දැක්වේ.

සිද්ධි අධ්‍යයනය 01

වී. පූනේන්ද්‍ර මහත්මිය, වයස 52 : රුකියාව ව්‍යාපාර කටයුතු.

"අපි නගර සභා සීමාවට පදිංචියට ඇවිත් අවුරුදු 10 ක් වෙනවා. කලින් හපුතලේ හිටියා. අපි කුලියට තමයි ඉන්නවා. වතුර නම් කරදරයක් නෑ. එක දිගටම වතුර ආවේ නැති වුනාට අපි ස්ටොක් (ගබඩා) කරගන්නවා. දවසක් හැර දවසක් පොලිස් කන්දට වතුර දෙන්නේ. මොනවා හරි පැමිණිලි කලොත් නගර සභාව ටක් ගාලා හදලා දෙනවා. ප්‍රශ්නයකට තියෙන්නේ, අපිට දෙසැම්බර් ඉඳන් බිල් තමා ආවේ නැත්තේ",

සිද්ධි අධ්‍යයනය 02

ප්‍රියංගනී රත්නායක, වයස 38 : ගෘහනියකි.

"අපි ගෙදර ප්‍රයෝජනයටත් වගාව සඳහාත් ජලය යොදා ගන්නවා. වගාවට බොහෝ විට ළිං ජලය ප්‍රයෝජනයට ගන්නේ. ජල මණ්ඩලයට ගත් කාලේ අපෝ කිසි වැඩක් වුන් නෑ. හරියට ජලය ලැබුනේ නෑ. නගර සභාව හොඳට කරන් යනවා. තව නගර සභාවට අයත් පොදු ළිං පිරිසිදු කරලා කහත්තේවෙලින් පහළ රෙසවෙශන් (වෙන් කළ රජයේ ඉඩම්) ඉඩම් තිරුවේ ස්වාභාවිකව ගලා යන වතුර පහර අල්ලලා පුංචි වැවක් හදන්න පුළුවන්" එය ප්‍රදේශයේ වගාවට යෙදා ගන්න පුළුවන්",

සිද්ධි අධ්‍යයනය 03

එච්. එම්. බන්දුසේන, වයස 54 : බැංකු විධායක නිලධාරී.

"අපි නගර සභා සීමාවෙන් පිට පදිංචි අය. අපිට නගර සභාවෙන් ජලය ලබා දීම ප්‍රශංසනීයයි. කුමන හෝ නඩත්තුවක් අවශ්‍ය වුනොත් කෝල් කරලා කියලා පැය 3ක් ඇතුළත හදලා දෙනවා. මේ බලතල මහජන නියෝජන ආයතනවලට දෙන්න ඕන. ප්‍රදේශය ගැන දන්නේ, ජල නිධි ගැන දන්නේ ඒ අය. පළාත් පාලන ආයතන විධිමත් කරලා මේ බලය දිය යුතුයි. නගර සභාව ජල නල පද්ධති එළිම තරමක් විධිමත් කළ යුතුයි",

සිද්ධි අධ්‍යයනය 04

හනිෆා මොහොමඩ් නියාස්, වයස 49 : රියදුරු පාසල් විදුහල්පති.

"නගරයේ වෙළඳ සැල් සඳහා හොඳ ජල සැපයුමක් තියෙනවා. ටැප් වතුර නැත්නම් බවුසරේ හරි දාලා පහසුව දෙනවා. නගර සභාව මහජන ආයතනයක්, ඒ නිසා ඒ අය ජනතාව සමඟ ඉන්නව. ඉන්නත් ඕන. හැබැයි මණ්ඩලයත් එක්ක ඒකාබද්ධ වෙමින් රට පුරාම මේ ජලය ලබා දෙනවා නම් ගොඩක් හොඳයි. මොකද හැම තැනම ජලය නැතේ. මණ්ඩලය මධ්‍යම රජයේ නේ. ඒ නිසා පළාත් පාලන ආයතනත් එක්කත් මේ අවශ්‍යතාව එක් වෙන්න ඕන. වතුර නාස්තිය ගැන මිනිස්සු දැනුවත් කරන්න ඕන",

ඉහත සම්මුඛ සාකච්ඡා කිහිපය තුළින් පැහැදිලි වන්නේ නගර සභාව මගින් ඉටු කරන ජල සම්පාදන ක්‍රියාවලිය කෙරෙහි මහජන ප්‍රසාදයක් ඇති බවයි. ජලය ජනතාවට සෘජුව දැනෙන අවශ්‍යතාවයක් වන බැවින් ජනතාවගේ ප්‍රතිචාර විමසා බැලීම අවශ්‍ය වේ. ඒ සඳහා අවශ්‍ය මහජන වේදිකාවක් පුරවැසි කමිටු හරහා ලැබී ඇත.

7.0 ව්‍යුහාත්මක වෙනසකට ඇති අභියෝග සහ විසඳුම්

ලංකාවේ පළාත් පාලන ආයතන වෙත නැවත ජල සම්පාදන බලතල ලබාදීමේදී ඇතිවන ප්‍රධාන ගැටලු කිහිපයකි. විශේෂයෙන්ම සෑම පළාත් පාලන ආයතනයකටම එක සමාන ආකාරයෙන් ජල මූලාශ්‍ර නොමැති වීම ප්‍රධාන අර්බුදයකි. ඒ සඳහා ලංකාව පුරා විහිදී ඇති ගංගා හා ඇළ මාර්ග සම්බන්ධ කරගත් ජාලයක අවශ්‍යතාවය ඇත. ඒ සඳහා පළාත් පාලන ආයතන හෙවත් ප්‍රාදේශීය ආණ්ඩුකරණ ඒකක අතර අන්තර් සම්බන්ධතාවයක් අවශ්‍ය වේ. ටැන්සානියාවේ ප්‍රාදේශීය ආණ්ඩුකරණ ඒකක අතර ඇති ජල සම්පත් බෙදාගැනීමේ හුවමාරු ක්‍රමවේදය එයට හොඳ උදාහරණයකි.

එසේම ජල පවිත්‍රකරණය හා පොම්පකරණය සඳහා අවශ්‍ය විශාල පිරිවැය දැරීමට පළාත් පාලන ආයතන වලට සිදුවන බැවින් ජල ගාස්තු උච්චාවචනය වීමේ සීඝ්‍රතාවය වැඩිවිය හැක. මෙය මහජන ආයතන වෙත මුහුණ දීමට සිදුවන ප්‍රධාන ගැටලුවකි. මන්දයත් මහජන සම්බන්ධතාවය පවත්වාගෙන යාමට මෙම ගාස්තු ඉහල යාම යම්කිසි බලපෑමක් ඇතිකරනු ලබන බැවිනි.

ප්‍රාදේශීය ආණ්ඩුකරණ ව්‍යුහය සකස් වීම කෙරෙහි අවශ්‍යම දේශපාලන ආණ්ඩුකරණ ආයතන, සිවිල් සමාජ සංවිධාන, ප්‍රාදේශීය ව්‍යාපාරික ප්‍රජාව ඒ අභිලාප මුදුන් පත් කර ගැනීමට ඒකාබද්ධ විය යුතුය (Harris,2004:p.11). ආමූල මට්ටමින් (Grass root level) ජනතාව සහභාගී

කර ගැනීමේ හැකියාව ප්‍රාදේශීය ආණ්ඩුකරණ ආයතනවලට හැකිය. විශේෂයෙන්ම පානීය ජල සංරක්ෂණ වැඩ සටහන් ප්‍රජාවගේ ස්වේච්ඡා සහභාගීත්වයකින් තොරව ඉටු කර ගත නොහැක. ඒ සඳහා සිවිල් සමාජ කව ලෙස ගමේ හෝ නිවාස ඒකකයේ ජනතාව සංවිධාන වීමෙන් සක්‍රියව එම කාර්යය සිදුකර ගත හැක. එම නිසා රේඛීය අමාත්‍යාංශ වෙතින් සිදුවන දැනට ක්‍රියාත්මක පානීය ජල වැඩ සටහන් හි වගකීම ප්‍රාදේශීය ආණ්ඩුකරණ ඒකක වෙත ලබා දීම එම ව්‍යාපෘති වඩාත් ඵලදායී වීමට හේතුවක් වනු ඇත.

ප්‍රාදේශීය ආණ්ඩුකරණයේදී ජනතා සහභාගීත්වය ලබා ගත හැකි කමිටු ක්‍රමය විවිධ විෂය තේමාවන් ඔස්සේ පුළුල් කළ හැකි නම් ප්‍රජා සහභාගීත්වය ඵලදායී ලෙස ලබා ගත හැක. (Laiten;2008 Aug, P 19). දැනට පනතේ ක්‍රියාත්මක වන ස්ථාවර කමිටුවලට (වගන්ති 26 :1– මහ නගර සභා ආඥා පනත, 29 :1– වගන්ති නගර සභා ආඥා පනත වගන්ති 12 :2– ප්‍රාදේශීය සභා පනත) අමතරව ක්‍රීඩා කමිටු, ළමා හා කාන්තා සුභ සාධන කමිටු, නීති කමිටු සහ සංවර්ධන කමිටුවලට අමතරව ජල සම්පත් කළමණාකරණයේදී ප්‍රජා සහභාගීත්වය සක්‍රියව ලබා ගැනීම සඳහා හෙවත් ආණ්ඩුකරණ ක්‍රියාවලියේ දායක කොටසක් (Inclusive) බවට පත් කර ගැනීම සඳහා ප්‍රජා ජල සම්පත් සුරැකීමේ කමිටුව හෝ ජල භාවිතා කමිටු සැකසීම සිදු කළ හැක.

8.0 නිගමනය

මෙම පර්යේෂණය අනුව පැහැදිලි වන්නේ ජල සම්පාදනය හා බෙදා හැරීම තිරසාර සංවර්ධන පදනම අරමුණු කරගෙන ක්‍රියාත්මක විය යුතු බවයි. එමගින් ජල කළමණාකරණයට අවශ්‍ය පදනම සැකසේ. එම සාධනීය ජල කළමණාකරණ ක්‍රියාවලිය සඳහා ප්‍රාදේශීය ආණ්ඩුකරණ ව්‍යුහය යොදාගත හැකි ආකාරය මෙම පර්යේෂණය මගින් පහැදිලි විය. ජල සම්පත ප්‍රජා අවශ්‍යතා සම්පූර්ණ කරන ස්වභාවික සම්පතක් වන අතර, ප්‍රජා පාදක වැඩසටහන් හරහා එම සම්පත කළමණාකරණය කිරීමේ හැකියාව වර්ධනය වේ. ප්‍රජා අවශ්‍යතා උදෙසා ප්‍රජා සහභාගීත්වය ලබාගැනීමට කටයුතු කිරීම එහි ප්‍රතිඵල සාධනීය වීමට හේතුවක් වනු ඇත. ඒ සඳහා අවශ්‍ය බලතල ලබාදෙමින් දැනට ක්‍රියාත්මක පළාත් පාලන පනත සංශෝධනයට ලක්විය යුතුය. තවද ග්‍රාමියව ඇති ජල මූලාශ්‍ර සංරක්ෂණය කිරීමට ප්‍රජා සහභාගීත්වයෙන් යුතු වැඩ පිළිවෙලක් සකස් කළ යුතුය. ජල දූෂණය හා නාස්තිය වැළැක්වීමට ප්‍රජාව දැනුවත් කළ යුතු අතර, ඔවුන් අතර සහමන්ත්‍රණීය සාකච්ඡා (deliberative discussion) ඇතිකළ යුතුයි. මේ අරමුණු සාක්ෂාත් කර ගනිමින් සාධනීය හා ඵලදායී ජල කළමණාකරණ ක්‍රියාවලියක් උදෙසා, ප්‍රාදේශීය ආණ්ඩුකරණ ඒකක සම්බන්ධ කරගත් ජල සම්පත් කළමණාකරණය කිරීමේ වැඩ පිළිවෙලක් ශ්‍රී ලංකාවට ඉදිරියේදී අවශ්‍ය වනු ඇත.

9.0 ආශ්‍රිත මූලාශ්‍ර

පනත්

1987 අංක 15 දරණ ප්‍රාදේශීය සභා පනත

1988 255 අධිකාරය දරණ නගර සභා ආඥාපනත

Books

Field, D. R.; Barron, J. C.; Long, B. F. (Eds).1974. *Water and Community Development: Social and Economic Perspective*, USA, Ann Arbor Science Publication.

Harris, J.; Stokke, K.; Tornquist, O. (Eds.) 2004. "Introduction New Local Politics of Democratization" in Harris John, Stokk Kristian and Tornquist, *Democratization Politicalising Democracy: The New Politics,* Palgrave, London.

Iyer, R. R. 2003. Water, Perspective, Issues, Concern. New Delhi, Sage Publication.

Jayal, N. G. Pai, S. (Eds.) 2001. *Democratic Governance in India,* Sage Publication.

Jha, S. N.; Mathur, P. C. 1999, *Decentralization and Local Politics.* Sage Publication.

Kirkby, J.; O'Keefe, P.; Timberlake, L. (Eds.) 1995.*The Erthscan Reader in Sustainable Development.* London, Earthscan Publication.

O' Hara, S. 2003. *Water Management in the Southern Caucasus*, and *Central Asia ; Drop by Drop.* Open Society Institute.

Wood, J. R. 2007. *The Politics of Water Resources Devolopment in India; The Narmada Dam Controversy,* London, Sage Publication.

Articles

Gleick, P. H. 1998. Agust.Water in Crises: Path to Sustainable, *Ecological Application*, VOL, 8, No 3

Weiss, T. G. 2000. Governance, Good Governance and Global Governance, *Third World Quarterly,* Vol 21, No 5.

Reports

Chale, G. 1996. Local Government in Tanzania, *The Local Government Think Tank* Ministry of Regional Administrative and Local Government FES Project.

Dlamini, V. 2007. *Report of Local Government Implementation of Policies for Integrated Water Services Provision – The Practice in Bushbuckridge Local Municipality,* CGIAR Challenge Program on Water and Food, South Africa.

Leitan, T. 2008 August. *Reports on People Participation in Local Authority Activity*, Institute of Local Governance of Sri Lanka, Colombo, Sri Lanka.

Trvers, T.; Esposito, L. 2003. *The Decline and Fall of Local Democracy*, England: Policy Exchange.

UNDP. 1997. *Governance for Sustainable Human Development*, New York. UNDP, 1997.

UNESCO. 1979. Socio Economic Aspects of Hydrology, UNESCO, Paris.

Water for Food Conference - June 9-11, 2009 - List of Attendees

1. Chaminda Sidath Bandara, Research Officer, Hector Kobbekaduwa Agrarian Reserach and Training Institute. 114, Wijerama Mawatha, Colombo 7. Tel: 2696981 ext: 323. Email: *chaminda.sidath@gmail.com*
2. Badra Kamaladasa, Deputy Director of Irrigation, Irrigation Department. P.O. Box 1138, Colombo. Tel: 2581837 Email: *bkamaladasa@gmail.com*
3. Y. M. Dayabandara Yapa, Research Assistant, Department of Export Agriculture. Research Station, Matale. Tel: 066-4460850.
4. Salma Peiris, Senior Program Management Specialist, USAID. 44, Galle Road, Colombo 4. Tel: 777703909 Email: *speiris@usaid.gov*
5. G. G. A. Godaliyadda, Director of Irrigation, Irrigation Department. 238, Bauddaloka Mawatha, Colombo 7. Tel: 2588879, 718008174 (private), Email: *ggagodaliyadda@yahoo.com*
6. Indika Sampath Ariyatilaka, Research and Development Assistant, Department of Export Agriculture. Research Station, Matale. Tel: 066-2222945,0718077468 / 081-2463284 (private), Fax: 066-2222822 Email: *dgis@email.com*
7. Wasantha Palugaswewa, Regional Director of Irrigation, Irrigation Department. Airport Road, Anuradhapura. Tel: 718291413.
8. Dhammage Ariyaratne, Regional Director of Irrigation - Colombo, Irrigation Department. 238, Bauddhaloka Mawatha, Colombo 7. Tel: 2588668, 77377654 (private).
9. Anusha Rashanthie Warnasooriya, Meteorologist, Department of Meteorology. Bauddhaloka Mawatha, Colombo 7. Tel: 2676259, 2973836 (private), Fax: 2698311, Email: *rashanthie@yahoo.com*
10. A. B. S. Nandalal, Regional Director of Irrigation - Moneragala, Irrigation Department. Moneragala. Tel: 718008061.
11. R. S. Wijesekera, Assistant General Manager (Hydro), Water Resources Board. 2A, Hector Kobbekaduwa Mawatha, Colombo 7. Tel: 2694835, 071-8357376 (private), Email: *wijesekeraranjith@yahoo.com*
12. Lalani Imbulana, Director (Preparedness Planning), Disaster Management Center. BMICH, Bauddhaloka Mawatha, Colombo 7. Tel: 077-3957898 (private), Email: *indra.imbulana@gmail.com*
13. J. A. T. P. Gunawardena, Director, Department of Agriculture. Socio Economic and Planning Center, Department of Agriculture, Peradeniya. Tel: 081-2388081, 081-2385477 (private), Email: *tgunawardena@gmai.com*
14. D. S. de Alwis, Director General, Mahaweli Authority of Sri Lanka. 500, T. B. Jayah Mawatha, Colombo 10. Tel: 2687238, 0772-282838 (private), Fax: 2687391.
15. K. G. Janaka Karunasena, Scientific Officer, National Science Foundation. 47/5, Maitland Place, Colombo 7. Tel: 714491582, Fax: 2694754, Email: *janaka@nsf.ac.lk*
16. K. P. Kumbukage, Research Officer for Additional Director, Fruit Crop Research and Development Center. Kananwila, Horana. Tel: 034-2261323, Fax: 034-2261323.
17. Ravindra Hewavitharana, Commissioner General, Department of Agrarian Development. 42, Marcus Fernando Mawatha, Colombo 7. Tel: 777557158, Fax: 2691060.
18. S. C. Wanigasuriya, Principal Scientist, RRDI. Bentota. Tel: 034-2275173, Email: *agricbentota@slt.lk*
19. H. A. Sumanasena, Research Officer (SLSS), Department of Export Agriculture. Research Station, Matale. Tel: 066-2222945, 066-2244297 (private), Fax: 066-2222822, Email: *hsumanasena@yahoo.com*
20. Chamindi Kudahetty, Geologist, Water Resources Board. 2A, Hector Kobbekaduwa Avenue, Colombo 7. Tel: 2669440, 071-8139069 (private), Email: *ck1978hetty@yahoo.com*

21. G. B. Giragama, Director (Development) SLUDA. Gatambe, Peradeniya, Tel: 0812-575061, 071-2021292 (private), Email: *gbgiragama@gmail.com*

22. K. Premakumar, Dean/Agriculture, Eastern University of Sri Lanka. Faculty of Agriculture, Eastern University of Sri Lanka, Chenkaladi. Tel: 065-2240530, 065-2246063 (private), Fax: 065-2240740, Email: *kanagaprem@yahoo.com*

23. E. Sumanadasa, Regional Director of Irrigation. Irrigation Department, New Town, Polonnaruwa. Tel: 027-2222361, 071-4410641 (private), Fax: 027-2222361.

24. P. Sivarajah, Senior Lecture and Head of Department, Eastern University of Sri Lanka. Department of Agric. Economics, Faculty of Agriculture, Eastern University of Sri Lanka, Chenkaladi. Tel: 065-2240759, Email: *sivaponniah@yahoo.com*

25. P. A. D. A. Kumara, Research Officer, National Aquatic Resources Agency (NARA). Crow Island, Mattakkuliya, Colombo 15. Tel: 2521005, 071-6370630 (private), Fax: 2524430, Email: *padajithkumara@yahoo.com*

26. Ananda Mallawatantri, Assitant Resident Representative UNDP. 202, Bauddhaloka Mawatha, Colombo 7. Tel: 0773 444146, Email: *ananda mallawatantri@undp.org*

27. R. G. Wickramaratne, Regional Director of Irrigation - Puttalam. Irrigation Department, Irrigation Office, Puttalam. Tel: 077-9784482.

28. D. A. Athukorala, Research Officer, National Aquatic Resources Research and Development Agency (NARA). Crow Island, Mattakkuliya, Colombo 15. Tel: 2521000, 071-4437251 (private), Email: *athuko@nara.ac.lk*

29. K. Mullegamgoda, Programme Officer, World Food Program. 6, Joseph Lane, Colombo 4. Tel: 077-3887493, Email: *kithsiri.mullegamgoda@wfp.org*

30. J. Katupotha, Professor, University of Jayewardenapura. Department of Geography, University of Jayewardenapura, Gangodawila, Nugegoda. Tel: 071-8011540, 060-2087696 (private), Email: *katupotha@gmail.com*

31. A. H. G. Mithrasena, Deputy Director (Research) RRRDC. RRRDC, Bombuwela. Tel: 034-2281673, 038-2237620 (private), Fax: 034-2281673, Email: *mithrasena@yahoo.com*

32. S. Mohanarajah, Regional Director of Irrigation, Irrigation Department. P. O. Box 2, Batticaloa. Tel: 065-2223195, 065-2222034 (private), Fax: 065-2224780, Email: *mohanarajah@sltnet.lk*

33. P. B. Dharmasena, Free Lance Consultant. 227, Government Quarters, Mahailuppallama. Tel: 777613234, Email: *dharmasenapb@yahoo.com*

34. P. P. G. Dias, Deputy Director, Irrigation Department. Hydrology Division, Irrigation Department, Bauddhaloka Mawatha, Colombo 7. Tel: 2581636, 723565834 (private), Fax: 2581636, Email: *ddhydrology@gmai.com*

35. H. P. S. Somasiri, Director General of Irrigation, Irrigation Department. Bauddhaloka Mawatha, Colombo 7. Tel: 071-8008080.

36. D. B. Wickramasinghe, Additional Director, Natural Resources Management Center (NRMC). P. O. Box 52, Peradeniya. Tel: 0812 388355, Fax: 0812 388355, *nrmcdoa@sltnet.lk*

37. Namika Raby, Professor, California State U-Long Beach. 1250, Bellflower Blvd, Long Beach, CA 90840, USA. Tel: 562 985 5186, 771674727 (private), Email: *nraby@csulb.edu*

38. S. M. S. B. Niyangoda, Chair, SLWP. 127, Sunil Mawatha, Pelawatte, Battaramulla. Tel: 777880627.

39. H. J. K. Kurukulasooriya, Project Leader, Plan Sri Lanka. 621/13, Godage Mawatha, Anuradhapura. Tel: 0714 222218, Email: *jagath.harischandra@plan-international.org*

40. M. R. D. L. Kulathunga, Research Officer, Department of Agriculture. RARDC, Aralaganwila. Tel: 071 4466176.

41. C. Kudagamage, Director General, Department of Agriculture. Peradeniya. Tel: 081 2388331.

42. Tilak Attanayaka, Dean, Faculty of Agriculture and Plant Management, University of Wayamba. Makandura, Gonawila (NWP). Tel: 031 2299704, Email: *dpstga@yahoo.com*

43. Senani Karunaratne, Lecturer, University of Wayamba. Faculty of Agriculture and Plant Management, Wayamba University, Makandura, Gonawila (NWP). Tel: 718298994, Email: *senawu51@gmail.com*

44. J. Jayasekara, Director, Coconut Research Institute. Lunuwila.Tel: 031 2255809, 2809270 (private), Fax: 031 2257391, Email: *director@cri.lk*

45. S. S. Sivakumar, Deputy Director of Irrigation Irrigation Department. Station Road, Vavuniya. Tel: 024 2220632, Fax: 024 2222347, Email: *sssivaddim@sltnet.lk*

46. Anoja Seneviratne, Assistant Director, Disaster Management Centre. 2-203, BMICH, Colombo 7. Tel: 2670048, Email: *anoja@dmc.gov.lk*

47. Shanthi de Silva, Professor and Head of Department, The Open University of Sri Lanka. Department of Agric. Eng., Faculty of Engineering, The Open University, Nawala, Nugegoda. Tel: 2881323, Email: *csdes@ou.ac.lk*

48. K. Nagathasan, Deputy Director, Department of Agriculture. Extension Training Division, Department of Agriculture, Peradeniya. Tel: 081 2388340, 0777 602565 (private).

49. Ivan de Silva, Secretary, Ministry of Irrigation and Water Management. Jawatte Road, Colombo 7. Tel: 077 3040857, Email: *desilva.ivan@yahoo.com*

50. I. R. Perera, Team Leader, Practical Action. 5, Lional Ed. Mawatha, Colombo 5. Tel: 2829412, 2703303 (private).

51. Shamalee Amuwala, Undergraduate, University of Colombo. Colombo 3. Tel: 071 8087727 (private).

52. Sulakohika Senalankadhikara, Student, University of Colombo. Colombo 3. Tel: 077 9093327 private).

53. Sisira Saddhamangala Withanachchi, Assistant Lecturer, University of Colombo. Department of Political Science and Public Policy, University of Colombo, Colombo 3. Tel: 071 6595795, Email: *sisira.cmb@gmail.com*

54. Muditha P. Perera, Lecturer, University of Peradeniya. Department of Geography, University of Peradeniya, Peradeniya. Tel: 077 6657847, Email: *mudithpras@gmail.com*

55. L. B. A. S. Balasuriya, Junior Professional (Researcher), Centre for Poverty Analysis (CEPA). 29, Gregory’s Road, Colombo 7. Tel: 2676955-8, 071 6630560 (private), Fax: 2676959, Email: *amila@cepa.lk*

56. A. M. S. Perera, Programme Assistant, Department of Agriculture. Socio Economics and Planning Center, Department of Agriculture, Peradeniya. Tel: 081-2388206, 071 8118237 (private).

57. I. Jinadarie de Zoysa, Director, Horticultural Crops Research and Development Institute. Gannoruwa, Peradeniya. Tel: 081-2388011-3, 081 2385639 (private), Fax: 081-2388234, Email: *dirhordi@yahoo.com*

58. Upali Wickramaratna, Director (Eng.), Ministry of Irrigation and Water Management. 11, Jawatta Road, Colombo. Tel: 2554034, Email: *upaliwic@sltnet.lk*

59. A. D. H. Muthukuda, Director, Plant Quarantine Department of Agriculture. Gannoruwa, Peradeniya. Tel: 081-2388044, Email: *scppl@sltnet.lk*

60. Tanuja Ariyananda, Director, Lanka Rain Water Harvesting Forum. 28/3A, Subadrarama Lane, Nugegoda. Tel: 5524612, Email: *tanuja@sltnet.lk*

61. W. G. Gnanadasa, Irrigation Engineer, Irrigation Department. CO-PD’s Office, PEACE Project, Anuradhapura. Tel: 071-8025537.

62. W. G. Somaratne, Advocacy and Programme Policy Manager, OXFAM Australia. Sri Lanka Office, 15, Rohini Road, Colombo 6. Tel: 077 2960284, Email: *wgsomaratne@yahoo.com*

63. D. M. N. Banda, Provincial Director of Agriculture (Uva), Provincial Department of Agriculture. Office of the Provincial Director of Agriculture, Ratwatte Road, Badulla. Tel: 055 2222318, 2229318, 077 3593593 (private), Fax: 055 2229318.

64. Uditha Dissanayake, Senior Agronomist World Vision. 1119/2/1, Madarana Road, Colombo 8. Tel: 077 3428459, Fax: 5337151, Email: *uditha_dissanayake@wvi.org*

65. Palitha Wadduwage, Provincial Director of Agriculture (NWP), Provincial Department of Agriculture. Dambulla Road, Kurunegala. Tel: 037-2220126, 037-2232271 (private), Fax: 037-2222325.

66. T. P. Alwis, Director (ITI), Irrigation Department. ITI, Galgamuwa. Tel: 037-2253780.

67. T. N. N. Priyadarshani, Programme Assistant (Agriculture), Rice Research and Development Institute. Batalagoda, Ibbagamuwa. Tel: 037-2259881, 071-4928153 (private), Fax: 037-2259881, Email: *tnnpriya@yahoo.com*

68. W. M. U. K. Rathnayake, Research Officer, Rice Research and Development Institute. Batalagoda, Ibbagamuwa. Tel: 037-2259881, 071-4432745 (private), Fax: 037-2259881, Email: *upulr@yahoo.co.uk*

69. W. Weerakoon, Senior Agronomist, Rice Research and Development Institute. Batalagoda, Ibbagamuwa. Tel: 037-2259881, 071-5337037 (private), Fax: 037-2259881, Email: *rice@sltnet.lk*

70. W. M. J. Bandara, Research Officer, Rice Research and Development Institute. Batalagoda, Ibbagamuwa. Tel: 037-2259881, 071-4489332 (private), Email: *wmj.bandara@yahoo.com*

71. D. N. Sirisena, Research Officer, Rice Research and Development Institute. Batalagoda, Ibbagamuwa. Tel: 037-2259881, Email: *rice@sltnet.lk*

72. W. D. S. Abeywickrama, Institutions Development Officer, Irrigation Department. R. D. I. Office, Deberawewa, Tissamaharamaya. Tel: 071-8082726.

73. P. C. Senaratne, Director, Irrigation Department. P. O. Box 1138, Colombo 7. Tel: 071-8008070.

74. T. Selliah, Professor, University of Peradeniya. Faculty of Agriculture, University of Peradeniya, Peradeniya. Tel: 081-2395507, Fax: 081-2395500, Email: *sthiru@pdn.co.lk*

75. P. C. Samarawickrama, Livelihood Programme Officer, Caritas Sri Lanka. 133, Kynsey Road, Colombo 8. Tel: 2693989, 077 1935348 and 2696990 (private), Email: *prasannasa@gmail.com*

76. S. M. Weerasinghe, Regional Director of Irrigation, Irrigation Department. RDI Office, Irrigation Department, Ampara. Tel: 077 3848380, 2622357 (private).

77. Frank Niranjan, Senior Research Officer, Sri Lanka Council for Agricultural Research Policy. 114/9, Wijerama Mawatha, Colombo 7. Tel: 2697103, Email: *niranjanfr-03@yahoo.com*

78. Bopitiya, Agrarian Development Officer, Department of Agrarian Development. ASC, Ratmalawinna, Balangoda. Tel: 071 4447867.

79. K. Herath, Research Officer, Hector Kobbekaduwa Agrarian Research and Training Institute. 114, Wijerama Mawatha, Colombo 7. Tel: 071 8220021, Email: *herathda@yahoo.com*

80. P. Mahadurage, Project Director, Agribusiness Promosion, Research and Training, Mahaweli Authority of Sri Lanka. 500, T. B. Jayah Mawatha, Colombo 10. Tel: 071-4803353, Email: *piyathilakam@yahoo.com*

81. Jayamina Udhara Munasinghe, Undergraduate, Rajarata University. 124, Saman Mawatha, Sirimal Uyana, Ratmalana. Tel: 0772 701044, 0777 701044 (private), Email: *udhara_7@yahoo.com*

82. Dinesh Pathiraja, Student. Tel: 072 3478753, Email: *dkpathiraja@gmail.com*

83. Chandana Rohana Withanachchi, Senior Lecturer, Rajarata University. Mihintale. Tel: 071 6123596, 060 2370153 (private), Email: *withanachchic@yahoo.com*

84. S. R. S. A. de Silva, Deputy Director (Research), RARDC. Regional Agri. Research & Dev. Center, Aralaganwila. Tel: 027 5671054, 066 2233528, Email: *agardes@yahoo.com*

85. Nandani Samarasinghe, Institutional Development Officer, Irrigation Management Division. Bauddhaloka Mawatha, Colombo 7. Tel: 071 2504515, 071 8031009 (private)

86. L. W. P. Warnasooriyage, Resident Project Manager, Irrigation Management Division. Bauddhaloka Mawatha, Colombo 7. Tel: 2504515.

87. K. C. Boomini Arachchi, Irrigation Engineer, Irrigation Department. I&WM Branch, Irrigation Department, Bauddhaloka Mawatha, Colombo 7. Tel: 2583004, 034 2226054, Fax: 2583004, Email: *kboomini@yahoo.com*

88. Dasarath Jayasuriya, Manager, Water Prediction, Bureau of Meteorology. 700, Collins Street, Docklands Vic 3008, Australia. Tel: 61409893706 (private), Email: d.jayasuriya@bom.gov.au

89. Ranjith Mahindapala, Country Representative IUCN - International Union for Conservation of Nature. 53, Horton Place, Colombo 7. Tel: 2694094, Fax: 2682470, Email: *ranjith@iucnsl.org*

90. A. P. Sanjaya Fernando, Lecturer, Rajarata Univeristy. Faculty of Agriculture, Rajarata University, Puliyankulama, Anuradhapura. Tel: 077 9643667, Email: *prageethaps@yahoo.com*

91. C. J. Liyanaarachchi. Tel: 071 4477520 (private), Email: *jaliya@myself.com*

92. Junichiro Yamada, Engineer, JICA. JICA Sri Lanka Office, DHPL Building, 42, Nawam Mawatha, Colombo 2. Tel: 0777 872823, Email: *jyamada2008@nitmail.jp*

93. D. A. D. N. C. Wimalaratne, Chairman, Rural and Community Development Cooperation. 21, Pirivena Road, Naranpitiya, Panadura. Tel: 4998800, Email: *nimaindu@hotmal.com*

94. D. C. S. Elakanda, Project Director - DSWRP Mahaweli Authority of Sri Lanka. 500, T. B. Jayah Mawatha, Colombo 10. Tel: 2675315, 077 3540350 (private), Email: *elamrrp@sltnet.lk*

95. D. D. P. Witharana, Engineer (Water Management), Department of Agrarian Development. 42, Sir Marcus Fernando Mawatha, Colombo 7.

96. D. D. Prabath Witharana, Engineer (Water Management), Department of Agrarian Development. 92, Sir Marcus Fernando Mawatha, Colombo 7. Tel: 4320839, Email: *watmngcolombo@yahoo.lk*

97. Janitha Liyanage, Professor in Chemistry, University of Kelaniya. Department of Chemistry, University of Kelaniya, Kelaniya. Tel: 071 4264812, Email: *janitha@kln.ac.lk*

98. Thilani Padmajani Munaweera, Research Officer Hector Kobbekaduwa Agrarian Research and Training Institute. 114, Wijerama Road, Colombo 7. Tel: 2696981, 071 8051710 (private), Email: *hilanimunaweera@yahoo.com*

99. S. D. K. Seneviratne, Research Officer Hector Kobbekaduwa Agrarian Research and Training Institute. 114, Wijerama Road, Colombo 7. Tel: 2696981, 077 3905469 (private), Email: *sanjaanmil@yahoo.com*

100. P. S. Rodrigo, Management Assistant, Irrigation Department. Co-Project Director's Office, Irrigation Department, Airport Road, Anuradhapura. Tel: 071 4490772, Email: *tmpsrodrigo@yahoo.com*

101. Karin Fernando, Senior Professional, Center for Poverty Analysis (CEPA). 29, Gregory's Road, Colombo 7. Email: *karin@cepa.lk*

102. Sasindu Gunawardana, Research Assistant University of Kelaniya. Faculty of Science, University of Kelaniya, Kelaniya. Tel: 077 3361343.

103. Sarala Damunupola, Student. Sri Sudharshana Ramaya, Nilpanagoda.

104. Anushka Manori Gunaratne, Research Assistant, University of Wayamba. Department of Agriculture and Fisheries, Wayamba University. Tel: 071 4235789, Email: *menokmp@yahoo.com*

105. Sunanda Jayakody, Senior Lecturer, University of Wayamba. Makandura, Gonapeenuwala.

106. R. M. K. Kumarihamy, Research Assistant Center for Environmental Studies. University of Peradeniya, Peradeniya. Tel: 077 5707067, Email: *kumarirmk@yahoo.com*

107. A. M. Ranasinghe, Scientific Officer, National Science Foundation. 45/7, Maitland Place, Colombo 7. Tel: 2696771-3 ext 140, Email: *amalir@nsf.ac.lk*

108. S. N. Jayawardena, Research Officer, Rice Research and Development Institute. Batalagoda, Ibbagamuwa. Email: *senarathjayawardena@yahoo.com*

109. Athula Senaratne, Research Fellow, Institute of Policy Studies. 99. St. Michael's Road, Colombo 3. Tel: 2431368 ext 408, 077 6432472 (private), Email: *athula@ips.lk*

110. Sanjeewani Marasinghe, Programme Officer, Plan-Sri Lanka. No. 6, Claessen Place, Colombo 5. Tel: 777298827, Email: *sanjeewani.marasinghe@plan-international.org*

111. Dhammika Dayawansa, Senior Lecturer University of Peradeniya. Department of Agric. Eng., University of Peradeniya, Peradeniya. Tel: 081 2395467, 071 4446763 (private), Fax: 081 2395454, Email: *dammid@pdn.ac.lk*

112. U. D. Ariyaratna, Environmental Engineer, Green Friend.

113. T. S. Samarasena, Student, University of Colombo. University of Colombo, Colombo. Tel: 2402585, 077 6023978 (private), Email: *charundya@yahoo.com.au*

114. E. R. N. Gunawardena, Professor, University of Peradeniya. Department of Agricultural Engineering, University of Peradeniya, Peradeniya. Tel: 081 2395455, 081 2389209, Email: *minalgun@pdn.ac.lk*

115. Ranjith Premalal de Silva, Professor, University of Peradeniya. Department of Agricultural Engineering, University of Peradeniya, Peradeniya. Tel: 777801712, Fax: 081 2395454, Email: *rpdesilva@pdn.ac.lk*

116. Mohamed Najim, Senior Lecturer, University of Kelaniya. Faculty of Science, University of Kelaniya, Kelaniya. Tel: 2903402, Email: *mnajim@kln.ac.lk*

117. H. Dasarathasiri Gunawardhana, Senior Professor, University of Colombo. Department of Chemistry, University of Colombo, Colombo 3. Tel: 2503367, 276552 (private), Fax: 2503367, Email: *hdg@chem.cmb.ac.lk*

118. S. C. Udagedara, Student, University of Kelaniya. Faculty of Science, University of Kelaniya, Kelaniya. Tel: 0715 696659, Email: *uscudagedara@gmail.com*

119. Kanchana Wickramasinghe, Research Officer, Institute of Policy Studies. 9, St. Michael's Road, Colombo 3. Tel: 0722 860728, Email: *kanchana@ips.lk*

120. Vindya Hewawasam, Research Assistant, Ministry of Environment and Natural Resources. 342, Air Resource Management and International Relations, Pitakotte, Kotte. Tel: 2816970, 0773631013 (private), Fax: 4410236, Email: *eeconga@yahoo.com*

121. R. L Perera, Environment Management Officer, Ministry of Environment and Natural Resources. 342, Suite House Building, Pitakotte Junction, Kotte. Tel: 2816970, 071 4242297 (private), Fax: 4410236, Email: *ruchi74@gmail.com*

122. Thusitha Amarasekara, Postgraduate Student, PGIA. PGIA, University of Peradeniya, Peradeniya. Tel: 071 4479148, Email: *thusithaamarasekara@yahoo.com*

123. Zvi Feler, Business Development Manager, Netafim Ltd. 10, Hashalom Road, Tel Aviv, Israel. Tel: 972 86724747, Email: *zvi.feler@netafim.com*

124. M. A. A. Madurapperuma, Temporary Lecturer, The Open Univeristy of Sri Lanka. The Study Center, The Open University of Sri Lanka, 24 Post, Bandiwewa, Jayanthipura, Polonnaruwa. Tel: 27 2225776, Fax: 27 2225776, Email: *buddhika_dilhan@yahoo.com*

125. Nethmini Perera, Project Officer, Institute of Policy Studies. 99, St. Michael's Road, Colombo 3. Tel: 2431368, Email: *nethmini@ips.lk*

126. B. V. R. Punyawardena, Research Officer, Department of Agriculture. NRMC, Department of Agriculture, Peradeniya. Tel: 071 415967, 081 2218510 (private), Fax: 081 2388333, Email: *nrmcsltnet@lk*

127. Namalee Madawalagama, Chief Engineer, Irrigation Department. AM Branch, Irrigation Department, Bauddhaloka Mawatha, Colombo 7. Tel: 2744295, Email: *namalee_madawalagama@yahoo.com*

128. Kusum Athukorala, NetWwater. No. 7, St. Mary's Lane, Colombo 15. Tel: 2521604, Email: *kusum@itmin.net*

129. Eranda K. Gunathilaka, Lecturer, University of Sabaragamuwa. Department of Surveying and Geodesy, Faculty of Geometrics, University of Sabaragamuwa, Belihuloya. Tel: 077 3976577, Email: *erandakan@gmail.com*

130. A. L. Wickramanayake, University of Sabaragamuwa. University of Sabaragamuwa, Belihuloya. Tel: 077 2072337 (private).

131. Nalaka Duminda Perera, University of Sabaragamuwa. University of Sabaragamuwa, Belihuloya. Tel: 077 2072388.

132. Dinesh Nishantha, Director, Young Dawn Foundation. 514, Iriyavatiya Road, Dalugama, Kelaniya. Tel: 2671152 (private), Email: *nishantha7uk@yahoo.com*

133. Thiranka Ariyaratne, Irrigation Engineer, Dam Safety Project. Mahaweli Authority of Sri Lanka, 500, T. B. Jayah Mawatha, Colombo 10. Email: *thiranka@yahoo.com*

134. Priyanka Dissanayake, Environment Scientist, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

135. Priyantha Jayakody, Research Officer, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

136. Geethika Yapa, Head, Research Division, National Science Foundation. 47/5, Maitland Place, Colombo 7. Tel: 2687991, 2823054 (private), Fax: 2694754, Email: *geethika@nsf.ac.lk*

137. Amila Silva, Irrigation Engineer, Irrigation Department. Irrigation Department, Bauddhaloka Mawatha, Colombo 7. Tel: 077 4287831, Email: *amila_rugby@yahoo.com*

138. K. P. A. Dharmaratne, Deputy Director, Disaster Managemet Centre. 2-222, BMICH, Bauddhaloka Mawatha, Colombo 7. Tel: 2670002 - ext. 234, 077 3957899 (private), Fax: 2670079, Email: *eoc@dmc.gov.lk*

139. Alexandra Evans, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

140. Madar Samad, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

141. K. Jinapala, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

142. Ranjith Ariyaratne, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

143. Nishadi Eriyagama, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

144. Aditi Mukherji, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

145. David Molden, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

146. Tushaar Shah, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

147. Sithara Atapattu, Consultant, IWMI.

148. Sanjiv De Silva, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

149. Sonali Senaratne Sellamuttu, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

150. Mark Giordano, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

151. Vladimir Smakhtin, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

152. Herath Manthritilake, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

153. Pay Drechsel, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

154. Priyanie Amerasinghe, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

155. Upali Amarasinghe, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

156. Mir Matin, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

157. Nishath Yapa, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

158. Mohideen Sadir, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

159. Sarath Gunasinghe, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

160. Ranjith Alankara, IWMI. 127, Sunil Mawatha, Pelawatte, Battaramulla.

161. C. R. Panabokke. 439/8, Sudharshana Mawatha, Nawala, Rajagiriya.

162. V. K. Nanayakkara, Director, Hector Kobbekaduwa Agrarian Research and Training Institute. 114, Wijerama Mawatha, Colombo 7.

163. Kamal Karunagoda, Agricultural Economist, Department of Agriculture. Socio Economic & Planning Division, Department of Agriculture, P.O Box 1, Peradeniya.

164. M. M. M. Aheeyar, Head, Environmental and Water Resource Management Division, Hector Kobbekaduwa Agrarian Research and Training Institute. 114, Wijerama Mawatha, Colombo 7.

165. H. M. Jayathilake, Director (Irrigation and Water Management), Irrigation Department. 238, Bauddhaloka Mawatha, Colombo 7.

166. D. J. Bandaragoda. 449, Pansala Para, Thalawatugoda.

167. Sarath Abayawardana, CEO, National Science Foundation. 47/5, Maitland Place, Colombo 7.

Related Publications

Amarasinghe, U. A.; Samad, M.; Anputhas, M. 2005. ***Locating the poor: spatially disaggregated poverty maps for Sri Lanka.*** Colombo, Sri Lanka: International Water Management Institute (IWMI). 38p. (IWMI Research Report 096)

www.iwmi.org/Publications/IWMI_Research_Reports/PDF/pub096/RR96.pdf

Bandaragoda, D. J. 2005. ***Stakeholder participation in developing institutions for integrated water resources management: lessons from Asia.*** Colombo, Sri Lanka: International Water Management Institute (IWMI). 33p. (IWMI Working Paper 096)

www.iwmi.org/Publications/Working_Papers/working/WOR96.pdf

Bandaragoda, D. J. 2006. ***Institutional adaptation for integrated water resources management: an effective strategy for managing Asian River Basins.*** Colombo, Sri Lanka: International Water Management Institute (IWMI). 27p. (IWMI Working Paper 107)

www.iwmi.org/Publications/Working_Papers/working/WOR107.pdf

Bandaragoda, D. J. 2006. ***Status of institutional reforms for integrated water resources management in Asia: indications from policy reviews in five countries.*** Colombo, Sri Lanka: International Water Management Institute (IWMI). 36p. (IWMI Working Paper 108)

www.iwmi.org/Publications/Working_Papers/working/WOR108.pdf

Hussain, I.; Giordano, M. (Eds.) 2004. ***Water and poverty linkages: case studies from Nepal, Pakistan and Sri Lanka - Project report 1.*** Colombo, Sri Lanka: International Water Management Institute (IWMI). 113p.

www.iwmi.org/propoor/files/ADB_Project/Research_Papers/Water_Poverty_Linkages_IWMI_GWP.pdf

Molle, F.; Renwick, M. 2005. ***Economics and politics of water resources development: Uda Walawe Irrigation Project, Sri Lanka.*** Colombo, Sri Lanka: International Water Management Institute (IWMI). 74p. (IWMI Research Report 087)

www.iwmi.org/Publications/IWMI_Research_Reports/PDF/pub087/Report87.pdf

Saleth, R. M.; Dinar, A.; Neubert, S.; Kamaiah, B.; Manoharan, S.; Abayawardana, S.; Ariyaratne, B. R.; de Silva, S. 2007. ***Institutions, impact synergies and food security: a methodology with results from the Kala Oya Basin, Sri Lanka.*** Colombo, Sri Lanka: International Water Management Institute (IWMI). 46p. (IWMI Research Report 124)

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Postal Address
P O Box 2075
Colombo
Sri Lanka

Location
127 Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Telephone
+94-11-2880000

Fax
+94-11-2786854

E-mail
iwmi@cgiar.org

Website
www.iwmi.org

IWMI
International
Water Management
Institute

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