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Preface

THE IRRIGATION RESEARCH MANAGEMENT UNIT (IRMU) was established in mid-1992 in the Irrigation Department, Sri Lanka. The main objective of it is to identify research needs, conduct and coordinate research and disseminate research results to improve efficiency, productivity and profitability of irrigated agriculture.

As part of its technology transfer program, the IRMU initiated a series of monthly seminars. During the year of 1994, eleven such seminars were held. The seminars covered the following program areas of IRMU and their distribution was as follows: Assessing and Improving Performance of Irrigation Systems—3, Local Management of Irrigation of Systems—3, Operational Management of Water Delivery and Disposal—1, Crop Diversification—1, and Environmental Studies—3.

Professionals and researchers from national and international agencies as well as free lance consultants dealing with irrigated agriculture and irrigation management participated as resource persons. Speakers came from the Department of Agriculture, the University of Peradeniya, the Irrigation Department, the Irrigation Research Management Unit, the Open University of Sri Lanka, the Field Crop Research and Development Institute—Maha Iluppallama, the International Irrigation Management Institute (IIMI) and the Food and Agriculture Organization of the United Nations/Regional Office for Asia and the Pacific (FAO/RAPA). IIMI was involved in three presentations (two on IRMU's work), the faculty members of the University of Peradeniya gave two presentations, the Irrigation Department, the Open University of Sri Lanka, the Field Crop Research and Development Institute, the Department of Agriculture, the FAO/RAPA and an independent consultant gave one presentation each. In addition to serving as a strong component of the technology transfer program, these seminars also provide essential inputs in strengthening IRMU's research program. These seminars, in general were well received, which was evident from the wide participation of different institutions and agencies.

This publication contains summaries of the eleven seminars presented during the year 1994.

Increasing Incomes in Irrigated Settlements

S.L. Amarasiri[1]

OWING TO INADEQUATE rainfall, many crops have to be supplemented with irrigation water, particularly in the dry zone, in order to make optimal use of the sunshine, land, crop varieties and human capital and bring about high productivity for the benefit of growers, consumers and the nation. While irrigation has provided a means of livelihood to hundreds of thousands of farm families, there is a need to review the economic status of the settlers and the sustainability of the irrigation system.

The yields of many irrigated crops including rice, mungbean, cowpea, blackgram and groundnut have remained stagnant over the last eight years. Farm incomes have been very low causing serious hardships to the farming community. Incomes from rice with adequate irrigation water and yielding about 4 tons per hectare (t/ha) are only about Rs 19,000[2] per hectare per season excluding imputed cost (not paying for family labor). Thus with a two season cultivation, the monthly income from farming one hectare of rice is about Rs 3,200 or about Rs 1,300 per acre. The incomes from mungbean, cowpea and blackgram are even less. While the income from chili and onion is much higher at present, expanded cultivation of these two crops for which irrigated land is available plentifully in *yala*, may bring lower returns in the future. With reduced state funds for maintenance of irrigation systems, many of them are in poor condition leading to inadequate, untimely and inequitable water issues. These repairs if not attended to speedily, can cause further damage to a vastly important national resource of inestimable value. While many farmer organizations have taken the responsibility of maintenance of the distributary and field channels, this is not happening satisfactorily in some areas due to lack of organizational skills and the poor financial conditions of the farming community. Extension services are extremely weak in some settlements, with one Agricultural Instructor serving about 4,000 families.

While increases in farm income are badly needed to uplift the economic status of the family as well as the sustainability of the irrigation system, substantial increases of income from cultivation of rice and other field crops cannot be expected due to several fundamental limitations. Taking rice for example, a quantum jump in rice yields would be somewhat difficult to attain. Bringing down the cost of cultivation would be near impossible, and substantially increasing the guaranteed price of rough rice purchases by the State not feasible, particularly when rice can be presently imported and retailed locally for as low as Rs 14.00 a kilogram.

Alternate crops that are more remunerative with assured markets need to be found. Three crops that may be suitable are banana, coconut and grape. Banana is extensively grown under gravity irrigation in Walawe, while coconuts are cultivated to a limited extent in Rajangana, and grapes have

[1]Director, Department of Agriculture, Peradeniya.

[2]US$1.00 = Sri Lanka Rs 40.01 in 1990.

been recently introduced in the Mahaweli System B. Floriculture for export is another attractive proposition. With the introduction of new crops, adoption of new technologies must essentially take place for increased production and high quality. A proper mix of chemical and organic fertilizers must be used to maximize profits and maintain soil fertility.

Since incomes from farming are low, attention should be directed towards increasing settler incomes from off-farm enterprises. This approach receives validity owing to the availability of slack periods in the cropping calendar. For example, although rice cultivation from land preparation to harvest may take five months, only about 45 man-days per acre are required for the actual operations, mainly during crop establishment and harvest.

Examples of such income-generating activities are inland fisheries, bee keeping, animal husbandry, industries that add value to the primary agricultural product, and other industries that are relevant to the locality. In this way the available water, land and human resources will be used for multiple purposes with farming as only one of the activities of the settlers.

Sediment Suspension and Transport by Waves

Nalin Wikramanayake[3]

COASTAL SEDIMENT TRANSPORT is one of the most important factors in determining the physical features of the coastal zone. Beach erosion, filling in of navigation channels, sand bar formation and other processes are governed by the rate and direction of sediment transport in the sea. The transport of sand is caused by both breaking and non-breaking waves. Transport in the zone where the waves break—known as the surf zone—is mostly parallel to the shore—known as longshore transport. Transport outside the surf zone is mostly in the shore-normal direction, known as cross-shore transport.

This paper discusses the mechanisms of cross-shore transport in a wave-dominated environment with particular reference to the deductions from recent field measurements and mathematical modeling. Cross-shore transport is particularly important for the determination of beach profiles, grain sorting and the movement of sediment from the beach to deep water.

For sediment to be transported it must first be mixed into the water—a process known as entrainment—and then moved by the water. In the surf zone, entrainment is caused by the violent turbulent motions caused by breaking waves and transport is by the mean longshore current. Outside the surf zone however, transport is mostly confined to the wave boundary layer. The wave boundary layer is a thin—of the order 1 to 10 centimeters (cm)—layer of fluid at the bottom of the sea.

In deep water, the motion caused by surface waves does not penetrate to the bottom. However when waves move close to the shore and the depth decreases, they "feel' the effect of the bottom. The bottom imposes a "no-slip" condition on the potential motion in the rest of the fluid, thereby causing high shear stresses and turbulence. This effect is confined to a thin layer by the periodic reversal of the near-bottom wave velocity. Important processes in the boundary layer are mobilization of sediment from the bed and dissipation of the wave energy.

In the past, the accepted concept of transport was that the sediment was mobilized by the strong wave and created bottom shear stress, and was transported by the weak currents that are normally present in the near-shore regions. Thus, transport was calculated by taking the product of the mean velocity and the mean concentration. This method completely ignores any correlation between the wave motion and the sediment concentration. However, recent field measurements have conclusively shown that the concentration has a strong periodic component that is highly correlated with the wave velocity. Therefore it is necessary to calculate the periodic components of the velocity and the concentration in order to estimate the total transport.

In order to model the transport we have to calculate both the velocity and the sediment concentration. This is done using a simple eddy viscosity formulation of the turbulent mixing in the boundary layer. The velocity is forced by the near-bottom wave motion and can be found at all points when this quantity is known. However, the sediment concentration is forced by the effect of the water

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moving over the bed. In this model the entrainment of sediment is taken to be proportional to the bottom shear stress.

By this method, both the velocity and the sediment concentration—and thus the transport—can be calculated. The only unknown parameter in the model is the constant of proportionality in the entrainment boundary condition. This must be determined by comparing model results with field data. The measured field data must be extrapolated down to the bed in order to make this comparison—a procedure which will involve errors if the point of measurement is far from the bed. In the past, it was not possible to make measurements close to the bed without disturbing the flow so that the calibration of the models was not very accurate.

These problems have been overcome with the development of the Acoustic Backscatter Sensor (ABS). This instrument is mounted on a tripod set on the bottom at a height of about 1 meter (m) from the bottom. A very short pulse of high frequency sound is emitted and the echoes from the sediment in the water are sampled. The magnitude of the echo is then related to the concentration. In this way the concentration can be sampled along a vertical line with a depth resolution of 0.5 cm and a time resolution of 0.5 seconds (s). The ABS can measure the concentration up to 0.5 cm from the bottom without disturbing the flow and therefore the data is very useful for the calibration of the model.

The profiles of mean concentration predicted by the model are in good agreement with the data. Furthermore, the model is able to reproduce many of the features in the observed time series of the concentration at various depths. The correspondence is particularly good at the lower frequencies which is the important range when considering the transport. The calculation of transport shows that the transport caused by the periodic (wave) motion is much greater than that due to the mean (current) motion. This result justifies the inclusion of the periodic components in the model, and means that the model is now able to make improved estimates of the transport.

Natural Environment and Irrigation

Sarath Kotagama[4]

THE MAIN OBJECTIVES of irrigation management is to: (i) provide adequate water to farmers for successful cultivation, and (ii) control excess water that may be harmful to human beings or crops, such as floods, water logging, salt intrusion, etc.

Meeting the water needs of farmers involves collecting, transferring, delivering, controlling and the disposal of water. Water is transported from a source such as temporary anicuts or permanent anicuts and reservoirs/tanks, to the point where it is used for agriculture and industrial or domestic use. Canals, existing rivers and streams are used to affect the transportation of water. This process may result in the creation of new wetlands such as rice fields, drainage areas, reservoir areas, etc. It may also be pointed out that Sri Lanka is probably the largest wetland in the world. All its water bodies are man-made in some form, shallow or deep. Preventive actions will result in restricting flows and increasing outflows. Habitat change will result in water regime control. Therefore, these actions have impacts on existing wetlands.

Control activities involve prevention of floods and salt intrusion. Sometimes, natural salt intrusion is caused by tide action. Since we are meddling with wetlands we should give grave consideration to the fact that Sri Lanka is probably the largest wetland in the world with no natural lakes whatsoever.

There are three components to the environmental structure. These are the natural system, the built system and the socioeconomic and cultural system. It is difficult for the natural system to prevail though we like it. There is no place in this planet whose natural conditions have not been directly or indirectly influenced by humans. When we consider an urban system, a built system and a socioeconomic and cultural system take over where the natural system has contracted. When we move away from the urban system, the natural system becomes larger but the influence of socioeconomic and cultural factors do not go away. If we really want to have a totally harmonized sustainable environment in the future, it could only be possible through the fusion (the coming together) of these three components as much as possible. Today, these three components are polarized. Therefore, the objective of this presentation is to examine how to bring the three together. This aspect has not been considered before, and what we have done in irrigation so far is to interfere with the natural system.

There are a number of positive as well as negative impacts of irrigation. The negative impacts are loss of habitats (forest and aquatic); loss of species (terrestrial and aquatic); loss of life style (river, stream, wetland, migrant and land); micro-climatic effects (increase in humidity, changes in phenology); habitat change (salinity, chemical balance); excess water/drainage; methane emissions (contributing to green house gasses); loss of aesthetics (waterfalls) and health hazards.

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[4]Senior Lecturer, Faculty of Natural Sciences, the Open University of Sri Lanka, Nugegoda.

The positive impacts are environmental amelioration (increase in humidity, availability of water in soil, water balance table); enrichment of habitat/increase in species diversity; and enhancement of socioeconomic conditions and aesthetic values.

One needs to "think environmentally" to realize the positive goals when undertaking irrigation projects. If one does something natural, nature will look after it and it will maintain itself. Why can't we make rivers instead of canals which provide environment friendly conditions? Planning has to be multi-dimensional and not of a "plain table" format as practiced in the past. Site specificity must be considered and emphasis must be placed on landscape design to achieve benefits with least changes and impact on the existing conditions which are not dependent upon reconstruction. It must be noted that the efficiency in design and construction should not be to maximize profit for the present, but to optimize benefits for the future. Therefore, it can be concluded that environmentally sound development is based on compromise and sacrifice of the present, but not the future. Thus, it is advisable to think ecologically.

Irrigation Management Transfer: International Issues and Results

Douglas Vermillion[5]

THE GREEN REVOLUTION was a technological and managerial revolution which consisted of a clear set of essential elements, including new seed varieties, fertilizer, pesticide, and a reliable water supply. If all elements were implemented together the result would be a dramatic improvement in agricultural productivity. If one or more of the elements were missing the revolution would not take place. It was a package deal. Similarly, the irrigation sector in developing countries is in need of a management revolution which consists of the essential elements needed to manage irrigation systems in an integrated way. These elements are a clear and sustainable water right, clearly defined responsibilities and incentives, appropriate and functional infrastructure, and adequate resources. If one or more of these elements is missing the needed irrigation management revolution will not happen.

Irrigation management transfer, or turnover, is being planned or implemented in many countries in Asia, Africa, and Latin America. We define it as the reduction in the role of nongovernmental organizations (NGOs) such as farmer groups in irrigation management. Governments are promoting management transfer largely because of their inability to finance the cost of irrigation management, their inability to recover the cost from farmers through fees, their poor performance in irrigation management, and a rising expectation about the capacity of farmers to take over the management of irrigation systems, either fully or partially. Management transfer is not likely to produce the kind of management revolution needed in the irrigation sector unless it consists of an integrated package of water rights, clear responsibilities and incentives, functional infrastructure and adequate resources.

The transfer of management roles to farmers is being done through various strategies in different countries. The introduction of an irrigation service fee in Indonesia, the Philippines and Mexico shifts responsibility for paying for irrigation from the government to the users. In the Philippines, the government provides management contracts to Water Users Associations (WUAs), still paying part of the cost, but transferring the role of management to farmers. In Indonesia, the government has a program of providing direct grants to villages which in turn use the funds for improving their irrigation systems through local labor. In the USA, Mexico and Colombia, farmers elect boards who govern and hire professional staff to do routine management. In China, villages provide franchise contracts to pump irrigation teams. In Indonesia, entire management for small-scale irrigation systems is being transferred to farmer organizations. Management of subsections of irrigation schemes is being transferred to WUAs in Mexico, the Philippines, China and Sri Lanka.

This often involves federating WUAs from tertiary to distributary levels. In Chile, New Zealand and Bangladesh, irrigation systems are sold outright to WUAs or other NGOs.

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[5]Institutional Specialist, IIMI, Colombo.

All of these strategies involve some degree of transfer of management to farmer organizations. Chile, the USA and New Zealand are perhaps the most extreme cases where full rights and ownership of irrigation systems are transferred. Most cases of turnover are only partial. The government continues some management roles, such as retaining subsidies for irrigation or continuing to manage the diversions and main canals of large systems. Most cases of turnover do not include the full set of essential elements needed for the management revolution. The elements which are most often lacking are a clear and enforceable water right, clearly defined responsibilities and management incentives in the WUA and adequate resources to finance sustainable irrigation. However, we cannot expect irrigation management transfer to succeed if these elements are not part of the change process. Local conditions which make turnover more likely to succeed include profitable agriculture, high socioeconomic dependence of farmers on irrigated agriculture, high hydrologic dependence of agriculture on irrigation, lack of severe social divisions and existence of local institutions and skills for irrigation.

In summary, experience to date with irrigation management transfer seems to be producing the following lessons:

* When management is transferred to farmers, they tend to place a higher priority on cost efficiency than do government agencies.

* Farmers often seek diversified sources of financing irrigation in addition to payment of water fees (such as side line enterprises in China or contracted services in Colombia).

* The emphasis on organizing and motivating farmers often tends to neglect the need for greater clarity about rules and rights of farmer organizations.

* Turnover processes which do not involve farmers in decision making or investments in infrastructure improvements do not enhance local self-reliance of farmer groups.

* Governments often fail to clearly define their future roles after turnover and redeploy staff accordingly. This can result in lower-level bureaucratic assistance to turnover and the continuance of placing agency staff in field operational positions even after turnover occurs.

* Farmers tend to want full control over system infrastructure and operations before they are willing to fully finance irrigation.

* Farmers often do not want complete withdrawal of the government in the irrigation sector. They are often still needed to regulate water allocation between irrigation systems along river basins, to mediate disputes, to provide technical guidance and support services.

* Farmers are beginning to organize their own support services.

Water Resources Development Planning as Seen in the Ancient Water and Soil Conservation Ecosystems (Irrigation Systems) in Sri Lanka

D.L.O. Mendis[6]

IN SRI LANKA, the pre-historic period dates back to about the 7th/8th century BC, and the proto-historic to about the 2nd/3rd century BC. The ancient irrigation works date from the proto-historic, and possibly from the pre-historic period.

The ancient irrigation works consist of river diversion systems and storage reservoirs. The former includes temporary or seasonal works, and permanent works. The latter includes small tanks and large reservoirs equipped with sluices. A special structure that has been recently recognized as a diversion structure is the small earth embankment (bund) not equipped with a sluice, large numbers of which are found in the dry zone, for example in the Mau Ara Basin in the Walawe Ganga, and shown on topographical survey sheets as "small tank (abandoned)."

A four-stage hypothesis for the evolution and development of ancient irrigation works on a hydraulic engineering basis was presented by R.L. Brohier in 1956. The hypothesis was forwarded due to the perception of the Irrigation Engineers to whom water is inanimate and passive, whereas water is seen to be animate and passive from an ecosystems perspective. This hypothesis was re-published by Joseph Needham in his classic, *Science and Civilization in China.* Needham has now recognized it as being erroneous and has invited me to revise those few pages in Volume 4, Part 3 of his great work.

This wrong hypothesis was used in the preparation of a so-called Water Resources Development Plan of Ceylon, published in 1959, in which a number of new large reservoirs have been identified on a purely hydraulic engineering basis. All the ancient irrigation works have been ignored when preparing this map, except for a few of the large storage reservoirs and channels. This map has been used for the identification and construction of new irrigation and multi-purpose development projects such as Uda Walawe and Lunugamvehera. Severe socioeconomic and agro-ecological stress has been experienced on these projects due to problems of environmental degradation, the ultimate cause of which may be traced to the hydraulic engineering perspective underlying their conceptual design.

When viewed from an ecosystems perspective, the ancient irrigation works may be correctly recognized as water and soil conservation ecosystems. Their evolution and development may then be seen to have occurred in seven stages as follows:

1. Rain-fed agriculture.

2. Seasonal or temporary river diversion and inundation irrigation.

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[6]Independent Consulting Engineer/Researcher.

3. Permanent river diversion and channel irrigation.

4. Construction of weirs and spillways on contour channels.

5. Invention of the sluice (*sorowwa*) fitted with its access tower (*bisokotuwa*).

6. Construction of storage reservoirs equipped with sluices.

7. Damming of a perennial river.

The seven-stage hypothesis may be used to understand how the ancient systems evolved down the ages, using Brohier's well known documentation in his 3 volumes, titled *Ancient Irrigation Works in Ceylon,* and in his paper, titled "Inter-Relation of Groups of Ancient Large Reservoirs and Channels." This hypothesis is necessary and sufficient for a correct understanding of water resources development planning as seen in the ancient irrigation works in Sri Lanka.

Sedimentation and Desiltation of Minor Tanks

P.B. Dharmasena[7]

MINOR TANKS IN the dry and intermediate zones of Sri Lanka are mostly rain harvesting earth structures capable of storing runoff from upstream area to provide irrigation water to the immediate downstream land. Centuries old irrigation works of this nature have undergone various changes in their geometry not only due to rehabilitation activities but also due to the sedimentation process. The magnitude of sediment deposits in these tanks sometimes exceeds one third of the original capacity. The rate of sedimentation appears to be high in recent years due to increased farming activities in the tank catchments.

Tank water balance studies carried out in the Nachchaduwa Watershed indicate that the tank water losses due to evaporation, seepage and percolation are higher than the actual amount used for irrigation. Half the storage is lost during a period of 3 to 4 months showing the low efficiency of tanks as water conservation systems. The rate of loss increases linearly with the area/height ratio of the water body. Tank renovation programs which had no desilting activities have increased area/height ratio in most of the tanks and paved the way to increasing tank water losses.

A partial desisting technique is proposed in this presentation with the objective of reducing tank water losses and saving a portion of the tank bed area which can be subsequently utilized for agricultural purposes. In this technique, the closer portion of the tank bed is excavated and the removed sediment is spread over the other portion. The desisting design can be worked out after carrying out tank bed and sedimentation surveys. Economics and other implications of this approach have yet to be studied.

[7]Research Officer, Field Crops Research and Development Institute, Maha Iluppallama.

Common Mistakes in Water Resources Designs

G.T. Dharmasena [8]

THIS PRESENTATION HIGHLIGHTS common mistakes in estimating some parameters related to water resources designs. Issues addressed here are mostly confined to some hydraulic and hydrologic parameters. These are briefly outlined below.

It is often required to estimate the average annual yield or average seasonal yield of a catchment, by analyzing the time series of flow volumes for 20 to 30 years. Similarly, we may have to estimate an average monthly or annual rainfall at a particular station from long-term records. During this process, the presence of outliers in the streamflow or the rainfall time series will lead to erroneous results, unless these outliers are properly identified and taken care of. The average value of a time series is also taken into account as an event with a 50 percent probability, though this is not necessarily true for the entire time series.

In low-flow analysis in the design of diversion structures for irrigation or drinking water, smoothing the flow series for a number of days is more appropriate instead of analyzing minimum daily flows.

In flood estimation the concept of probability is very common, but in the application of probability theories assumptions behind the concept are sometimes poorly understood. For example, the definition of a flood of a particular return period, interrelationship between the return period of a flood and the return period of the rain storm which causes the flood, and the mixing of the normal probability with combined and conditional probabilities can be sited.

Regarding the techniques of flood estimation for small catchments, rational formulae and Synders techniques are very popular. However, the limitations in the application of these techniques and estimation of parameters of these models need a review.

In the design of a weir, it is required to estimate the weir length to pass a certain magnitude of a flood. The required length of the weir at a particular point of a stream depends on the control of flow by the structure itself. Sometimes, oversized structures have been adopted by making an attempt to design the structure for a particular return period such as 50 years or 100 years, instead of designing the structure for bank full discharge with provision for outflanking.

In the estimation of irrigation water requirements, there is a considerable amount of uncertainty on losses due to percolation from rice fields and on conveyance losses in canal systems. Experiments carried out by some researchers show that percolation rates are very much more than what is assumed in conventional designs. In addition, the reduction of seepage losses in concrete lined canals in comparison to a well-consolidated unlined earthen canal is not very significant.

Regarding the crop water requirement for rice, the requirement of water has to be viewed in the light of agrochemicals. This requirement is quite different to the water requirement given in FAO 24 which is certainly relevant for other flood crops (OFCs), but not for rice. One should be aware of the fact that

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[8] Deputy Director (Hydrology), Irrigation Department, Colombo.

even in the USA where rice is cultivated in a limited scale, the quantity of water used for a season is as high as 7.0 feet. Many forums where we discuss water management for rice cultivation, highlight weed control with water. This issue is debatable in the light of the cost-effectiveness of agrochemicals. Therefore, it is interesting to find out the multiple co-relationships between crop yield, quantity of water and the cost of agrochemicals used.

Tank Cascade Systems in Sri Lanka: Some Thoughts on Their Development Implications

C.M. Madduma Bandara[9]

IT WAS ALMOST 10 years ago, that the concept of tank cascade systems was introduced as such to the literature on water resources in the dry zone of Sri Lanka (Madduma Bandara 1985). A cascade was defined as a "connected series of tanks organized within a micro-catchment of the dry zone landscape, storing, conveying and utilizing water from an ephemeral rivulet." It was also found that, in the north central region, over 85 percent of all the operational village tanks were located within the cascade systems. The balance were mostly found to be *olagam* or tanks without settlements. The mean size of a catchment area of a cascade was observed to be around 6 to 7 square kilometers and the average number of tanks per cascade was about four, although in some it exceeded even ten.

During the last ten years, some effort appears to have been devoted to detailed studies on the hydrology of cascades (Gamage 1990; Dharmasena 1991; Itakura et al. 1993). It seems however, that similar attention has not been paid to the social organization within the cascades except for some occasional references (Tilakasiri 1989; Sandal 1987; Wong 1988). It is only recently that, some attempt appears to have been directed towards organizing irrigation management activities of village tanks on a cascade basis. Apart from their historical significance as original irrigation systems in the dry zone, I would argue that the concept of cascade systems has much potential for the development of a sustainable water resources management strategy for areas outside the major irrigation systems. The essence of my argument is that, irrigation management in the respective areas has to rise from treating each individual tank separately, towards adopting a strategy that treats the system as a whole.

Any attempt at utilizing the concept of cascades for improving water resources management efficiency has to be rooted in scientific knowledge of the hydro-ecology of the systems as well as in the sociology of respective village communities. Land use planning covering the whole system undoubtedly provides the key to any transformation towards sustainability (Gangodawila 1992). Devising a suitable social organizational strategy for bringing together all diverse social groups in a cascade is an equally challenging task for the planners. This may require the formulation of some conventions and agreements based on tradition and past experience, through participation of the communities concerned. Any attempt at applying the social benefit-cost analysis to cascade management must be extended to encompass the environmental dimension and the long-term gains and losses.

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[9]Vice Chancellor, University of Peradeniya, Peradeniya.

Participatory Training of Water Users Associations: A Tool for Irrigation Management Transfer

Joost Geijer,[10] Margot Porton[11] and Martin Smith[12]

THE PAPER PRESENTS a case study from Indonesia on Participatory Training of Water Users Association developed under the On-Farm Water Management Project with Food and Agriculture Organization of the United Nations (FAO) Technical Assistance. Based on experiences over a ten-year period from 1983 till 1994, the project developed an innovative methodology to introduce on-farm water management improvements for increased and intensified crop production and for farmers' self-reliance on the operation and maintenance of the farm irrigation system. The methodology and approach of the farmer training is based on the principles of Participatory Rural Appraisal (PRA). In a range of training sessions phased over a two-year period, farmers identify the potential for water management improvements and initiate simple and practical improvements of the farm irrigation system through the WUA. Benefits of improved water management is ensured by intensifying and diversifying agricultural production, while a sustained support over an extended period develops the necessary skills in the community to effectively assume responsibilities for operation and maintenance of the farm irrigation system. Technical staff and extension workers carry out the farmer training activities and provide technical advise to the farmers; also, special staff training programs were developed designed for this purpose for each staff category. Farmer training was introduced and tested in seven provinces in Indonesia and is initiated in several regional irrigation development programs. The training curricula for both farmers and agricultural staff have been extensively tested and afterwards implemented in seven provinces. Six hundred and seventy WUAs covering 40,000 hectares have received training, while about 160,000 farmers were involved. Costs including staff training and incentives for on-farm improvements amount to US dollars 50 per hectare, with benefits in agricultural production estimated to increase in the order of 20 to 30 percent.

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Farmer Involvement in NIRP Rehabilitation: Some Preliminary Observations

Jeff Brewer,[13] Azharul Haq[14] and Jayaprakash Upasena[15]

FARMER PARTICIPATION IN rehabilitation is a key issue under the National Irrigation Rehabilitation Project (NIRP), Sri Lanka. This paper analyses different aspects of farmer participation in rehabilitation such as farmer organization (FO) creation and preparation, farmer participation in planning and design, farmers contributing the mandatory 10 percent of the resources, construction contracting to FOs, and construction supervision by farmers or FOs. Other than these, some other issues like FOs' influence on the success of rehabilitation and effects of rehabilitation on the development of FOs' management abilities have been addressed.

Three medium schemes—Wennoru Wewa (WW) (tank, Kurunegala), Gampola Wela Raja Ela (GWRE), and Udugoda Bandara Ela (UBE) (anicuts, Kandy)—and two minor schemes—Kobeigane Maha Wewa (KMW) (tank, Kurunegala) and Udawela Maha Ela (UME) (anicut, Kandy) were selected as the field sites. WW, GWRE, and KMW were under construction while UBE and UME had been prepared to undertake rehabilitation.

Strengths and weaknesses of FOs in participating in the rehabilitation process and the effectiveness of agency involvement have been identified and documented. Political issues, shortcomings of the agencies, financial loss of FOs from contracts due to low rates of estimates, presence of part-time farmers, agency's inability to honor major requests of farmers (such as desiltation of tanks), disputes among farmers, economic and political disparity (the poor versus the rich), seasonal tenancy, weak leadership, lack of benefits from FOs as perceived by the farmers, are some of the factors which contributed to weakening the FOs. Some of the issues are common to all schemes while some others are site specific.

It is very difficult to conclude at this stage on whether FOs would be able to successfully undertake O&M responsibilities of these schemes after rehabilitation. Major issues identified in this study would be studied in depth in the Phase II of the study. The following have been identified as key areas needing immediate attention:

* FOs' activities should be supervised more closely by senior officials.
* FOs should be formed well in advance to allow them adequate time to prepare for rehabilitation work.

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* FOs should be formed well in advance to allow them adequate time to prepare for rehabilitation work.

* Training programs should be conducted more effectively by including topics like financial management.

* Wherever possible, different FO models including community-based FOs instead of channel-based ones may be tried.

* Field officers should be encouraged to more positively support FOs.

* Progress should be continuously monitored to check achievements against targets. An appropriate feedback and monitoring mechanism should be institutionalized.

* Inter-agency cooperation needs to be further improved.

* There should be more effective supervision contracts awarded to contractors. FOs should be provided with technical assistance by the relevant agencies to enable them to successfully execute contracts.

* The present practice of awarding contracts to FOs on profit/loss basis should be reviewed and ways need to be found so that they do not incur any financial loss in this learning exercise.

* FOs need to be properly oriented before handing over of the rehabilitation scheme.

* FOs should be assisted to develop appropriate mechanisms for resource mobilization for operation and maintenance (O&M) of the schemes after turnover.

Agro-Wells: Their Socioeconomic Profile and Potential for Conjunctive Use with Surface Water

K.A. Haq[16]

AGRO-WELLS (OPEN dug wells) have been introduced in the dry zone of Sri Lanka primarily to augment the availability, adequacy and equity of irrigation water throughout the year. By 1992 nearly 5,000 agro-wells had been constructed and the program is continuing. For this study, conducted in 1993, a stratified sample of 15 wells was selected from two topographies—in highlands (upstream of storage tanks) and in lowlands (downstream of storage tanks) in Galgamuwa. Agro-wells, unlike ordinary domestic wells, have a much higher capacity by virtue of their larger size. Excluding the family labor used by the farmer families in the construction and preparation of irrigation systems, the cost of construction of a well varied from Rs 15,000 to Rs 75,000.[17] The sample included wells of various types of construction such as unlined, unplastered, and fully plastered wells. The average cost of a pumping set and accessories was Rs 15,000.

The study observed that the majority of the owners were from the poor or lower middle classes of rural society. All the farmers except two in the sample drew their main income from agriculture. The average family size was five. The age of the sample farmers varied from 23 to 66 years, with an average of 42 years. The number of years of schooling by sample farmers varied between 2 to 10, with an average of six. All the owners borrowed money from the bank to purchase the pumping set.

Static water table data indicated that the wells located downstream of the reservoirs are hydraulically connected to the irrigation canals and as such, the water table in the wells responds directly to the changes in the water level of the canals. It was also observed that the water table in the wells downstream of the reservoir showed less fluctuation than those located in the highlands and away from the influence of the tanks. The static water table in the wells located in well-drained rice soils ranged from 3.2 meters (m) from the ground level in early June to 4.65 m by the end of September. In the wells located in poorly drained rice lands, the maximum distance to the static water table from ground level was 3.0 m even in the peak dry period during which there were no water issues from the reservoir. During the same period, the maximum distance to the static water table from ground level in wells located in the highlands varied from 3.3 m to 6.2 m. The maximum amount of water pumped from wells located in the highlands, and in well-drained and poorly drained rice soils were 1,017 cubic meters (m^3), 1,089 m^3, and 753 m^3, respectively, from June to September. These figures imply that water removal from the wells located in poorly drained rice soils is well below their potential. The average recharge rate ranged from 0.05 to 0.10 liters per second (lps). Even in the peak dry period, nearly 70 percent and 60 percent recharge occurred within 24 hours in wells located respectively in poorly drained and well-drained rice soils.

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[17]US$ 1.00 = Sri Lanka Rs 47.75 in 1993.

percent recharge occurred within 24 hours in wells located respectively in poorly drained and well-drained rice soils.

The cropping potential of an agro-well located in the highlands is such that it can maintain a long-duration crop with supplementary irrigation during *maha* (wet season) and a short-duration crop during *yala* (dry season). The wells located in the lowlands are capable of providing water for long-duration crops even in the yala season. Wells located downstream of the reservoirs were used for supplementing surface water for irrigating rice in the latter part of the 1992/93 maha season. Upland wells were used exclusively to grow other field crops, mainly chili, by supplementing rainfall. The average command area of a well was 0.21 hectare. The farmers cultivated small extents and also used low inputs.

Costs and returns from the wells indicated that the average net income was Rs 74,558.00 per hectare per season (from chili). It appears that most of the farmers who own agro-wells are not in a position to use their full potential due to lack of capital and knowledge about economically attractive crops and on-farm water management.

Farmers owning wells downstream of the reservoirs practised limited conjunctive use of well water with surface water for rice during the 1993 yala season, but indicated that as rice is a high water consuming crop, pumping a large quantity of water is near cost prohibitive. Pumping tests indicated, however, that potential exists for conjunctively using surface water and groundwater even for rice cultivation.

IRMU MONTHLY SEMINARS

DATE	TITLE	RESOURCE PERSON(S)
24.02.94	Increasing Incomes in Irrigated Settlements	S.L. Amarasiri
31.03.94	Sediment Suspension and Transport by Waves	P.N. Wickramanayake
28.04.94	Natural Environment and Irrigation	Sarath Kotagama
19.05.94	Irrigation Management Transfer: International Issues and Results	Douglas Vermillion
30.06.94	Water Resources Development Planning as Seen in the Ancient Water and Soil Conservation Ecosystems in Sri Lanka	D.L.O. Mendis
25.07.94	Sedimentation and Desiltation of Minor Tanks	P.B. Dharmasena
29.08.94	Common Mistakes in Water Resources Designs	G.T. Dharmasena
20.09.94	Tank Cascade Systems in Sri Lanka: Some Thoughts on Their Development Implications	Prof. C.M. Madduma Bandara
19.11.94	Participatory Training of Water Users Associations: A Tool for Irrigation Management Transfer	Joost Geijer Margot Porton Martin Smith
30.11.94	Farmer Involvement in NIRP Rehabilitation: Some Preliminary Observations	Jeff Brewer K.A. Haq J. Upasena
19.12.94	Agro-Wells: Their Socioeconomic Profile and Potential for Conjunctive Use with Surface Water	K.A. Haq