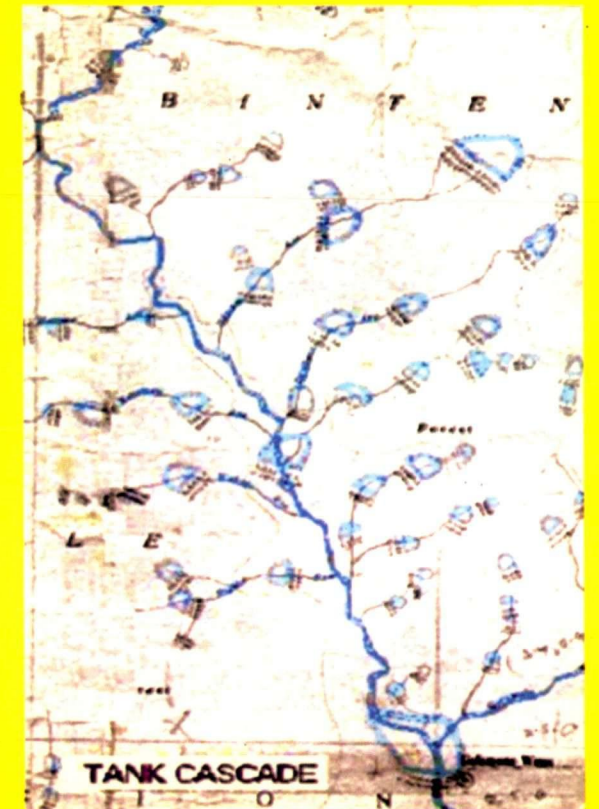


Small Tank Settlements in Sri Lanka



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Sri Lanka

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Small Tank Settlements in Sri Lanka

Proceedings of a Symposium

21 August 2004

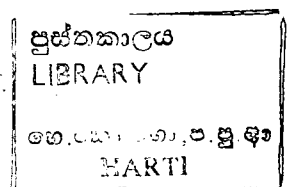
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Dr. W.M.G.B. Giragama & M.M.M. Aheeyar
Symposium Coordinators

TABLE OF CONTENTS

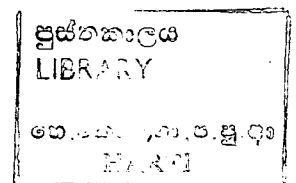
	Page
Acknowledgment	i
Table of Contents	ii
Foreword	iii
Address by Lakshman Jayakody	vii

TECHNICAL SESSION ONE

Tanks are not Mono-functional: they are Multifunctional Dr. M.U.A. Tennakoon	1
Global Diversity and Multifunctional Role of Tank Irrigation in Sri Lanka Eng. G.T. Dharmasena	8
Village Tank Categorization Eng. D.D. Prabath Witharana	16
Small Tank Heritage and Current Problems Dr. P.B. Dharmasena	31
Discussion on Session One Discussants	40
Eng. A.D.S. Gunawardena	40
Mr. Nanda Abeywickrama	41

TECHNICAL SESSION TWO

Small Tank Cascade Systems: Their Relevance for Minor Irrigation Rehabilitation Prof. C.M. Madduma Bandara	43
Understanding Rainfall as a First Prerequisite to Tank Management and Rehabilitation Dr. J Handawela	48
Small Tank Settlements in Sri Lanka Dr. C.R. Panabokke	56
Discussion on Session Two Discussants	69
Dr. R.D. Wanigaratne	69
Eng. S. Selvarajah	71
Dr. M. Samad	71
List of Participants	75



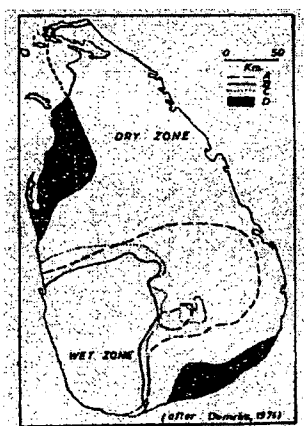
FOREWORD

An image of the tank and the dagaba as the twin supports of Sinhala culture has been central in accounts of this country. As much of the country was covered by mini-webs of small irrigation works, anicuts among them, the provenance of Buddhism covered the entire island and temples came to be established everywhere. The fact that many of the *raja maha vihara* have been vandalized, under the cover of 'treasure-hunting' and with increasing intensity over the last ten years, is indicative of a larger agenda for destroying an agriculture-based village culture that had been destabilized particularly during colonial rule.

However, besides the village temples, there are the exquisite sculptures at Tantirimale, Maligawila, Aukana, Polonnaruwa and elsewhere that show no obvious connection with the 'tank and dagaba' structures. As important too were other monasteries, located mostly in forests or mountains, that had no such symbiotic relationship with the villages around them. We might note, too, that most of the small village tanks are in the North Central, North Western and South Eastern dry zones - areas in which the people have been acculturated to a greater reliance on gods such as Ayyanayaka and Skanda, as well as local village deities, than on the *buddha-dhamma*.

Small tanks are associated with villages, i.e., with human settlements. It does not follow, though, that the tanks merely served man's need to produce food in the immediate sense. Many of the tanks were built to protect the ground water table, to function as silt traps for tanks, some of them the larger ones of record, below them, and to provide water for non-human life around them. As the papers in this book show, many of them contributed to the maintenance of groundwater levels of a zone that received all its rainfall within four months of the year.

Definitions of our dry zone vary, according to the criteria employed as shown below:



- A = 75 inches (=1,904 mm) isohyets of the mean annual rainfall.
- B = 20 inches (=508 mm) isohyets of the mean S.W. monsoon rainfall (June-September)
- C = Boundary line of 'effective dry period'
- D = Areas with less than 50 inches (=1,270 mm) mean annual rainfall, also described as 'Arid Zone'

Fig. : The division of Ceylon into the Wet Zone and Dry Zone according to various climactic statistical criteria

Source : "Sustainable Agroforestry Systems in the Dry Zone", H. M. J. K. Herath, U. Rajapaksha, and H. Susuma, *Tropics*, Vol 12 (2), 2002.

Neither was it the case that in the past paddy was the major supplier of food. In much of the dry zone, villagers engaged in some form of swidden / *chena* cultivation. The *chena* or *hena* not only supplied the coarse grains, yams and vegetables but that mix acted as "a biological fence against pests and diseases" (Herath et al.), while the scrubland surrounding village settlements also provided fodder for cattle.

The area available for *chena* cultivation has dwindled sharply over the last 150 years. The process commenced with the "Crown" Lands (Encroachment) Ordinance and the "Waste" Lands Ordinance through which the British colonial administration appropriated land and water for coffee, tea and rubber plantations and the timber to finance that 'enterprise'. The seizure of the central highlands in which the source of our major rivers is located and which held the water that fed the major irrigation systems in the

north western, north central, north eastern and south eastern dry zones, led to severe land degradation. It is clear already that the reservoirs at Kotmale, Teldeniya and Randenigala that were designed to hold the water for diversion to the north central and north eastern dry zone are themselves being silted up due to the mismanagement of land that characterized the plantations.

Over the past half-century the expansion of human settlements and of irrigation systems for the cultivation of paddy in the dry zone have made further inroads into that system of land use. In the areas in which the small tanks are in use their catchments have been denuded of forest cover, siltation has become virtually irreversible over the short term, and their recharge by rainfall can only be expected to sustain paddy on little more than the extents that have been already *aswedumised*.

The irrigable area under minor irrigation works has been estimated to be around 500,000 acres, but we must bear in mind that less than half the 'command area' is actually cultivated.

It has been suggested that the most reliable indicator of the boundaries of the dry zone is the distribution of irrigation works. A broad profile of village tanks would show that the bulk of them are located in the north western region of the country, principally in the basins of the Deduru Oya, the Malwatu Oya and the Kala Oya. More than one fourth of the village tanks that are now in use for cultivation lie in the Deduru Oya basin and a further sixth in the Malwatu Oya basin. Not surprisingly one third of the 'abandoned' tanks also lie within those two basins. One would surmise that they were all designed and constructed by the village community and where necessary in concert with a superior chain of decision making that had responsibility for major irrigation systems to which the village tanks had to relate and vice versa. Such particulars, in their juxtaposition, are relevant in framing a strategy for intervention by the State at this point in time.

The Deduru, Kala, Malwathu and Mi Oya are the basins that call for particular attention, as is now being given them, in the project for rehabilitating our village tank heritage. Given its present catchment yield, reduced beyond a critical level through depredations made under cover of law-makers and law enforcers, the Deduru Oya needs to be augmented over the medium term, until catchment protection is strictly enforced and made routine.

The *hath korale* or *wayamba*, or the North Western Province as drawn by the British colonial administration, is a major paddy producing area and contributes more to the national supply of rice than any other administrative area. The distribution of that production by source of water in Kurunegala district is as follows:

Season	Gross Extent Sown ('000ha)			Average Yield (Metric Tons)		
	Major	Minor	Rainfed	Major	Minor	Rainfed
2002/03	13	34	29	4,255	3,417	3,315
Maha						
2003 Yala	11	27	21	3,610	3,058	3,081

Source: Census of Agriculture, 2002

These figures show that there is little difference between the 'rainfed' fields and those augmented by minor irrigation works, both as to their total extent and to the average yield recorded. Indeed, in the *maha* season, the area brought under the plough without the aid of an artificial supply of water exceeds that fed by minor irrigation systems.

In that context, the figures for Kurunegala District for *yala* 2003, and *maha* 2003/2004, rounded off for convenience, and including the percentage harvested of that sown, are illuminating:

Yala 2003	Extent sown (ha)	Extent harvested (ha)	%	Average Yield (metric tons)
Major Systems	11,000	10,000	91	3600
Minor Systems	27,000	25,000	93	3050
Rainfed	21,000	19,000	90	3080

Source: Data Bank, HARTI

The picture is quite different for the drought-stricken season of *maha* 2003/2004:

Yala 2003	Extent Sown (ha)	Extent harvested (ha)	%	Average Yield (metric tons)
Major Systems	8,300	7,800	94	4,300
Minor Systems	17,300	8,900	51	3,200
Rainfed	19,400	4,100	21	3,200

Source: Data Bank, HARTI

The extent sown, the extent harvested and the average yield by source of water for the two seasons show the following relationship, - *maha* in relation to the preceding *yala*, indicative of farmer response under different water regimes in a period of prolonged drought.

Yala 2003	Changes in extent sown	Changes in extent harvested	Changes in average yield
Major Systems	75%	78%	+ 19%
Minor Systems	64%	35%	+ 4%
Rainfed	92%	21%	+4%

Those figures show that farmers who had no access to an artificial supply of water for cultivation sowed their fields in a larger proportion than those who had a reasonable expectation of such supplies, - and that their prospects of ensuring a harvest at the end of a dry season were much lower than the others. In other words, in relation to the present program for improving small irrigation systems, in a bad season such systems could provide a harvest two-thirds higher than those who had to rely exclusively on the rains might expect. A longitudinal study would provide a firmer base for such a hypothesis.

The information gathered at the last Census of Agriculture in 2002 gives, further, a dramatic picture of the straits to which the people in that region have been reduced within a period of twenty years. The data gathered through that census is yet to be disaggregated to give us a view of what changes have occurred - they are not likely to have been substantial - with respect to paddy fields. Nevertheless, the data on holdings of agricultural land, in the country and in Kurunegala in particular show an alarming incidence of land fragmentation. The following figures tell their own tale: the number of agricultural holdings increased from 219,000 in 1982 to 344,000 in 2002, an increase of 57%. The total extent of agricultural holdings however increased only by 1.3% from 534,000 in 1982 to 541,000 in 2002.

Such are features of that landscape that need to be taken into account in framing a long-term solution to the multifarious problems associated with land use, and must be undertaken with further studies into the problems of water use. While land is a fixed entity, water is not, and the latter depends for its augmentation not merely on trans-basin diversions but on measures for the rehabilitation of the catchments of our 103 river basins. Such a program must accord the highest priority to the execution of a radical change in land use in the central highlands. That has necessarily to commence with the reforestation of the embankments of the rivers and of the streams that feed them, the enforcement of soil conservation measures in the (mostly) tea plantations that have for more than a century served to erode the land but supply today only a little over one-third of the tea produced in this country, as well as of the cultivation of short-term crops (which is of more recent vintage but as harmful to the stability of the soil). The entire economy of the hill country has to be restructured if the current attempt to restore the infrastructure of village irrigation in the dry zone is to succeed.

The question of the technical efficiency of these village irrigation systems was examined by J.S.Kennedy, Director of Irrigation in the 1930s. In his path-breaking paper on the subject, delivered before the Engineering Association in 1933, he said,

“There are many cases where the total yield of the catchment could be more efficiently and economically stored in one improved tank instead of in half a dozen or more, and used with scientifically guaranteed certainty of sufficiency for the irrigation of all the present fields, and of all beds of the superfluous tanks as well, *if tradition would allow them to be turned into paddy fields*. If tradition would not allow, a promising development project has to be reduced in its scope, to irrigate only the present fields, and such extension thereof as will not encroach on the territory occupied by the jealously preserved tanks.” He went on to caution his fellow engineers against applying their parameters of ‘efficiency’ in the following terms:

“Science must recognize of course, that the traditional preservation of redundant tanks is, at least in part, due to the other conveniences, which they confer on the village, besides that of efficient storage for irrigation. In any case, anything like high-handed interference in the traditional rights would be a calamitous blow to all hopes of cooperative progress.” (J.S. Kennedy: ‘Evolution of Scientific Development of Village Irrigation Water in Ceylon, Proceedings of the Engineering Association of Ceylon, 1934. Quoted by D. L. O. Mendis in “Water for People in Nature; Arumugam Commemoration Volume 2003, p. 100).

Whatever the basis on which village tanks are taken up for rehabilitation or restoration, whether it be on the basis of an existing cascade system or is dictated by local imperatives that might well be transitory, it is of paramount importance that their possible adverse impact on the environment generally and on other tanks in the vicinity in particular should be soberly assessed before such interventions are made. In any case whatever criteria are adopted in selecting them for attention, the rehabilitation of such tanks would indeed be a boon to the villages served by them.

The papers in this book have been prepared by scientists who have specialized in this field and it is hoped that their analyses would be examined carefully by our policy makers.

D.G.P. Seneviratne
Director

Address by Lakshman Jayakody
Senior Advisor to the Her Excellency President on Social Infrastructure

I am extremely happy that I have been asked to say a few words for fifteen minutes on the very special subject of social infrastructure, which is one of most important aspects of society, of *Wewa* culture or the dry zone culture and if I may expand it, the wet zone culture as well.

I feel that the subject we have chosen and the eminent personalities cited are excellence in these fields in the country. I feel that there is a new impetus in the country to develop small tanks in this country. There was a time when we renovated or constructed big tanks. People wrote why we are neglecting small tanks. The plea was that these tanks were organizations not only for water collection, agriculture, and power generation or on land matters. It is something much more and socially very important in this country. At last we can focus this matter to the general public and also to the politicians, who should be correctly advised and educated on the correct perspective.

I have been a politician for about 40 years and I have seen one side of the story. I was keen to leave the Parliament and get into others such as the administration and scientific sectors. The sectors which are not political and which I find very interesting. I feel that some of us who were in the political field were not specialist however I always believed that a Minister, as a politician obviously a man with a lot of common sense who can pick the brains of eminent personalities, scientists, technologists, and others. Following which, we can focus our attention on the very important aspect that we in this country do not make use of the opportunities that come up with the problems that arise from time to time. Here when we get an opportunity we grasp it as a problem and do not make use of it to solve the problem. Therefore we have got into a very difficult situation. That is unfortunate. I could recollect my connection with agriculture and how we faced the war. Few seniors like Dr. Panabokke would remember how we fared during the war. There we had a massive food shortage and the directorate of the Agriculture Department felt that we have to import food. They foresaw that German was interfering with food transportation from the West. They also observed that the Japanese were entering the war and therefore the means of supplies from the East were affected. The only safeguard was India. Hence, they made plans to open a food pipeline from India. It was decided to strengthen the railway line to Mannar and from there extend it to Talai-Mannar pier. There we had the route from which we got all the required food from India.

Second one was in 1971-crash programm for food production in the country. Late Mr. Sydney Silva, Mr. Sarath Perera, Ms. Sunethra Bandaranaike and Mr. Ratnadeshapriya Senanayke and myself were in it. We took control over some paddy lands. We were given areas to operate. I was given Polonnaruwa and Ampara.

Third opportunity we had and succeed was Srma – Sharsthri pact. And today we have another problem, the food crisis. It has given us an opportunity, if we can face it in the right manner with correct statistics. We know the statistics are there, the number of tons of food that we need etc., but I feel that still correct statistics are not given to the hierarchy from the village level. That is something we should guard ourselves from figures sent to the top planning secretariat are not true and I would say all concocted. It has been collected by the most junior officers in the public services i.e. *Grama Sevaka*. Unfortunately the village level extension workers lack basic knowledge on agronomy. In fact they are the most incompetent agricultural extension officers I have ever seen. You cannot blame them for this situation, but the politicians. Blaming the politician is not enough now. You have to take remedial steps in the correct direction. One step would be that all extension officers should come under particular research station. From research it goes down to the Ministries then to the Department. From there it goes to the GAs, AGAs down to the *Grama Sevaka*. Once its get there, some of it is not properly constructed so as to enlighten the people. Thus it affects all the facts and figures that we get from *Grama Sevaka* level. For example, some say there are 12,000 small tanks in Anuradhapura and some say there are 7,000. When you add up all the work that you have done particularly the work connected with the village irrigation tanks, VIRP, NIRP, NORAD in Hambantota, and the Dry zone irrigation project we have spent all the money that we got. Imagine if we had spent Rs. 400,000 per tank with that money, we would have completed all the tanks by now. But, did we do it? Why didn't we do it? Look at the figures and find what happened. Then there we

could get a better picture. I think the figures we have about renovated and rehabilitated tanks are all concocted. These figures that are used by officers of your caliber to come to a final decision.

And then I find that the technology that has been used for small tanks, particularly heavy machinery such as bulldozers has created a lot of problems. As policy makers have come to the conclusion that these tanks have to be renovated we must make sure that these things are properly done tanks definitely get water, that water gets collected there and it provides benefits to both the agricultural sector as well as the social infrastructure.

I have made a note sometime ago with regard to the number of ministers that we should have in this country. Because the number keeps on expanding, we may lose proper coordination. I am of the opinion that this country needs only 10 Ministries. One is the presidential subject, then Macro-economic Policy Planning, Agriculture, Industries, Economic Infrastructure, Social Infrastructure, Administration, Foreign Affairs, Heritage and so on. Social infrastructure to my mind is a priority as it deals with human life. It includes subjects like water and housing. Some time ago when Mr. C. P. de Silva was a Minister I asked him 'you are the Minister of Agriculture, Irrigation and Power' and how do you manage such a big area? That was in 1960 or so. He later told me that he is not doing agriculture, neither irrigation nor power or land. He does only one thing he said 'I only control water that was his thinking. We were lucky that we have water management, part of irrigation under Mahaweli. We have completed Mahaweli, but we have some problems.

It is high time that we look in to the country's drainage problem. That is to find ways to use excess water for the benefit of man. This particularly so in the South-West where the rivers like *Kelani ganga*, *Kalu ganga* right upto *Nilwala*. It is the excess water rather than irrigation. That is the problem I made this proposal long ago when Dr. Amunugama was the Minister and he took some steps on it. That is one area we have to get expertise with our people in the group to formulate a scheme.

I am not going to talk about culture. There is an important decision taken at UN about 6-7 years ago, that culture and development goes together. It took much discussion and persuasion to convince the World Bank on this matter. Finally they too agreed culture and development goes together. It does not mean tourism and eco-tourism or things like that. It has a very wide meaning. There is a new concept given to us by USAID called 'millennium challenges' where culture and development goes hand to hand. So that is one area we have to look into. I am trying to meet them and discuss this matter. Here what I want is to infuse cultural aspect into our tank development effort. That is very important as far as the social infrastructure is concerned.

The period from July to September is the ideal period for new tank construction or renovation work. We have to be extra careful in doing these things because tank irrigation systems differ from Anuradhapura to that of Hambantota. Introduction of new technology to the cascade system in Anuradhapura i.e. construction of bunds and other renovation appear to be creating a problematic situation. Here we have to be extra careful. Otherwise it does not assist us in maximizing the utilization of the cascade system. It could upset the whole system or become a threat rather than be an opportunity for us.

Ultimately the western coast we also have in the Gampaha District or for that matter all the districts in the North Western area in the semi-dry zone. In all these areas we had little tanks everywhere. Before coconut was cultivated, we were told that there were little tanks in the lands taken over by the State. It has completely gone. But, it is very feasible to have small tanks, to safeguard the wet zone in case there is a dry spell coming. Again we must concentrate much more on the drainage system. Because all the water that fall on the western areas of the country just flows out. It is a criminal act to allow this water to flow into the sea. Everybody is responsible for that. Even the Government is responsible.

Finally I would like to thank you. We would like to see certain deliberations are made. We also would like you to pay attention to *Hambantota Mavu aru*, *Kirama Oya* and *Kirindi Oya* associated problems. The technologies and eminent people on this subject should focus attention on these matters and make available your points of view to policy makers.

Thank you.

Technical Session One

TANKS ARE NOT MONO FUNCTIONAL: THEY ARE MULTI FUNCTIONAL

Dr. M.U.A. Tennakoon

Director General, Mahaweli Authority of Sri Lanka

Abstract

Though tanks are of many types, they are not isolated entities. They are inter-linked members of networks in different cascades and their physical, environmental and cultural elements and functions are inseparably entwined. Seldom a tank is mono-functional. The vast majority of them are indeed multi-functional or multi-purpose. This functional and purpose-wise plurality has to be well understood before decisions are made to restore/rehabilitate tanks. Ad hoc selection of tanks for restoration/renovation can cause more problems than solving those existing ones in land and water management practices.

It is, therefore, prudent to examine thoroughly all the tanks in an existing tank network within a particular cascade and carefully select and prioritize those tanks which need restoration/renovation first, so that, a particular restoration/renovation of a tank does not negatively affect the purposes and functions of yet another tank in a cascading system of water flow.

In the past, we had very systematic tank management institutional arrangements in place with distinctly limit to management leadership. These time-tested institutional arrangements have been subsequently changed to be broader based and 'democratic,' expecting every one to be managerially responsible. But the expected everybody's responsibility has now become nobody's responsibility. This needs an early correction.

Tanks in Cascades

Tanks are integral parts of a whole cascade system in a sub-watershed of a River Basin. These tanks are constructed across: (a) a main axis stream taking its rise from a summit (*mudunna*) flowing downstream in a cascading valley until it reaches a large reservoir or a large water course (*oya* or a river); and (b) on the side slope ephemeral rivulets which join the main stream of the keel of a cascading valley. Each axis valley is separated from one another by low ridges (*heennas*) as could be seen in (Figure -1).

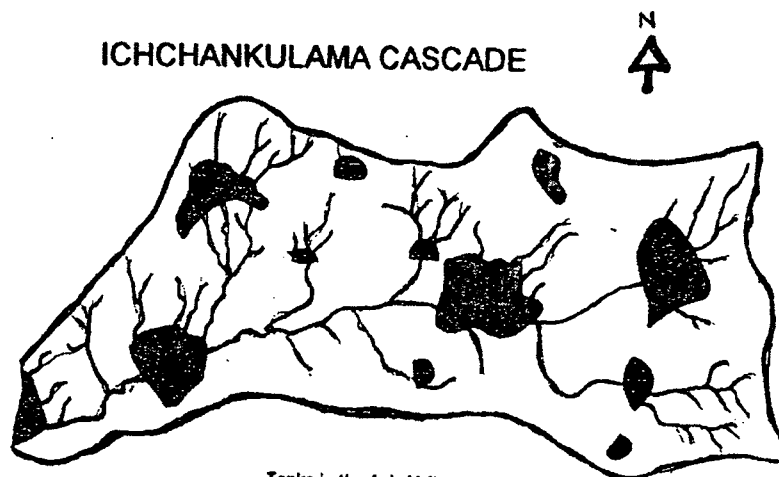


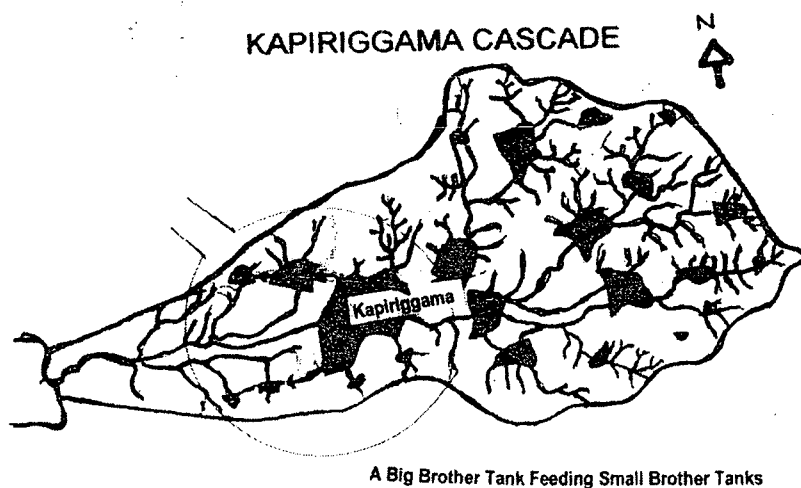
Fig. 1. Tanks in the Axis Valley and in the Hanging Side-slope Valleys

(Adopted from Panabokke - 2000)

Tanks are not Isolated Entities

Notably the down stream tanks both in (a) and (b) above depend on upstream tanks and their catchments. The general situation is, that, “small brothers ” feed the “big brother” tanks” (Panabokke, personal communication). However, there are notable exceptions. In some situations, big brothers feed the “small brothers”. A large village tank generally rendering its excess water from the spills at both ends of the bund are made to be contour-guided to downstream small tanks on side-slopes of low hills bordering a cascade. As these large tanks feed the small tanks, they are even recognized as feeder tanks. For example *Kapiriggama* tank feeding small tanks downstream is shown in Figure – 2.

Figure No. 2: Kapiriggama Cascade



(Adopted from Panabokke – 2000)

Tanks are of Different Types

In a cascading valley in association with the main axis stream in its keel and in association with the side slope ephemeral rivulets joining the main axis stream, many types of tanks are found. They are the *godawalas* (shallow troughs created), *Kulu vew* (silt traps), *Olagam vew* (supplementary tanks), *Pin vew* (Temple Tanks), and *village tanks*.

For easy exposition, if we for a moment concentrate on a single tank, we see that its different components act symbiotically. These components are: (a) physical; (b) environmental; (c) economic; and (d) socio-cultural. As in human anatomy, though different parts are separately identifiable, all or some of them at different times synchronize functions that they perform. There is a high degree of interdependence or a linkage of these components.

Linkage of Physical and Environmental Components

Physical and environmental components of a tank include:

- (a) Tank water spread area (*diyagiluma*) ;
- (b) Tree- girdle (*gasgommana*) at the upper shore line of the tank ;
- (c) Upstream meadow (*thavalla*) upstream of the tree girdle (*gasgommana*) which is the immediate catchments of the tank ;
- (d) Upstream catchment still upstream of the meadow, which include upstream tanks, their catchments and command areas as well as the upstream forests, downstream for the water-divides of *heennas* or low ridges and the summit (*mudunna*) from which ephemeral rivulets flow downstream to the main stream in the keel of the valley up to particular tank.

- (e) Alkalinity trap zone (*Kattakaduwa*) at the outer tore of the tank bund, which accumulates alkalinity of the water that reaches there, from the tank through capillary action, preventing alkalinity spreading onto the command area further downstream of the tank;
- (f) Fields, both old fields (*purana Welas*) and recently established *akkaravelas* in the command area;
- (g) Irrigation channels and canals downstream of the tank;
- (h) Drainage canals;
- (i) Settled highland areas (s) or *gamgoda* (s);
- (j) Village parklands (*pitiya*);
- (k) Village forestland;
- (l) Prevailing micro- climate; and
- (m) Even groundwater levels in sub –soils.

Economic Components in a Tank Environment

All forms of agriculture – irrigated farming, un-irrigated farming, garden farming and chena cultivation – are conditioned by the terrain, environmental components, volume of tank water, extent of command area, gardens and even village forest for *chena* cultivation. Trees in forest, catchments, tree-girdle (*gasgommana*) in the tank and those trees in home gardens have varying economic values to the village residents. The meadows, the catchments, the command areas, the parklands and the forests are the source grounds of cattle feed. Though there is some dairy farming underway, the potential for it is vast and that will be associated practically with all physical and environmental components described above.

The economic value of inland fisheries is becoming increasingly important. In a recently concluded study (Carlos, 2002) it has been revealed that if the extents of 57, 000 hectares of peripheral tanks and 50,000 hectares of seasonal tanks are used for fish breeding, that will result 3,400 tons of tank fish worth about Rs. 1.71 billion annually. This, in the year 2002, was only marginally less than the total Central Government grant received by the North Central Provincial Council.

Even though less significant, there are other natural raw materials such as, clay, reeds, fruits etc which, can be increasingly harnessed to use in a variety of income generating activities. Tank environmental economy itself, is a fascinating area of study, which requires special attention.

Tank water is the life–blood of the villagers. Water is the wealth to be protected, managed, respected and used. Wealth creation from agriculture animal husbandry and fisheries depends on tank water. Groundwater behaviour in a tank environment is largely influenced by the availability of tank water over time. With the drop in tank water levels the water levels of the near by wells too drop. When tanks are dried, nearby wells too starve. So, the protection and management of tank water with stringent uses adhered to, become the prime necessity.

In the past the villagers strictly adhered to water protection and management. Closing sluice gates when it rains, expecting farmers to use rainwater for land preparation and irrigation of standing crops, channeling of tank water to fields stringently, imposing fines to violators of the field irrigation laws, norms and practices were such careful management practices followed in the past.

Socio –cultural Components

In collective efforts of the people in a community, they evolve norms and procedures. They eventually become customs. For the sustenance of these customs people seek binding threads such as the religions that they follow, and even super natural powers that they rely upon. Rituals emerge in respecting their faiths and in appeasing super natural powers of their choice. Thus, ritual and religio –cultural practices come to stay with people.

All these strengthen the co-operative spirit of the members of a community, enhance them courage to do better and succeed, make them to be fair to the others and, above all, to ensure sustainability, without wasteful management of all environmental resources. In the process, disciplined socio-cultural rituals develop without which the betterment of the communities would have deteriorated or collapsed. They

have become guiding lights of tank-based or tank-associated resource uses for the betterment of a village community.

Tank water being the **lifeblood** of the villagers it has become their food and wealth giver. Hence, the people gave their best in the past, to own, protect, manage, respect and use water carefully. Wherever possible, in order to strengthen their own efforts to do better in all above activities, they involved the blessing of their religious teachings and super-natural powers in many forms of rituals. These include the appeasing of God *Ayyanayake*, according to tradition is the guardian god of tanks, *Ganesh* or *Pullayare* the protector of crops from elephants and also the protector of village cattle from all adversities, Goddess *Pattini* believed to be the protector of people from epidemics. All these aimed to ensure collective sustainability be they the “**pot ceremonies**” (*muttinemeema*), *Kiri-itireema* or vows made to fulfill respectively to God *Ayyanayake*, *Pullayare* and Goddess *Pattini* (Ievers, 1899).

Given the inseparable nature of the physical, environmental, economic and socio-cultural components of our tank civilization, it is appropriate here to probe into multi-purpose and multi-functionality of the tank, the core of the whole complex system of operation.

Multi-purposeness and Multi-functionality

Research conducted over the years in the North Central Dry Zone (Tennakoon 1974, 1980, 1986) and many others have enabled to identify the following purposes of a tank.

- Regular storage of water in several places of the cascade, so that water is available to maximize the land use in an around many settlements, taking water guided by gravity, to the lower contours of the side slopes of the cascade parts and downstream of those tanks to command areas proper.
- Regulated storage of water in upstream tanks in a cascade, reducing the risk of breaching the bunds of those downstream or tail-end tanks, during the seasons of above average rainfall.
- Regulated storage and regulated release of only excess water, through the sluices whereby flood damages downstream are avoided or minimized.
- Through the storage process, avoid water scarcity during the dry seasons by having a regulated supply even during those dry seasons. This is a man versus nature game. In it, the nature makes a move from “**raining**” to “**not - raining**” and to effectively meet the latter, man collects and keep water in tanks when the nature rains, so as to use that collected water when it does not rain. Similarly, when it rains, man’s invention, that is tank, keeps necessary amount of water in the tanks, making the excess to spill over.
- Cultivation of irrigated field crops.
- Meeting the drinking needs of neat cattle, buffaloes and even wild animals and meeting the wallowing and some food needs of the buffaloes.
- Meeting some grazing needs of cattle in upper tank bed, notably on the margins of gradually receding upper show line providing green pasture during the dry periods in particular.
- Meeting fish consumption requirements of the villagers.
- Meeting some items of the “**basket of food**” of the villagers such as roots, nuts, stems and waterfront leafy wild vegetable needs during the dry seasons in particular.
- Keeping the groundwater levels high to provide water in wells for safe drinking and domestic uses when quality of water in tanks deteriorates with decreasing quantity of water.
- Improving the microclimate in the immediate tank environment, which brings relief to the tree crops in adjacent gardens during the dry seasons.

- Being a wetland during the dry season facilitating the growth of reeds (*pan vatu*) for mat and bag weaving and even a few vegetables with manual lifting of water using *Yotu* (grooved wooden swindles) on limited scales. [Incidentally in Panabokke's Moragahawela – Bandara Ratmale – Timbiriwewa- Kallanchiya cascade No 3/KAL6, No 3/KAL6, Timbiriwewa is now known as Labuwewa because in the 1930^s and 1940^s villagers grew *Labu* (gourd) in the tank bed during the dry seasons]. For such upstream crop / vegetable plot irrigation, power driven pump sets are being increasingly used today.

Tank Restoration/Rehabilitation

Here, we need to draw some lessons from the events and their consequences during our recent past. During the latter half of the twentieth century, the swing of the development pendulum was towards the construction of large reservoirs, complex irrigation system constructions and maintenance of them. In fact, the latter has become an increasing headache to the irrigation bureaucrats and the state.

These large irrigation works will survive so long as the state can manage them. Where the state operation failed they too have immediately failed in the past. The gigantic irrigation works successfully attempted after the 6th century A.D. by the kings collapsed or deteriorated when the rulers failed to patronize continuous maintenance of them. But a large number of small tank irrigation systems withstood all challenges for nearly thirteen centuries after the 6th century A.D. in the Rajarata for Rhys David to identify 1,574 functioning tank-based settlements in 1871 and Levers to identify more or less a similar number of tank-based villages in 1899 in the North Central Province. This was because these small tank irrigation systems were manageable by the ordinary villagers within their own command and that they had a sense of ownership of those tanks.

Whatever the merits of globalization and market orientated global economy that we long for, it is absolutely necessary to have a spatially and temporally well distributed food security for our own safety. Dispersed but cascade-based tank settlements have distinct advantages in this regard. Even the establishment of cascade-based grain storages is well worth special consideration. Why some rice produced in Polonnaruwa having subjected to many value additions come to Colombo and go back to some in Polonnaruwa with a further value addition (transport cost) for consumption?

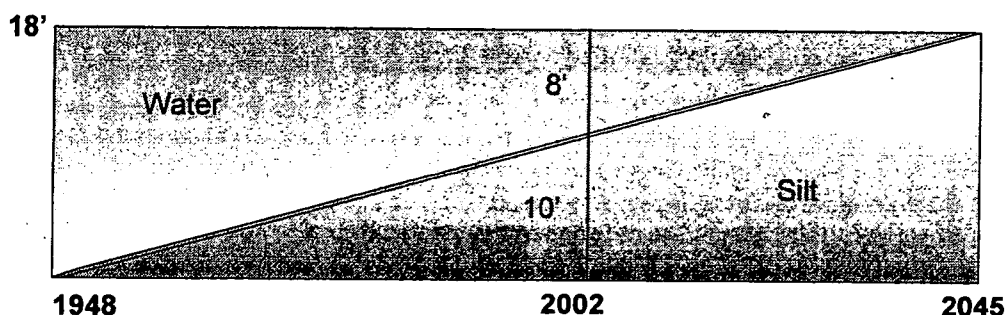
Small cascade-based tank system had been a classic example of man's ability to maintain a long lasting symbiotic relationship of man with available and much preserved water, vegetation, cultivation, soil characteristics, animals domesticated and wild, being a partner of a well renowned hydraulic civilization. Its revival is, therefore, urgently called for.

Recommendations

- Attempt a partial removal of silt so as to increase the tank storage. In this regard Dharmasena (1992) has clearly shown how this could be done. This should be followed in de-silting. As could be seen in Fig. 3, if de-silting is ignored, in another half a century we will loose water storage capacities of many small tanks, which in any case need to be avoided.

Fig.3

Silt Accumulation in the Kallanchiya tank (Near Rambewa Anuradhapura)



(Adopted from Tennakoon -2002)

- Small tanks are integral parts of a network of tanks within a cascade. Hence, to begin with, instead of selecting tanks here and there, for political or individual gains be made last in the priority list. Before an ad hoc selection of a tank in a cascade is made and it is restored or renovated, think of all its positive and negative consequences very carefully. If a tank is selected and renovated/ restored its command area may increase, cropping intensity may increase, village wells will have more water, the tank may not run dry during the prolonged dry season and micro-climatology around it may be improved. But on the other hand, it may create great imbalances such as submergence of fields under the immediate upstream tank, water starvation of tank or tanks downstream of the renovated/restored tank, difficult flood control throughout the cascade etc. The mistakes made in the past notably in the tank modernization efforts made in the North Central Province cannot be easily ignored. They created more problems than solving problems. Some villages still suffer from these blunders.
- Instead of going for the restoration of isolated tanks in different cascades, first, select manageable and most needy cascades with the participation of professionals and the immediate beneficiaries. Then, plan for total development in selected cascades, which will certainly enable to minimize negative results after rehabilitation. The system as a whole has to be taken up and just as much as the individuals in a single community in a single village, individual communities in all the villages in a cascade must have a common agreement. Restoration of all tanks needs the blessing of all communities in each tank – based settlement. They must have a common understanding in developing the whole cascade, though they have different slots of immediate responsibilities but within a single system (cascade).
- **There is nothing to hide the fact that, by and large, that at least the Rajarata – based village settlements are generally *variga* and caste based. Ad hoc tank selection may cause social disharmony and conflicts when one group benefits over yet another group of caste or *variga*. This country has had enough of racial/ ethnic tension. Do we want to see going further deep into caste and creed divisions and disputes, by advocating ad hoc selections? Best solution is to take all village tanks in a cascade system which is fool –proof.**
- Restoration/renovation needs to be immediately followed with a strong institutional development for management. We have a penchant to build but a complaisance to manage and maintain. In the past, we had strong institutions of management under the *Rajakariya* system, which was abolished in 1832 branding it as a form of slavery. It was not slavery but simply a “social responsibility” that the members of a community called upon to fulfill under the supervision of the *Gamarala* (elderly village fore-runner). Though the *Rajakariya* (fulfillment of social responsibility towards the ruler) was abolished, many of its main functional forms in a village and its sub-categories of them such as, *Devakariya* (appeasing god), *Wevata rajakariya* (service to the tank) and *Velata Rajakariya* (service to the field) continued in subdued forms under the *Vidane* (irrigation headman) system which replaced the *Gamarala* institution.
- However, the cultivation committee management, which replaced the *Vidane* system in the late 1950s, became ineffective and the responsibilities expected of them became no body’s business thereafter. This state of affairs persists even today. An effective institutional set up is called therefore.

The re-iteration is, that, all tanks in a cascade be taken in totality for renovation/ rehabilitation (leaving out those already rehabilitated) and once rehabilitated as a **whole system**, develop a strong institutional set up or improve the existing institutional set up for proper and continuous management.

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GLOBAL DIVERSITY AND MULTIFUNCTIONAL ROLE OF TANK IRRIGATION IN SRI LANKA

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Introduction

It is understood that while the demand for food is increasing, the available quantity of fresh water resources is diminishing. This is the global picture, but it is important to realize that availability of freshwater in space is site-specific. The variability of water in space varies from country to country. This is due to the high variability of rainfall in space.

The annual average rainfall varies from 800 mm in coastal areas to 5000 mm in the central hills of Sri Lanka. About 15% of this water is being used for agricultural, drinking, industries etc in comparison to the annual rainfall volume. In comparison to the available fresh water in rivers and streams, only about 35% of the water is being used for agricultural and other purposes. Therefore 65% of the available surface water is still going to the sea without being used. In this background it is necessary to emphasize that, while rehabilitation of existing irrigation schemes, provision of infrastructure facilities for regulation of this 65% of surplus water by construction of new reservoirs is also necessary. It may be appropriate to use the surplus water for the development of the agricultural sector in rural areas while enhancing the drinking, industrial and environmental water in urban areas.

In Sri Lanka more than 30,000 minor tanks exist in the dry zone to supply water for irrigation, drinking and other purposes thus illustrating a highly efficient multiple water use technique. This minor tank irrigation was supplemented by a series of large reservoirs such as Parakrama Samudra, Kalawewa, Kantale, Nachchaduwa, Minneriya, Kaudulla, Padaviya, Rajangana etc. Rehabilitation of these ancient irrigation systems which went into disuse in the 12th century, notably commenced after the arrival of the British in 1796. Having almost all the major irrigation works and a good percentage of the minor tanks restored by the British and subsequent governments since independence, water resources development policy for agricultural development in Sri Lanka came to a cross road in early 1990s. This was mainly due to the global debate on the Global Water Crisis highlighting the fact that 70% of the fresh water in the world is being used by the irrigation sector in the Asian region.

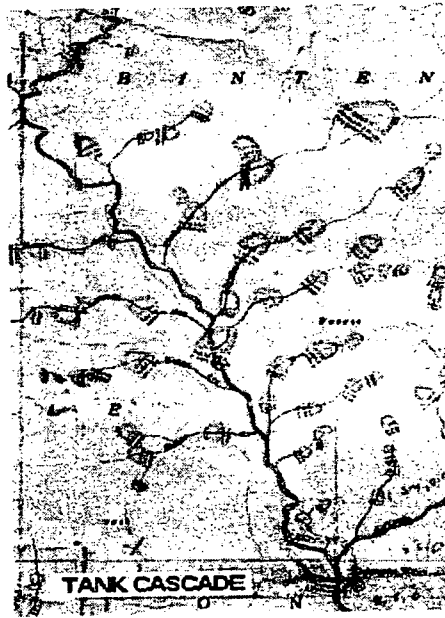
International forums are sounding alarms about a deterioration of the environment within the next 100 years and a global water crisis is highlighted unless the water usage for paddy irrigation is brought under control. A careful examination of these statements and declarations made at global forums demands an in-depth study and a critical review of the underlining factors for these serious statements. These statements will have implications over the water resources planning and development strategy in the monsoonal region of Asia, which is distinct from the semi arid and arid regions of the western world.

Minor Tank Eco-systems

Water is no longer considered as two atoms of hydrogen and one atom of oxygen. It is an agent that transports nutrients in life supporting ecosystems in the planet. In the light of the above, today's water resources development projects are viewed as multifunctional from the holistic ecosystem approach and not from the narrow angle of hydraulic engineering. It focuses on the basic issue of poverty alleviation and interrelationship between water & poverty. An ecosystem approach to understand the irrigation system and its interaction among organisms themselves and their environment is essential. Agriculture is an important link between humans and nature. It plays an indispensable role in maintaining the balance of an entire ecosystem and thereby sustaining human life. The system of minor tank cascades is a common feature in Sri Lanka. These ancient systems were developed about 2000 years back during the Sinhalese kings and most of these tanks are functional even today. It was believed that similar systems had been in China, Thailand and India during the ancient hydraulic civilization, but due to some unknown reasons these minor tanks disappeared in those countries and therefore there is an inadequate understanding among the water resources planners, engineers and scientists regarding these ecosystems, which are multi functional. These cascades illustrate the unique and highly efficient water conservation system developed by the ancient

Sinhalese kings of Sri Lanka. Fig.1 shows a part of the Tibolketiya topo sheet where the density of river minor is highest.

Fig. 1: Timbolketiya Topo Sheet

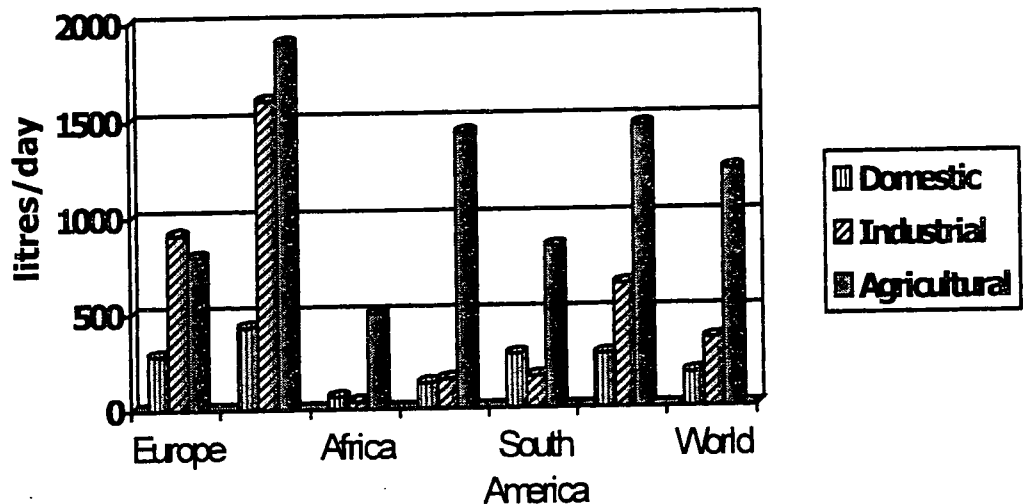


Source: 1 Mile : 1 inch. – Topo sheet of Timbolketiya

Global Diversity of Water

Rainfall is the primary source of water to the Asian region and the annual average rainfall in the world ranges from 2620 mm in Indonesia to 65 mm in Egypt. Sri Lanka receives 1500 mm of rainfall annually (See Fig. 2).

Fig. 2: Annual Average Rainfall Distribution



Source: Water Resources Department, National Land & Water Resources Bureau, Ministry of Land, Infrastructure & transport, Water Resources of Japan (2002)

Regions of the world are classified under arid, semi arid and humid zones according to the annual precipitations and the following is one of the classifications of climates.

Arid	-	100 mm – 250 mm	Rainfall
Semi Arid	-	250 mm – 500 mm	Rainfall
Dry sub humid	-	500 mm – 1000 mm	Rainfall
Humid	-	More than 1000 mm	Rainfall

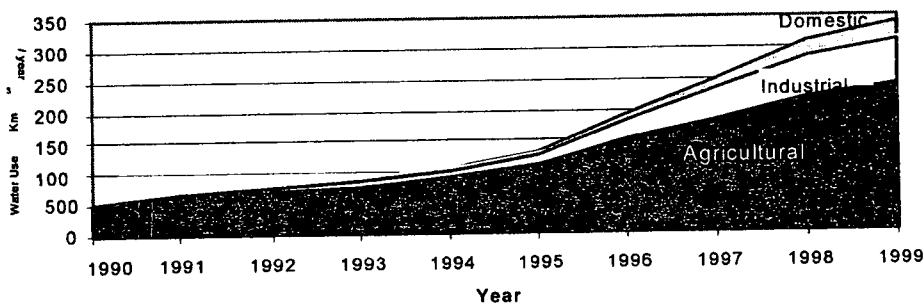
Among the countries listed in the Fig. 2, annual average rainfall in U.S.A. 760 mm, Australia 460 mm, China 660 mm and France 750 mm. Therefore it shows that Sri Lanka is blessed with adequate rainfall when the annual rainfall of other countries is considered. From the available fresh water in the globe, Asia has the highest percentage of global water, which is 58.5%. The annual volume of water flowing in rivers is given in the table No. 1 below:

Table No: 1: River Water Volumes (x 1000 Km³ / Year)

Europe	2.9	Asia	13.5
North America	7.7	South America	12.0
Africa	4.0	Australia	2.4

Water usage can be classified under agricultural, drinking, domestic and industrial use. Transition in world water use during the last 100 years is depicted below. See Fig. 3.

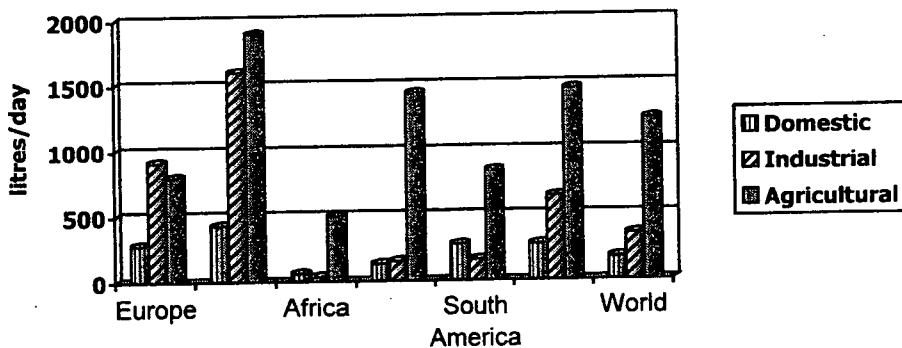
Fig. 3: Transition in World Water Use



Source: I, A. Shiklomanov, 1996

It is clear from the above that agricultural use of water has increased over time and the industrial & drinking water demand too has increased after 1950. The percentage of water use in Asia for agriculture is comparatively high and industrial and other uses are minimum. It can be seen that in America, industrial and agricultural waters are comparable (See Fig. 4).

Fig. 4: Per Capita Water Use 1995



Source: * I.A. Shiklomanov, 1996 * "Japan's Water Resources", (2002)

Discussions on Global Water Scarcity

Most of the reports and presentations presented by international organizations highlight a crisis situation in regard to the use of water. These organizations are sounding an alert that there is a limit to our overall use of global water resources. These efforts of raising the alarm about water being a limiting natural resource are held with respect and highly regarded in professional circles. However we must at least now graduate from the mere general discussion of the warning stage and recognize the necessity for engaging in more analytical and exhaustive deliberations by considering the regional diversity and site-specific issues. The actual situation is that the present discussions do not encompass the realities of highly diverse regions of the world. That means the discussions have been over generalized and do not fully address the diversity of water use especially in the developing countries in the Asian Region.

A report titled "The limits to growth" published by the Club of Rome (1972) predicted a degradation of the environment within the next 100 years, if water consumption at the present rate continues. In mid 1990 the World Bank issued a report entitled "Global Water Crisis". This brought water into the forefront of international forums.

Subsequently, the United Nations organized several world conferences with international academics, scientists, planners & engineers. The following events are some that need closer review. The Dublin Principles emerged in 1992 with the following four statements, with the four statements mentioned here are not given. The fourth one is being the most debatable.

- a) Fresh water is a finite and vulnerable resource.
- b) Water management should be based on participatory approach.
- c) Women play a central role in water management.
- d) Water is an economic good.

Source: Irrigation Department (2003)

From conference to conference the number of countries and participants increased with the most recent Kyoto Conference in 2003 with 8000 participants representing 160 countries. A list of important events related to global water is presented below:

Important Global Events on Water

- a) In 1972 the club of Rome issued a report titled "The limits to Growth". This report predicted that resources consumption at the present rate would deteriorate the environment within the next 100 years.
- b) UN Conference on Desertification- Mar del Plata, Argentina (1977)
- c) In mid 1990 the World Bank issued a report titled "Global Water Crisis".
- d) 1st World Water Forum-Morocco with 500 participants
- e) Conference on "Water & Sustainable development" – Dublin in 1992
- f) "Earth Summit" in Rio De Janeiro – Brazil in 1992.
- g) In 1996 World Water Council (WWC) was established by water experts, academics, scientists and international organizations to act as a think tank.
- h) World bank in 1995 stated "Earth faces water Crisis".
- i) 2nd World Water Forum in The Hague, the Netherlands in 2000 with 5700 participants, from 156 countries - Dublin 4th Principle was changed to "Water is an Economic, Social and Environmental good" at this conference.
- j) International Conference on Fresh water, Bonn, Germany – 2001
- k) World summit for sustainable development Johannesburg-2002
3rd World Water Forum in Kyoto, Japan in 2003 with 8000 participants from 160 countries

Characteristics of Water Conferences

The following are some of the notable characteristics of these water conferences:

- i) There is no one single huge meeting as one might think. Several different meetings at different locations are going on at the same time.
- ii) NGO meetings involving international agencies and environment authorities without any direct links.
- iii) Governments official meetings have more prestige, but produce poor results due to modification of recommendations by unofficial counterparts
- iv) These conferences were mostly aimed to highlight the wastage of water by the Asian farmers who use large percentage of global water. The following are some of the comments and recommendations leveled against the paddy farmers.
 - a) Irrigated agriculture accounts for 70% of global fresh water use.
 - b) Low Efficiency of Irrigation.
 - c) Necessity for Water saving measures.
 - d) Water pricing has to be introduced.
 - e) Reallocation of water to other sectors using water rights.
 - f) Participatory water management has to be introduced.
 - g) Interaction between Irrigation and Environment is necessary.
 - h) Rate of expansion of lands under irrigation is the most important determinant creating the water stress.
 - i) Agriculture will consume virtually all the water withdrawn and therefore industrial and domestic consumers have to be protected.
 - j) Excessive operation and maintenance cost.
 - k) Increased food production is done at an ecological cost.
 - l) 1 ton of wheat requires 1000 m³ of water whereas 1 ton of rice requires 3000 m³ of water thus illustrating the heavy consumption of water for rice production.

Organizers of the above conferences embarked upon a new project to introduce new terminology for water resources planners and new concepts are introduced for water market. The following are some of the terminology geared to promote the water market.

- i) Full cost recovery
- ii) Water pricing
- iii) Shadow price
- iv) Water is a commodity
- v) Virtual water concept
- vi) More crops per drop
- vii) Participatory management

Terms of reference for newly formed Non Governmental Organizations were prepared to build concerns to convince the world that agricultural water is inefficient and most wasteful. Some of these N.G.OO collaborate with the UNDP and therefore the true picture and the objectives of these N.G.OO cannot be easily seen.

Multiple Role of Village Tanks:

In particular village tanks are multifunctional and a tank is the nucleus of the village. When a tank breaches villages disappear. The tank is like village cattle as it has numerous efficiencies catering for multiple water use. The following are some of the multiple uses.

Irrigation benefits
Food Security

Ground Water Recharge
Bio-diversity in the aquatic landscape
Micro Climate
Other uses (Bathing, Drinking, and Recreation)
Grazing grounds for cattle

While providing direct agricultural benefits, village tanks contribute towards the prevention of soil erosion and mitigation of flood hazards too

Utilization of water in Sri Lanka

The following statistics show the water utilization and food production in Sri Lanka.

- i) Total Land area 65,000 sq. km
- ii) Annual Rainfall varies from 900 mm to 6000 mm
- iii) Dry zone receives less than 1500 mm
- iv) Run off from rainfall in the dry zone 30%
- v) Run off from rainfall in the wet zone 60%
- vi) From available fresh water 30% is used for agriculture
- vii) For Drinking and Industries 5%
- viii) 65% of the water still goes to the sea

Source: Irrigation Department (2003)

Diversity in Irrigation Technology:

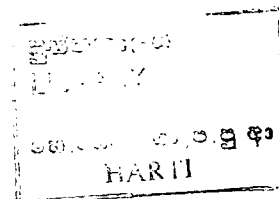
In the evolution of irrigation methods it is known that irrigation of cereals such as paddy was first evolved as far back as 4000 BC in Asia. Irrigation of non-paddy irrigation (OFC) is a recent phenomenon practised mostly in arid zones in the Western World. They present diverse aspects such as, spatial changes in climate and technology, community based irrigation or individuals carrying out the acts, the strength of the relationship with the local community including cultural ties and the impact on the sustainability of water resources and the natural environment.

Irrigation throughout the world is typically divided into irrigation in arid and semi arid regions and irrigation in humid regions. When described with further exactness, irrigation can be classified into irrigation to provide the entire volume of water that crops require and irrigation to supplement the shortage of water supplied naturally by precipitation, which changes dynamically over time. In addition, irrigation can be divided into non-paddy field irrigation and paddy field irrigation.

Besides the types of classifications already mentioned, irrigation can be more precisely classified into irrigation to supply only the volume of water consumed by crops raised on one lot of farmland and irrigation of crops that reuse and consume the water discharged by the upper farmland. Paddy irrigation, more particularly village tank irrigation belongs to this second category. It would be hard to say that the current international discussion on water properly accommodates the above actual conditions of these types of irrigation practices.

In particular, the estimation of field water requirement at the farm level shows diversity in relation to crops, irrigation systems and climate of the humid region. The climate in the monsoonal Asian region (annual rainfall more than 1000 mm) differs from semi humid (annual rainfall less than 500 mm) regions in western countries. The experience of irrigation in western countries is mostly on other field crops such as barley, vegetables, fruits, corn etc. and experience in irrigation of rice crops is very limited. Moreover re use of water does not exist as in the case of the typical cascade system of tank irrigation in Sri Lanka or terrace cultivation in Nepal, China, Thailand and Japan. Most of the rainfall during the year in the arid & semi arid regions is effective to plant growth but in humid regions surface runoff will appear due to high intensity of rainfall and therefore only a part of rainfall will become effective. There are many other differences between these two systems and the following table clearly differentiates between these two. Providing technology on farm irrigation is based on the experience in the semi arid regions of the world, which is not applicable to paddy irrigation in monsoonal Asia.

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The following differences between paddy cultivation and OFC have to be considered in designing irrigation systems.

	Humid (Paddy)	Semi Arid (OFC)
a)	Crop Water Requirements can not be pre determined	Crop Water Requirements can be determined
b)	Re use is possible	Can be used only once
c)	Part of the rain is effective	All rain is effective
d)	Efficiency cannot be defined	Efficiency criteria can be easily defined.
e)	Multiple use	Single use
f)	Benefits cannot be easily quantified	Benefits can be easily quantified
g)	Efficiency can be defined for the entire basin	Efficiency can be defined for a particular tract
h)	Variable shadow price	Shadow price is constant
i)	Surplus water during the season	Scarcity of water during the season
j)	Only supplementary irrigation	Full irrigation
k)	External economy	No external economy

Conclusions

In view of the above discussions it can be concluded that there is an inadequate global understanding of the irrigation and water conservation systems and paddy irrigation in the Asian Region. The system of village tanks in a cascade is a highly efficient water conservation ecosystem where benefit function cannot be narrowed down to the direct benefit of irrigation of lands for crop production. Techniques adopted to design on farm irrigation systems for paddy are based on the techniques developed in the semi arid regions for cultivation of other crops.

While appreciating the global water shortage for drinking, agriculture and industries, there is an inadequate understanding and attention to the diversity of these aspects from region to region. In Sri Lanka 65% of the surface water goes to the sea and therefore regulation of this large quantity of water is required by means of sustainable infrastructure arrangements. Participatory management of water is not something new and there is enough traditional experiences in the Asian region.

While appreciating certain concerns expressed at these global conferences it has to be emphasized that international debates on water have to be more consistent and rational. The main issues related to irrigation water in Asia are as below:

- a) Water dialogue to date has been largely dominated by the expertise in non- humid regions of the world. (USA, Europe & Australia).
- b) Irrigation practices across the globe are highly diverse.
- c) Paddy irrigation in Asia generates considerable amount of net economic externalities and social benefits because of multi-functional roles.
- d) International debate on water needs to be more consistent with reality

Finally it has to be emphasized that we should move away from general slogans and prepare our own water resources development policy by undertaking the diversity of our irrigation systems and the importance of food security in a developing country.

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VILLAGE TANK CATEGORIZATION

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Abstract

Village Tank is a marvelous man made ecological construction, which involves high degree of natural resource management. History of village tank systems dates back to 4th century B.C. or before. According to the history, ancient kings have constructed both major and village tanks simultaneously up to the end of Rajarata period in 12th century A.D. It is important to identify the ancient typology of these systems to understand its functions during the early days. Statistics related to attributes and distribution of Village Tanks help to get a clear picture of its present status.

Present typology of small tanks can be derived through command area class distribution, distribution based on agro ecological regions and river basin approach. Rainfall-runoff models for catchments, water balance models for the geometry of tank beds, cascade concept (hydrologically interconnected tanks) are some of the parameters that can be used for tank categorization. Hydrological endowment and Physical Status Scoring (PSS) are two important parameters for Village Tank Rehabilitation. Emergency assistance and development assistance are two different modes of rehabilitation.

Precise statistics about the abandon tanks are not available but it is essential to derive the reasons for abandonment prior to the restoration of such systems. It is evident that there is a considerable potential to restore abandon village tanks specially in Southern & Uva Provinces of Sri Lanka.

Finally, it can be concluded that village tank systems are faced with many problems, which can be addressed only through a scientific approach to village tank categorization. Further, village irrigation infrastructure development should be considered as a part of rural resource management.

Rationale

Village tanks play a vital role in the rural society of dry and intermediate zones in this country, even today. It has been realized that "village means a tank" and those tanks are functioning as the base of natural resources of this country. These man-made constructions have acclimatized to the nature to such an extent that this has become a part and parcel of rural eco system. Such systems of immense value have been facing many problems today that should be sorted out and remedied urgently in a scientific manner.

History

Recorded history of the irrigation in this country leads back to the 4th Century B.C. or before. Basawakkulama also known as "Abaya Wewa" is the first ancient major tank constructed by King Pandukhabaya in 4th Century B.C. Discovery of very successful hydraulic structure called "Bisokotuwa", which was defined by the British as "Valve Pit", may resulted to have a jump start to go for massive reservoirs with high tank water heads. It is understood now that the construction of village tanks lead back to the era of few centuries prior to 4th Century B.C. and according to *Mahawansa*, our ancient kings had built major tanks and village tanks simultaneously. As an example, King Parakramabahu, the Great had constructed 165 dams, 3,910 canal, 163 major tanks and 2,376 village tanks during the last lap of Rajarata. Therefore, it is understood that major tank and village tank are two different constructions with different entities and also for different purposes.

Traditional Sri Lankan village tank is the heart of the village settlement and can be considered as one of the most successful ecological constructions made by the ancient people for the purpose of water and soil conservation. But, there are evidences in ancient irrigation documents to prove that all the tanks were not exclusively for irrigation and some tanks were built for some other purposes.

Ancient Typology of Small Tanks

Following types of tanks can be identified based on the tank location.

- a) Cascade tanks – Tanks that are located at different positions of cascade. Cascades can be categorized further.
- b) Isolated tanks – These are the tanks located out side cascade system.
- c) Located in the upper catchment – located in the upstream of the major reservoir and one idea of these tanks was to protect the major tanks from flood peaks by working as retarding basins.
- d) Located in the lower catchment – located in the downstream of the major reservoir and some of them were fed by a major tank.

Following types of tanks can be identified as far as the purpose of the tank is concerned.

- a) Multifunctional and traditional Tank eco system -
Traditional village tanks are multifunctional that serve surface as well as ground water purposes.
- b) Kulu wewa or Pota wewa – These tanks are built as a silt trap for a major tank and streams.
- c) Ecological tanks – These tanks were constructed, especially to maintain the groundwater levels and other ecological needs. Some times the water of these tanks is diverted when water scarcity condition prevails in surrounding areas.
- d) Tanks for domestic purposes – These tanks are constructed especially for the use of monasteries and household needs.

The real purposes of Village tanks were not only for water conservation but also for soil conservation.

The types of tanks described in b and c category are visible not only in the low country, but also in the mid and up-country regions.

Tanks can also be categorized as follows, based on the demographical features of the settlement.

- a) Main tank (Maha Wewa or Periyakulama) – Major community settlement is established around this tank.
ex: Gangoda, *chena* etc.
- b) Olagama – These tanks are also known as Remote Control Tank. Villagers are not settled near the tank, but they visit the tank during the cultivation periods. The cultivation income from this tank is considered as their secondary source of income.

Present, Maha Wewa and Olagama are not the original status of those tanks and interchanges have taken place from time to time mainly due to its demographical changes. Every village tank had an upper as well as lower ceiling of population to ensure the tank's sustainability in the rural sphere.

The importance of the historical evaluation of those eco friendly constructions should not be undermined when formulating development strategies for the future. R.L. Brohier, a great Sri Lanka citizen and author of "Ancient Irrigation Works of Ceylon" stated as, "History becomes the back sight of surveying. No future which is the foresight of surveying can be derived without knowing the history".

Present Status

There are nearly 12,120 working village tanks and a large number of abandoned tanks scattered over the country, specially concentrated in the dry and intermediate zones. Total command area under the working village tanks is 168,788 ha and about 320,090 farmer families are living under these irrigation systems (Department of Agrarian Development, 2000).

Average tank size and some other important parameters of a representative tank in present day are stated below, but figures sharply deviate from the mean, especially between the agro-ecological regions.

Command area	–	13 ha (33 ac)
Water spread area	–	8 ha (20 ac)
Tank water height	–	1.8 m (6 ft)

No. of farmer families - 26
 Cultivated area - 6 ha (15 ac)
 (Last 10 years average)

The extent of cultivated area/command area ratio (10 years average) gives a glimpse of idea of low cropping intensity of nearly 46 and reasons for this situation should be thoroughly examined.

Command Area Class Distribution

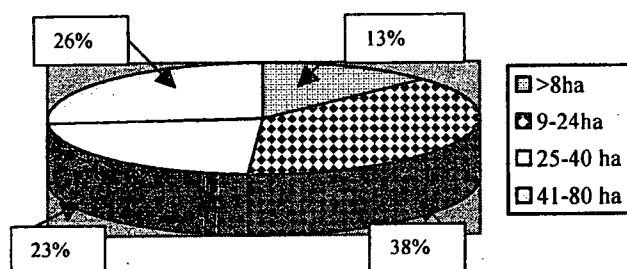
Tank distribution on command area class is one of the methods to analyse the present status of village tanks. The command area class distribution shown in table 1, depicts that the 9 – 16 ha class has the majority of figures and 72% of the working tanks are having command area of less than 16 ha (40 ac). But, in terms of total command area, figures are rather uniformly distributed and 51% of the command area are belongs to less than 24 ha (60 ac) category. The command area of the majority of the tanks lie within the range of 9 to 24 ha, that is 38% of the total command area under small tanks in Sri Lanka.

Table 1: Tank Categorization Based on Command Area

Command Area Class (ha)	No. of Tanks	% of Total Number of tanks	Total Command Area (ha)	% of Total Command Area%
> 4	3342	27	5440	4
5 – 8	2465	20	13204	9
9 – 16	2991	25	32705	21
17 - 24	1362	11	25256	17
25 – 32	794	7	21183	14
33 – 40	406	3	13912	9
41 – 60	494	4	23019	15
61 - 80	266	3	17840	11

Source: Department of Agrarian Development, 2000

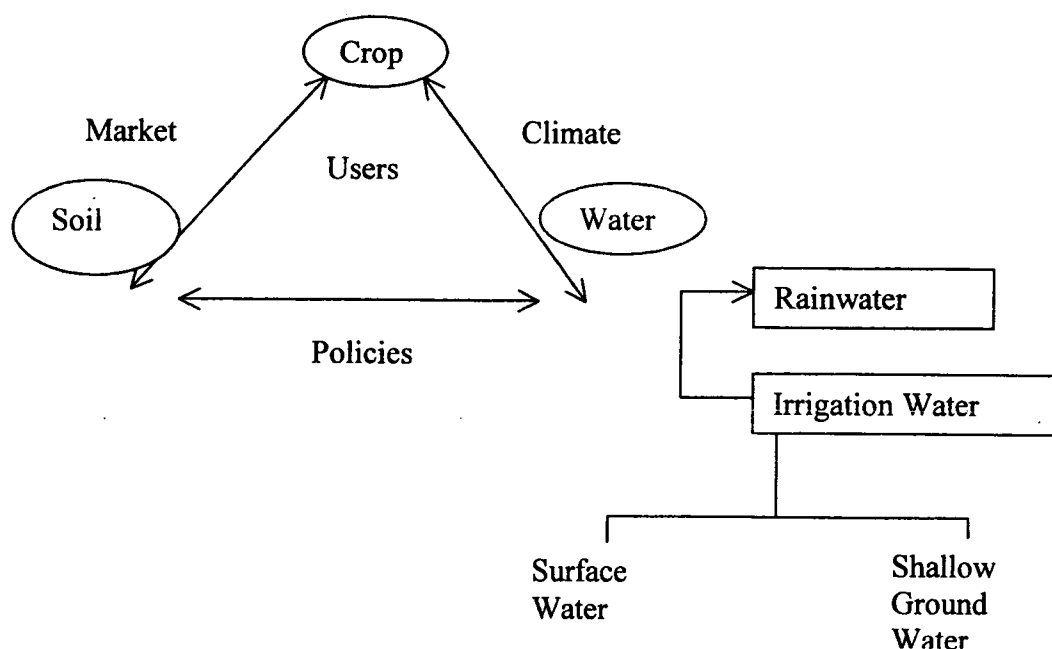
Figure 1: Command Area Class Distribution (ha)



System Analysis

Village tank is a typical example for agriculture based resource management where high degree of rural infrastructure involves. Conceptual analysis of the system components can be illustrated as given in Figure No.2. Categorization and priority identification of community level infrastructure development can be clearly understood by analyzing the above relationship. Water is a prime source that plays a vital role in this context and village tank is the focal point in the dry zone where agricultural objectives dominates.

Fig. 2 – System Components of Agricultural Based Resource Management



Agro Ecological Regions (AE-region)

Sri Lanka has been divided into 24 Agro-Ecological regions by considering altitude, Soil type and landform and rainfall distribution. The territories covered by three main climatic zones are stated below.

Wet Zone	–	20.3%
Intermediate Zone	–	21.6%
Dry Zone	–	58.1%

The majority of the village tanks are concentrated in low country dry zone one (DL-1), low country intermediate zone one (IL-1) and low country intermediate zone three (IL-3). The Village Tank distributions in these three dominant zones are given in table 2.

Table 2: Distribution of Village Tanks in the Three Dominant AE Regions

AE - Region	% of Land covered in the Island	No. of Tanks	Total Command Area (ha)
DL-1	32	5122	90617
IL-1	4	1606	13323
IL-3	3	2362	18308

The important features of representative model tank with respect to the three main AE-regions are shown in Table 3.

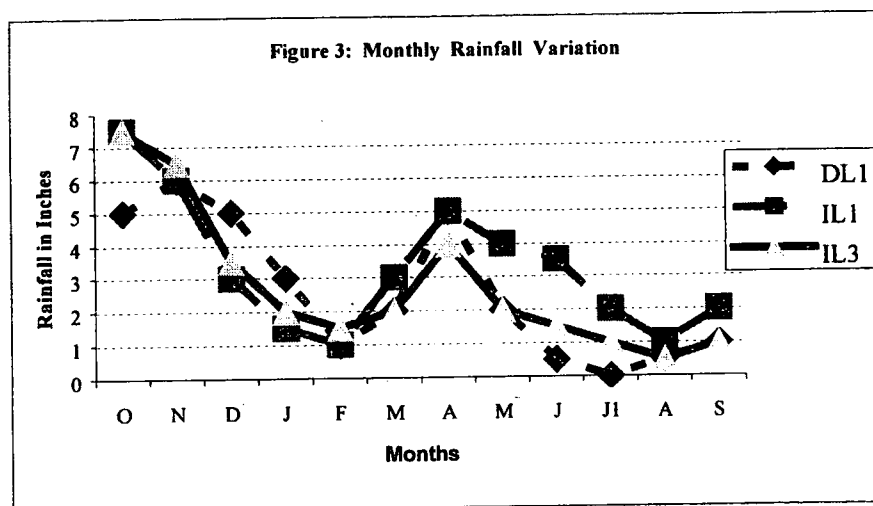
In the case of DL-1 AE region, runoff to the village tank can be expected only in *Maha* season and *yala* cultivation is very limited due to the lack of rainfall. *Maha* rainfall in IL-1 and IL-3 is almost same, but in IL-1 rainfall is uniformly distributed in *Yala* Season and cultivation is more successful in that Season. Therefore, runoff during *yala* Season also can be expected in IL-1. The above relationships are graphically illustrated in Figure 3.

Table 3: Dominant AE-regions Vs Model Tank Features

AE Region	Tank Duty (mm)	Av. WSA (ha)	Av. T.W.H. (m)	Av. Command Area (ha)	Av. Cultivated Area (ha)	Av. No. of Farmer Families	% of Forest in the Catchment
Island Figure	550	8	1.83	13	5.6	26	-
DL-1	700	13	2.13	18	4.0	30	-
IL-1	365	4	1.83	8.4	6.4	25	5
IL-3	457	4	1.83	7.6	6.0	22	7

(Source – Department of Agrarian Development, 2000)

Note: Av-average, WSA-Water Spread Area, TWH-Tank Water Height,



Source: Panabokke, 1996

Following remarks can be generated using above statistics.

- a) Actual design duty of village tanks in DL-1, agro-ecological region is rather low that is 700 mm (2.3 Ft) whereas the expected value is 915 mm (3 Ft). This is an indicator for over exploitation of village tank catchments in the DL₁ area.
- b) Cropping intensity of dry zone tanks (Cultivated Area/Command Area x 100) is nearly 23 with contrary to the cropping intensity figures of 79 for tanks in the intermediate zone. It is experienced that the potential cropping intensity of a village tank in the DL-1 AE region is 120. It is also evidenced from past data that, the cropping intensity of dry zone village tanks are low even in the years with favourable rainfall pattern.
- c) Visible size of the tank that is water spread area at full supply level in the dry zone is more than three times bigger, compared to the tanks in the intermediate zone. Excessive tank water height increases the tank water spread area resulting high water losses and finally leads to low tank water efficiency.

It is obvious that the problem of low cropping intensity of dry zone tanks could not be overcome by a single solution and therefore thorough studies and package of proposals are necessary to increase efficiency and effectiveness of such systems.

River Basin Approach

River basin concept had been identified and introduced by our ancient Kings for water resource development activities during the ancient days of this country. It is revealed that identification of water sources and preparation of ancient water resource development plans including boundary demarcation were completed by 4th Century AD, that is the period of King Mahasen who is also known as God of Minneriya.

Table 4: History of River Basin Development

River Basin	Period of Start
Walawa	112 AD
Kirindi Oya	104 BC
Mahaweli	65 AD
Yan Oya	276 AD
Malwatu Oya (Aruvi Aru)	4 th Century BC
Kala Oya	109 AD
Deduru Oya	276 AD

Source: Arumugam, 1969

Table 5: River Basin Vs Distribution of Village Tanks

River Basin	% of Area Covered in the Island	No. of Tanks*	% of Tanks
Walawa	4.2	92	0.7
Kirindi	2	66	0.5
Mahaweli	17.9	809	7
Yan Oya	2.6	556	5
Aruvi Aru	5.6	1261	10
Modaragam Aru	10.6	170	1.4
Kala Oya	4.8	854	7
Mi Oya	2.6	589	5
Deduru Oya	4.5	3225	26

* Number of working village tanks only

Source: Department of Agrarian Development, 2000

The above figures depict that the present village tanks are concentrated more in Deduru Oya, Malwathu Oya (Aruvi Aru), Kala Oya and Mi Oya basins, located in North Central and North Western provinces of the country. This picture is completely different from the ancient situation where same Tank density prevailed in Southern & Uva area.

Abandoned Tanks

No adequate studies have been carried out on abandoned tanks in the country and therefore no real statistics are available. The following details are based on the database available in the Department of Agrarian Development (2000) and from one-inch topographical revised maps produced by the Survey Department (1973). Only six AE-regions in the dry zone are considered for this study.

Table 6: Agro-Ecological Regions Vs Abandon Tanks

AE-Region	Total No. of Abandoned Tanks	Abandon Tanks in Restricted Areas
DL-1	1625	797
DL-3	408	112
DL-5	105	15
IL-1	114	-
IL-2	57	-
IL-3	407	17
Total	2716	941

The above six AE-regions are consisted of highest number of village tanks. Third column depicts the number of abandoned tanks located in forest reserves, sanctuaries, densed forest etc. that can be considered as restricted areas, whereas the second column depicts the total number of abandoned tanks.

Table 7: River Basin Vs Abandon Tanks

River Basin	No. of Abandoned Tanks	Abandoned Tanks in Restricted Areas
Modaragam Aru	223	69
Deduru Oya	376	30
Kurunda Ara	131	34
Kumbukkan Oya	240	10
Kala Oya	279	148
Kirindi Oya	173	43
Kuda Oya	69	13
Katupila Ara	11	3
Ma Oya	125	54
Mee Oya	187	36
Mi Oya	247	26
Malwathu Oya	342	169
Manik Ganga	136	30
Rathambala Oya	55	-
Walawa	179	33
Total	2755	693

The 15 river basins listed in the table No. 7 are the dominant river basins as far as the location of abandoned tanks are concerned. Generally, village tank catchments in the DL-1 AE region are already over exploited and therefore, restoration of abandoned tanks may cause severe problems to the existing tanks.

Following recommendations can be made with respect to the restoration of abandoned tanks and feeder canals.

- a) Reasons for the abandonment should be discovered prior to the improvement.
- b) Thorough hydrological studies should be carried out to assess the hydrological endowment of such tanks as well as the effect of restoration on other existing tanks.
- c) The tanks located even in the restricted areas may be restored for ecological purposes when it is hydrologically and geologically feasible, as they are multifunctional.
- d) It reveals that there is a considerable potential to restore the abandoned village tanks as well as feeder canal systems that help to augment the existing tank systems. Abandon tanks in Southern & Uva area and feeder canals in north central & Wayamba area have a considerable potential for restoration.

As a general comment, it is worthwhile to state that a large number of abandoned village tanks are still visible in the thick jungle and those tanks are not marked on maps and therefore no statistics are available. Therefore, the situation demonstrated by the existing statistics may not be true and realistic as far as the large numbers of unidentified abandoned tanks are considered. More interestingly, the hidden story of the ancient water resource development taken place in Southern and Uva provinces can be described, if more realistic figures of abandoned irrigation schemes could be retrieved. Story of the abandoned tanks in the thick jungle is not restricted to village tanks, but also applicable for major and medium irrigation schemes as well.

Criteria for Tank Categorization

The following important criteria related to the performance of a village tank can be used for the purpose of tank categorization.

a) Run Off Model

Micro catchment that assigned to a village tank plays a very vital role with respect to the tank performance. In addition to the catchment area, other characteristics of catchments such as soil type, vegetation, slope etc directly determine the volume of surface and sub surface run off, generated for the tank storage.

Initial loss (threshold) and run off percentage varies from place to place to make it location specific. The initial loss depends upon the initial moisture content of soil and the time difference between two successive initial rains. Generally, the average initial loss for the Maha Season in the dry zone varies from 100 – 150 mm. Figs. 4 and 5 illustrate the behavior of initial loss in the soil profile and the tank model shown in figure 4 is the best way of illustrating such function. Fig. 6 illustrates both initial loss as well as the rainfall – runoff relationship. The initial loss vary from tank to tank and can even favourably change by altering catchment cover if necessary (Shinogi, Ian Makin and Witharana, 2000).

Figure No. 4: Tank Model

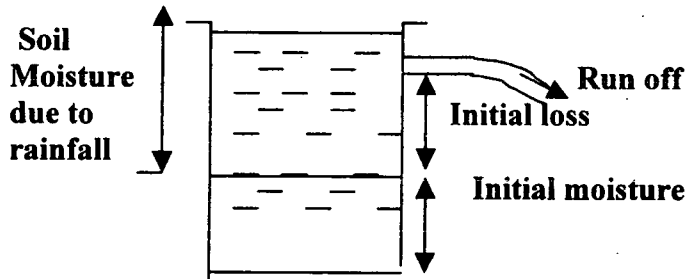


Figure No. 5: Schematic Model for Soil Moisture & Runoff in a Village Tank Catchment in the Dry Zone

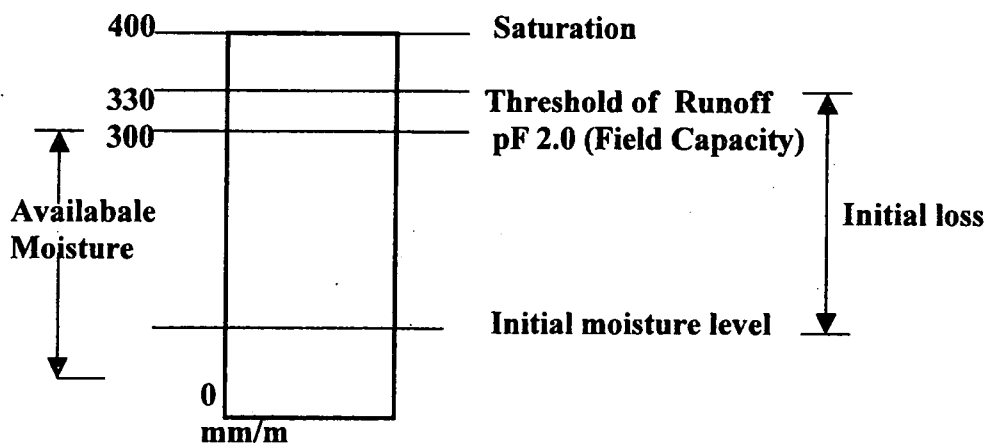
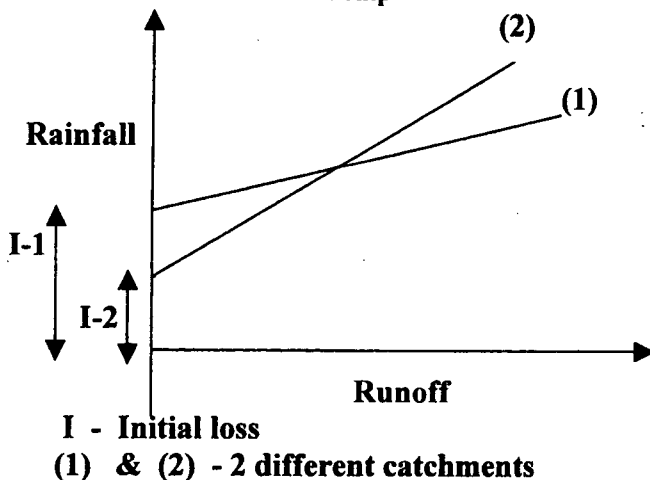


Figure No. 6: Rainfall-Runoff Relationship



b) Water Balance Model

Following water balance components have been experimentally derived for DL1 AE region and generalized figures are as follows. These figures are with assumption of the total rainfall to the catchment is as 100 units. However, these components vary from tank to tank and are also a function of catchment characters such as land use, slope, soil type etc.

	<u>Water Balance Components</u>	<u>Units</u>
i)	Soil retention	70
ii)	Ground water replenishment	10
iii)	Surface run off to the tank	20

c) Cascade Concept

Cascade is a hydrologically interconnected tank system that are hanging one below the other in the same water way and some times known as "Meso-catchment". This is one of the marvelous man- made ecological constructions to preserve both water and soil and specially to facilitate re-utilization of water. Tanks in the cascade can be categorized by considering its location in the cascade such as top, middle and bottom etc. as the performances of these tanks differ from one to another.

Cascades are also can be categorized by considering the following features.

- i) Shape of the cascade–
 - Fan shape
 - Fern leaf shape
- ii) Location in the flow tree
 - Linear cascade – discharge of flow to the main stream
 - Secondary cascade– discharge of flow to the linear cascade
 - Transitional cascade– discharge of flow to the secondary cascade
- iii) Direction of discharge
 - Direction of return flow and spillage are in a same direction
 - Direction of the return flow is perpendicular to the direction of the spillage.
- iv) Balance cascade
Spillage of upstream tanks is not contributed to the down stream tanks because all the tanks in the cascade spill simultaneously.
- v) Unbalance cascade
Spillage is a contribution to the downstream tank because upstream tank get spills before the downstream tank.

Following recommendations can be made with respect to the cascade concept.

- i. Cascade boundaries should be demarked, identified, studied and categorized based on the parameters stated above.
- ii. The least unit of village tank development should be the "cascade" as the tanks are highly interdependent within the cascade boundary.

d) Hydrological Endowment

Following parameters can be used to determine the hydrological endowment of either a tank system or a cascade (Witharana, 1994; IWMI, 1996).

- i. Catchment area/Command area ratio
Limiting values of the ratio varies from 5 to 10 for DL-1 AE region.
- ii. Command area/water spread area ratio
Values are less than one (1) for DL1-AE region and less than two (2) for IL-1 AE region.

- iii. Catchment area/water spread area ratio - limiting values are more than 10 for DL1-AE region and more than 7.5 for IL-1 AE region.
- iv. Cropping intensity (CI) – Weighted value can be introduced for cascades after considering the command area.

$$CI_w = \frac{\sum_1^n (CI * CommandArea)}{\sum_1^n CommandArea}$$

CI = Cropping intensity
 n = Number of tanks in the cascade
 w = Weighed cropping intensity

- v. Spilling history of the tank – Seven Spilling records out of ten consecutive years is a favorable condition.
- vi. Yield/Capacity Ratio (Y/C ratio)

This is the ratio between the total annual inflow (yield) and the tank capacity. It varies from 1.25 to 4 in DL-1. This parameter seems to be more effective than the design duty. Village Tanks can be grouped as follows based on Y/C ratio.

<u>Group</u>	<u>Y/C ratio</u>
One	1 >
Two	1 – 2
Three	2 – 3
Four	3 – 4 (or 4 <)

Based on past experiences, the tanks with less design duty but having high Y/C ratio, produce good results. Tanks can be categorized based on the hydrological endowment parameters and different development approaches may be introduced there on.

e) Physical Status

Physical Status Scoring (PSS) (Witharana, 1994) is an index, which calculated by giving weighing factors for the different tank components depending on their status. PSS can be introduced to determine the physical (engineering) status of the tank that directly affects the overall performance of the system.

Different PSS formats can be developed for different types of irrigation systems. The following irrigation components can be taken into consideration in calculating PSS.

1. Head Works: Tank bund, spill, sluices, depth gauge, geometry of the tank bed (depth of siltation), existence of tank ecosystem (ex:- Gasgommana, Kattakaduwa etc.)
2. Down Stream Works: Canal network, flow measuring device, canal control structures, parallel water course
3. Irrigation Activities: Water storage system, water release, flow measurement, conveyance efficiency, irrigation maintenance, irrigation operation, village tanks can be categorized in to three main groups considering PSS (Witharana , 1994).

Table No. 8: Tank Categorization based on PSS

Group	Score (out of 100)	Status
A	>60	Progressive
B	40 – 60	Hold the Line
C	<40	Regressive

Majority of the Village tanks lie within the range of score of 40 – 60 and hence falls into group “B”.

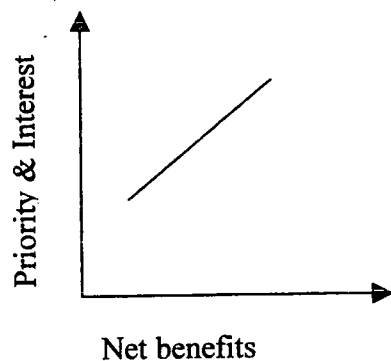


Fig-7

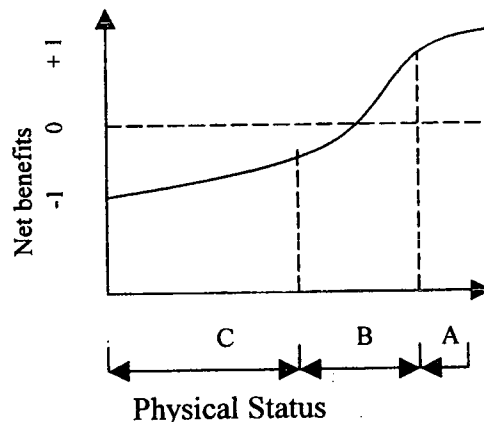


Fig-8

Figure - 7 illustrate the relationship between the priority and interest of beneficiaries and the benefits gain by them. Benefits may be direct (ex: net income) as well as indirect.

Figure - 8 illustrates the relationship between the physical status of the scheme and the benefits gain out of the scheme.

It is experienced that the farmers prefer to live with the village tank system even under the condition of negative net income because the value of indirect benefits (ex: - ecological) out of the scheme is worth than the direct benefits in most of the cases.

Rehabilitation

Definition of Rehabilitation is to restore the system into former privileges or to proper condition.

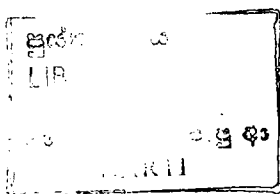
Modes of Rehabilitation

There are two major modes of rehabilitation adopted in the past.

- I. **Development Assistance Programme**
Thorough studies and package of proposals are involved in this method. Number of activities should be executed to a correct direction simultaneously. Under this approach, long term and sustainable benefits can be achieved.
- II. **Emergency Assistance Programme**
Executing single proposal at a shorter time will facilitate limited number of people for limited period and contribute to emergency assistance programme. Only short-term benefits can be gained and simple set of selection criteria can be used.

Following remarks can be noted with respect to the modes of rehabilitation.

- i. Most of the development approaches made during the recent past falls under emergency assistance programmes.
- ii. Emergency assistance approach with high prorates and high cost involvement within a shorter period is not recommended.



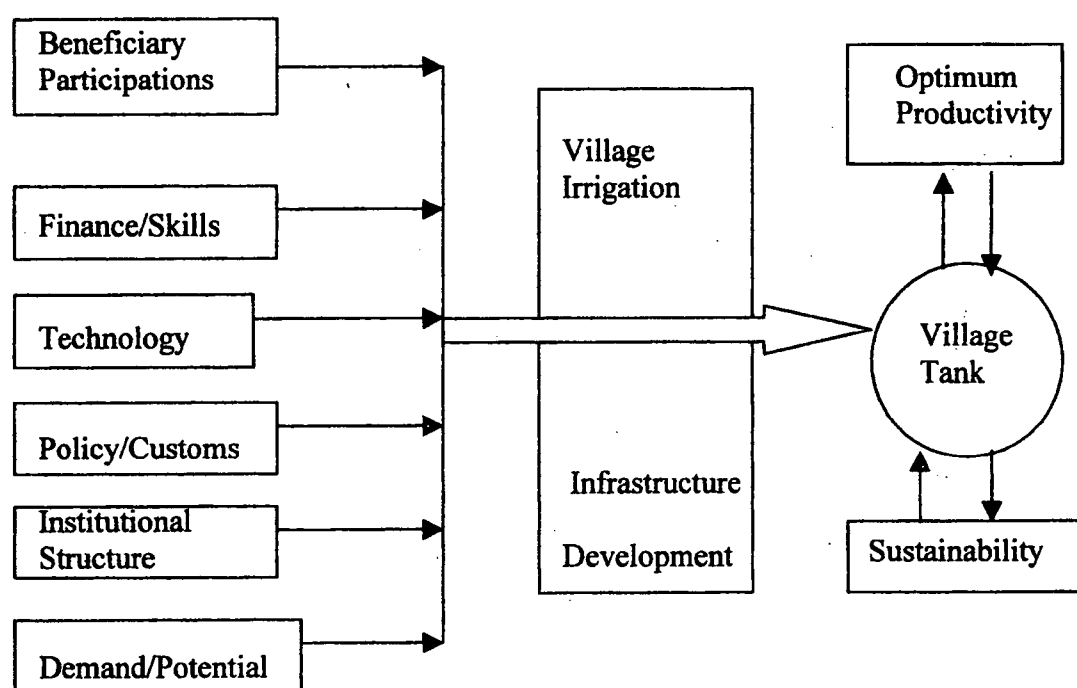
Rural Resource Management

It is necessary to answer the questions of "community level village tank infrastructure development is for what? and how it would be performed successfully.....?"

Following reasons are the real causes of tank rehabilitation.

- i. Bad maintenance
- ii. Weak construction
- iii. Wrong designs
- iv. Inappropriate technology
- v. Natural disaster
- vi. Deterioration of customs and traditions and the rural institutional structures.

Fig 9: Village Irrigation Infrastructure Development as a Part of Rural Resource Management



Five drivers of this mechanism can be identified as a driving force that keeps the system in momentum.

Driving Forces of the Infrastructure Development Mechanism

- i. **Beneficiary Participation**
Efficient beneficiary participation is a must and should be clearly identified and assured from very first stage of decision-making.
- ii. **Finance and Skills**
Adequate amount of finance and skills has to be maintained to conduct PSS and for good operation and maintenance programme.
- iii. **Technology**
Technology can be divided into two groups. One is the traditional technology available with the rural community and the other one is the appropriate technology that should be introduced by the

State. Continuous technical inputs are necessary for decision-making process and improved operation and maintenance.

Fig. 10 shows the structure of "Karahana", which is a rare traditional flow-measuring device made out of wooden stem and also a symbol of traditional know how. These types of structures are still in use in Anuradhapura district.



Fig. 10 : Karahana

iv. Policy or Customs

Customary laws and the State order successfully governed the village irrigation activities in the ancient times. These traditional systems are now paralyzed in most of the cases, and a vacuum has been created in this regard. Existing policy gaps related to village irrigation should be bridged through rejuvenating the earlier policies or formulating appropriate policies.

v. Institutional Structure

The farmers were well organized even prior to the introduction of new organization structures after independence. The important feature of these organizational structures was that, they were compatible with the underlying agrarian structure.

vi. Demand or Potential

Community driven off demand driven approach should be adopted in realization of development potential.

The above described management concept had been clearly identified and successfully implemented during the period of ancient kings and the rudiments of different versions of the above mechanism are still alive at the rural level in this country.

Conclusion

Following major constrains have been identified with respect to Village Tanks.

- Lack of Vision and Existence of Policy Gaps
- Adoption of Haphazard Development Approaches in (Water and Land Sector)
- Lack of correct Priority identification
- Lack of Technical Inputs
- Land Tenancy Problems and Fragmentation
- Use of Inappropriate Technology
- Lack of Irrigation Infrastructures
- Tank Bed Siltation
- Loss of Real and Sense of Ownership
- Poor Skills
- Fading out Customs and Traditional Know how in the Management
- Weak Organizations and Poor Maintenance.

Fig. 9 illustrates the present problem analysis of Village Irrigation arena in Sri Lanka. Causes related to the degradation of village tank systems have been changing very rapidly so that no unique approach is applicable as remedial measures of those systems. Research, studies, pilot learning etc are very much essential to develop innovative approaches, in order to overcome such problems. Categorization of village tanks in a scientific manner and introduce appropriate development strategies with bundle of proposals will only reduce the burden of this national crisis.

“Same water cannot be cross twice as the flowing water is always new”--Greek saying

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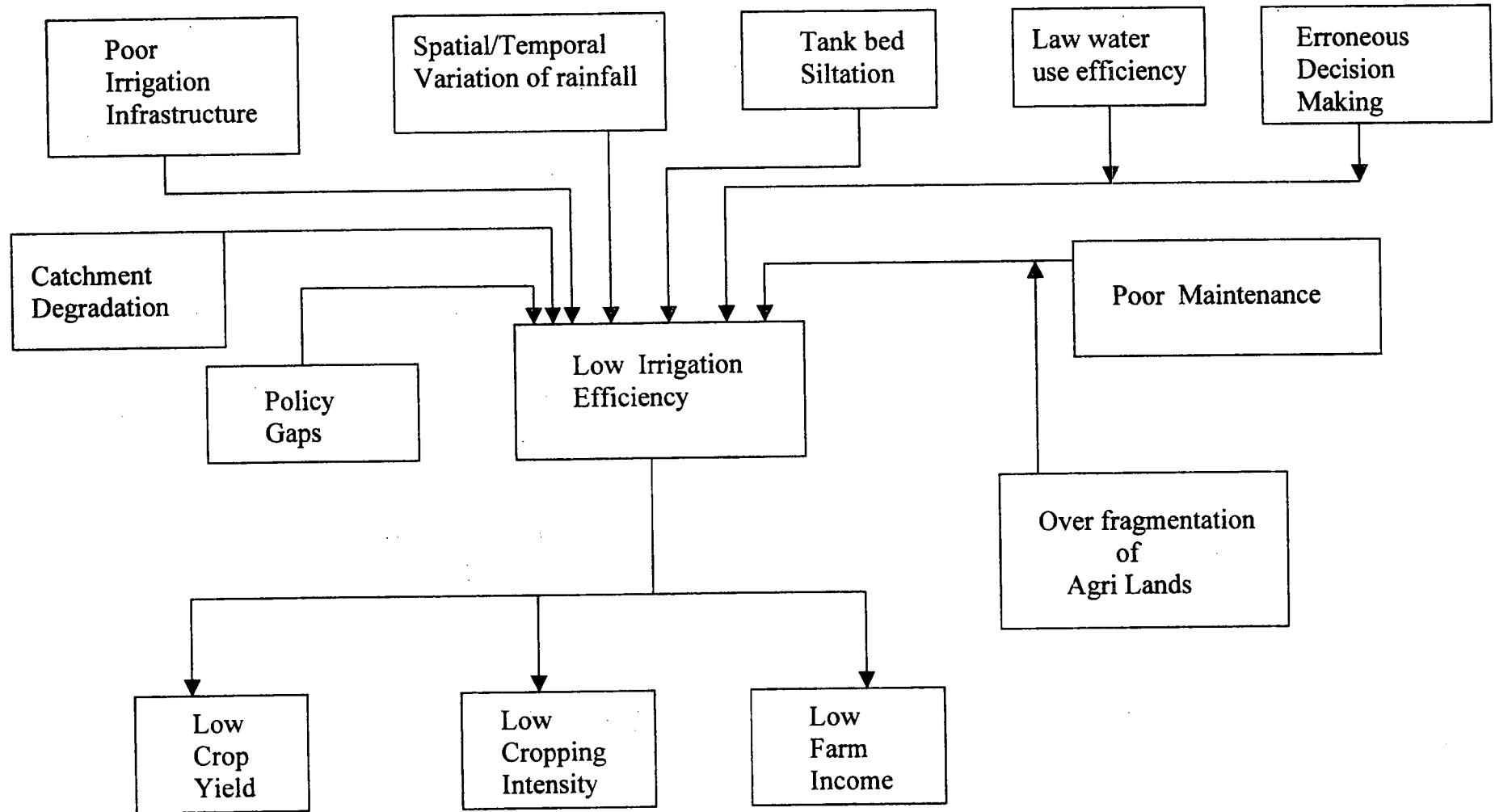
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Annex 1: Problem Analysis of Irrigation Arena in Sri Lanka



SMALL TANK HERITAGE AND CURRENT PROBLEMS

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Abstract

When a community becomes unstable in living environment the people are vulnerable to sudden physical, social and economical stresses. Small tank village communities are hence more affected by recurrent droughts than many other communities as their sustainable living environment has disappeared during last few decades. Agricultural potential has severely declined in this environment due to low fertility of farming lands, water shortage, poverty, tank sedimentation, high tank water losses etc. Further, it has been observed that rehabilitation and development programs carried out in these villages have not brought anticipated impacts on the economy and living standard of the people. Most pronounced reason for this failure is that no cognizance was taken from their deep-rooted customs and traditional wisdom for planning present development activities.

In the traditional system agriculture had been manipulated to absorb any weather vagaries by shifting the cultivation time and selecting cultivation practices. Traditional communities made every attempt to conserve soil, water, and natural habitat. Food security was one of the in-built aspects of their culture. Use of groundwater for agriculture was never practised by them, and it assured the water security. There was a broad diversity in flora and fauna. Sharing resources equally and the equity of ownership were the most striking features of their culture, which led to build up a peaceful and sustainable rural society. Environmental pollution had never been an issue for them to bother. With the disappearance of these features the whole system was subjected to deteriorate socially, physically and economically making the community vulnerable to disasters. The paper discusses some strategies to rehabilitate the system through adoption of most appropriate approaches such as physical resource conservation, restoration of ecologically important features, tank storage improvement, strengthening institutional mechanism, attitudinal changes etc. to bring back the sustainability, which evade the poverty and vulnerability of the small tank community to natural disasters.

Introduction

It has long been recognized that the drought is a natural phenomenon, the effects of which are aggravated due to ignorance and negligence of the people and the rulers. The best comparison comes from USA and Ethiopia (Walker, 1989). The 1983 drought in the USA reduced the grain yields more than 22 million tons. The Government supported farmers more than they earned from their farming. As a consequence, the disaster was averted. In 1984 the food production in Ethiopia was dropped by two million tons and most probably more than 400,000 people died. It reminds the fact that without vulnerable people there can be no disaster. We are now experiencing a drought moving towards a disaster. Most affected districts are Kurunegala, Anuradhapura and Puttalam, which received 77.5, 37.0 and 63.3 percent reduction of rainfalls respectively in the *Maha* 2003/04 season. About 67,400 farming families were seriously affected and in need of food assistance. Paddy production during *Maha* 2003/04 season in these districts was reduced to half due to the drought. It is expected that the production in *Yala* 2004 season would also be dropped by 68 percent. Other field crops such as maize, various pulses and chillies mainly grown under rainfed conditions in *Maha* 2003/04 season were heavily damaged (FAO, 2004). Depletion of reservoir storage levels at the end of *Maha* 2003/04 season is a clear indicator to illustrate the magnitude of the disaster (Table 1). Almost all small tanks have gone dry and villagers are digging holes in tank beds for water.

Table 1: Reservoir levels ending *maha* 2002/03 and 2003/04 seasons in selected districts of Sri Lanka (as percent potential capacity)

District	2002/03	2003/04
Anuradhapura	87	34
Kurunegala	97	26
Hambantota	29	15
Badulla	74	29
Moneragala	71	21
Puttalam	100	21

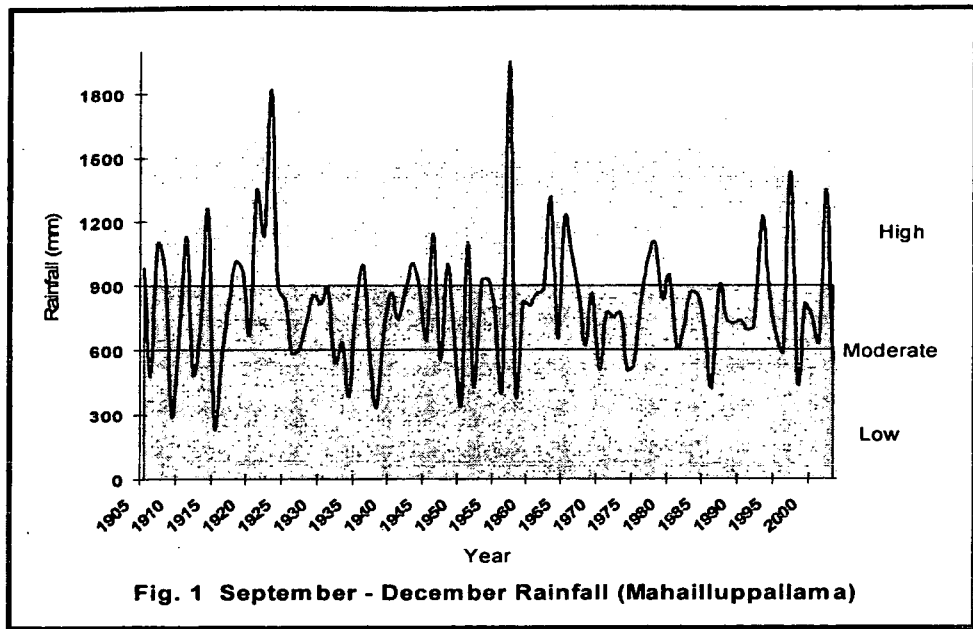
When examined long-term rainfall records it shows that the drought prevailed at present is a frequent event (Fig. 1); however the negative effects tend to be more acute than that in past. Vulnerability is developed in a community when it has exhausted all its reserves and is totally dependent for food on the current year's crop and then the drought spells disaster. However, determining both the vulnerability status of the community and the occurrence of drought are no easy matters. Traditional societies act in two ways to mitigate the effect of drought. First is the preparedness and second is the adoption of coping strategies. The objective of this paper is to discuss how small tank communities averted the risk of drought effects, what reasons caused to develop the vulnerable situation and the possible measures on long run that can be adopted to restore their sustainable living environment.

Present Situation of Tank-Village System

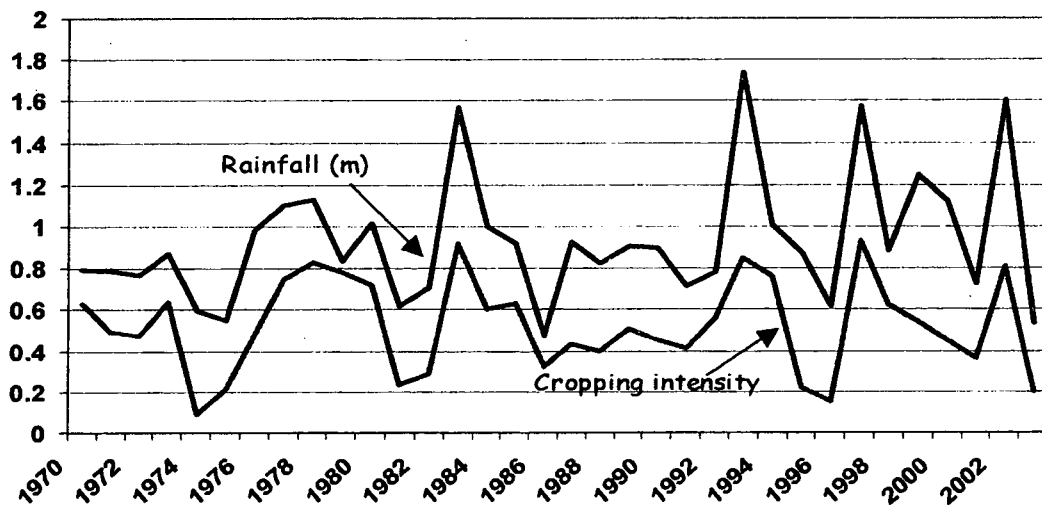
In a comparison made on rice yield data between small and major irrigation schemes it was observed that the rice yields are always lower in small irrigation schemes. This situation has emerged due to several reasons. Most important factors are low level of crop and water management, lack of proper weed, pest and diseases management, poor tillage operations and lack of proper drainage.

Cropping intensity is very low in small tank systems. In a study carried out for Anuradhapura District using rice cultivation statistics recorded from 1970 to 2003, it was observed that the cropping intensity had never exceeded one, and it fluctuated according to the rainfall received during *Maha* season (Fig. 2). With all efforts made to renovate small tanks under various tank rehabilitation projects implemented during this period in Anuradhapura District, no significant improvement in cropping intensity could be achieved. This would drive us to make serious thoughts on present tank rehabilitation methodology and its impact on water storage efficiency of tanks.

Cultivable extent from small tanks decreases gradually due to tank siltation and high tank water losses. A study carried out in 1990 showed that three small tanks; Paindikulama, Siwalagala and Marikaragama in the Nachchaduwa major watershed have been silted up by 35, 30 and 23 percent respectively of their initial capacity (Dharmasena, 1992). Siltation of tanks not only causes reduction of storage capacity but also leads to alter the tank bed geometry. Subsequent rehabilitation works, where the capacity has been improved by raising the spill and the tank bund would create a shallow water body spreading over a larger surface area. This makes the situation more complicated creating several other problems. They are: a) inundation of upstream paddy lands; b) development of salinity conditions in the upper area; c) increase of tank water losses; d) disappearance of the tree strips in the high flood region (*Gasgommana*) and the grass cover (*Perahana*) underneath; and e) disappearance of some indigenous fish species, which cannot survive in shallow waters or do not find a favourable breeding environment.



Water losses from small tanks are very high. Within a period of 2 – 3 months since the seasonal rains cease, most of the tanks appear as somewhat marshy lands infested with aquatic weeds. Total tank water loss through evaporation and percolation varies from 35 to 90 percent depending upon geometry of the water body. Water losses are higher from tanks with shallower water bodies than those with deep water. Therefore, it is clear that tank bed geometry determines more the water storing efficiency of a tank than other factors do. These results indicate that about half the storage stored in a tank would not remain to irrigate the downstream command area. Fig. 3 shows the relationship between percent annual tank water loss and the tank geometry. It indicates that if the tank geometry could be altered to form a high capacity: area ratio, water loss would be reduced to a very satisfactory level.



In increasing storage capacities of tanks yields were estimated by using conventional iso-yield curves, which do not consider land use or the land cover as a factor. Studies revealed that the percent weekly runoff

could vary from 1 to 11 depending up on the catchment vegetation (Dharmasena and Goodwill, 1999). Water losses were also very much under-estimated but studies showed that it could be in the range of 1.4 - 5.3 percent of the storage per month. There is no one central agency for tank rehabilitation, therefore repetition, avoidance etc. can frequently occur. Further, rehabilitation programs do not have any efforts to restore the surrounding eco-system and improve the drainage conditions in the paddy field. As these aspects were not considered in rehabilitation planning the outcome of the programs has not been up to expectations.

Traditional System

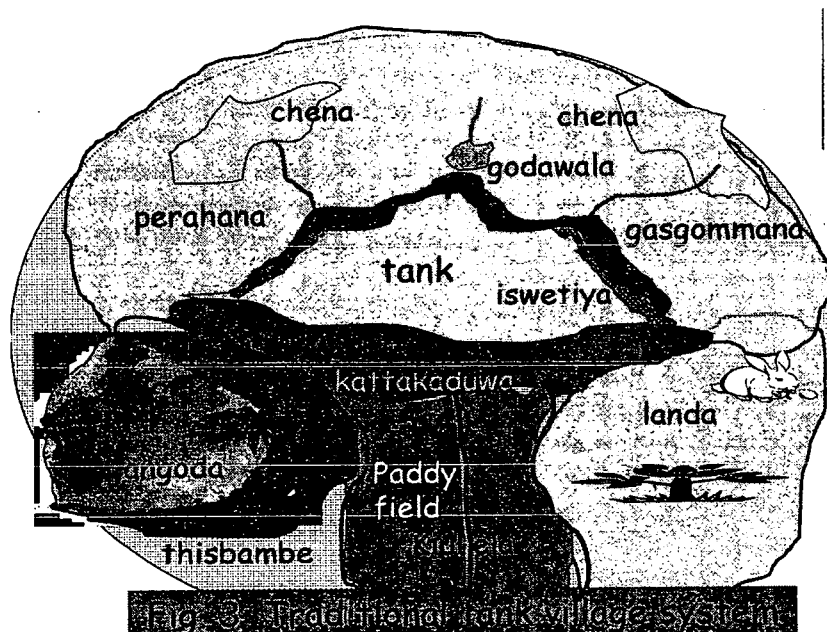
(i) Special Features of the Traditional System

Traditional wisdom in agriculture and the living has not been developed within few decades. It is a long time-tested knowledge, which created an environmentally adapted, disaster tolerant and sustainable living system. Their agriculture had been adjusted to absorb any weather vagaries by shifting the cultivation time and selecting farming practices. They cultivated *chena* and paddy lands according to the seasonality of rains thus; at least they could get a successful harvest from one cultivation. *Kekulama* (dry sowing), *Bethma* (shared cultivation), *Thaulu govithena* (tank bed cultivation) etc. are the best examples showing how they could avert the drought effects on their farming. Traditional communities made every attempt to conserve soil, water, and natural habitat. Food security was one of the in-built aspects of their culture. Use of groundwater for agriculture was never practiced by them, and it assured the water security. An adequate dead storage was found in tanks to be utilized during dry period for all purposes and had been the only source of water for cattle and wild animals. There was a broad diversity in flora and fauna and the availability of water in the tank during the dry period assured the survival of them. Sharing resources equally and the equity of ownership were the most striking features of their culture, which led to build up a peaceful and sustainable rural society. Environmental pollution was not a topic for discussion. With the disappearance of the features discussed above the whole system was subjected to deteriorate socially, physically and economically leaving vulnerability to disasters with them.

(ii) Traditional Tank-Village System

Sustainability of the traditional tank-village system had been maintained in the past simply not only from structural maintenance. Each and every component of the eco-system was given due consideration. The attention was paid not only on macro-land uses such as paddy land, settlement area, chena lands, tank bed etc. but also on micro-land uses such as *goda wala*, *iswetiya*, *gasgommana*, *perahana*, *kattakaduwa*, *tisbambe*, *kiul-ela* etc. Fig. 3. illustrates the geographical setting of these land uses, and descriptions and importance of them are discussed below.

Gasgommana - It is the upstream land strip above the tank bed, accommodating water only when spilling. Large trees such as *kumbuk*, *nabada*, *maila*, *damba* etc. and climbers such as *kaila*, *elipaththa*, *katukeliya*, *kalawel*, *bokalawel* etc. are found in this area. This vegetation is natural and seeds are floating on water. The *gasgommana* acts as a wind barrier reducing evaporation from the tank and lowering water temperature. It gets closure to the bund from either side where roots of large trees make water cages creating breeding and living places for some fish species. This strip of tree demarcates the territory between human and wild animals.



Perahana – It is the meadow developed under *gasgommana* and filters the sediment flow coming from upstream chena lands.

Iswetiya or *potawetiya* - An upstream soil ridge constructed at either side of the tank bund to prevent entering eroded soil from upper land slopes.

Godawala - A manmade water hole to trap sediment and it provides water to wild animals. This might had been a strategy to evade man-animal conflict.

Kuluwewa - A small tank constructed above relatively large reservoirs only to trap sediment and not for irrigation purpose. It provides water for cattle and wild animals.

Thisbambe – It is a fertile land strip found around the settlement area (*gangoda*) and does not belong to any body. Tree species such as *mee, mango, coconut etc.* are grown in scattered manner. Mostly this area was used for sanitary purposes as the resting place of buffaloes. Buffaloes were used as a protection mechanism from wild animals and malaria.

Kiul ela – This is the old natural stream utilized as the common drainage. Tree species such as *karanda, mee, mat grass, ikiri, vetakeya etc.* and few rare small fish species are also found in water holes along the *kiul ela*. Most importantly it removes salts and iron polluted water and improves the drainage condition of the paddy tract.

Kattakaduwa – This is a reserved land below the tank bund. It consists of three micro-climatic environments: water hole; wetland; and dry upland, therefore, diverse vegetation is developed. This land phase prevents entering salts and Ferric ions into the paddy field. The water hole referred to as '*yathuruwala*' minimizes bund seepage by raising the groundwater table. Villagers plant *vetakeya* along the toe of the bund to strengthen the bund stability. It appears to be a village garden, where people utilize various parts of the vegetation for purposes such as fuel wood, medicine, timber, fencing materials, household and farm implements, food, fruits, vegetables etc. (Dharmasena, 1995). Specifically they harvest row materials from this vegetation for cottage industries. Some products derived from the vegetation of *kattakaduwa* are shown in Table 2.

Table 2: Species for cottage industries

Plant species	Products
Indi	Hats, bags, baskets
Vetakeya	Bags, baskets, mats.
Bambo	Wood carving, flower vase, building materials
Rattan	Baskets, furniture
Palmaira	Mats, bags, baskets, sweets, toddy
Mat grass	Mats, baskets etc.
Pata-beli	Ropes, strings etc.

Value of Water

Scarcity of freshwater is one of the major concerns now at global scale. Increased water use by humans for agriculture, domestic and industrial purposes has endangered aquatic ecosystems and their dependant species. Therefore, the trade-off between freshwater for basic human needs, food production and maintenance of the freshwater ecosystem is already on the agenda in many countries of the world, particularly those with limited water resources. As estimated in 1990, the annual water resource in Sri Lanka is 4.32 mil. ha.m, of which about 20 percent is the present withdrawal and 96 percent of the withdrawal is for irrigated agriculture spreading over an extent of 0.58 million ha (Amarasighe et al, 1999). By the year 2025 the country's population is estimated to reach 24.9 million and annual production requirement of rice would increase accordingly up to 3.5 million ha to feed the nation. Table 3 shows the requirement of expanding the irrigated area and development of storage capacities, both of which are difficult target to achieve and very expensive. A scenario could be suggested that if the irrigation effectiveness could be increased from present level of 37 percent to 45 percent the need of spending money for irrigation structures and additional land development would not arise. This clearly shows the importance of efficient water management in country's agriculture. Therefore, our future vision should be to restore our reservoirs, canals and other water management structures to obtain maximum effectiveness, and promote farmers for efficient management of water resources in agriculture.

Table 3. A scenario to achieve production requirement of rice in 2025 by increasing the irrigation effectiveness

	1990	Projection to 2025	Proposed scenario for 2025
Population (million)	17.2	24.9	24.9
Rice production (mil. mt)	2.2	3.5	3.5
Rice yield (t/ha)	3.8	3.8	5
Extent of irrigated farming (mil. ha)	0.58	0.93	0.69
Irrigation water requirement (m ha.m)	0.86	1.38	0.86
Irrigation effectiveness	37 %	37 %	45 %
Cropping intensity	1.3	1.3	1.6

Strategies towards Sustainability

(i) Cascade approach

Small tanks do not exist as individuals. Natural drainage system in a watershed is blocked by earth bunds in appropriate locations to store water forming a series of tanks along the drainage. The drainage pattern formed in the undulating topographic formation in the dry zone landscape can be classified as dendritic drainage pattern. This ramifying nature of the drainage system has led to form clusters of small tanks found in series, which are connected to form a system known as 'tank cascades' (Madduma Bandara, 1985).

Existence of small tanks in a cascade pattern is an advantageous feature in many ways. Surface water bodies spread over an area can maintain the groundwater level closer to the land surface at least in lower portions of the minor basins. It can be stipulated that absence of such a branched system of tanks could lead to rapid depletion of groundwater due to natural gradient of the drainage system. Therefore, in the absence of tank cascade systems natural vegetation seeing now would have not been in the same composition with deep-rooted large tree species found in the various positions along the catenary slope.

Upper tanks in a tank cascade system act as buffer reservoirs to absorb flood-generating rainfall, which would otherwise bring the risk of breaching lower tanks. Similarly, these upper tanks are buffer reservoirs to supply water to the lower tanks when they are in short of water to save the crop. Since the tanks exist not in isolation but as clusters, and they are hydrologically inter-related, planning for individual tanks could create conflicts in water resource management among them.

(ii) Catchment Conservation

Conservation of tank catchment should be an integral part of the tank rehabilitation programs. At present, severe erosion taking place cause depletion of soil fertility in the catchment land whilst sedimentation of tanks below. Immediate upstream area of tanks should be reserved to grow natural vegetation. Lands already being utilized for rainfed farming should be conserved through adoption of conservation measures and promoting conservation farming practices. Studies have shown that the adoptions of conservation farming practices do not disturb the water yield to the tank (Dharmasena, 1994).

(iii) Partial desilting concept

In tank rehabilitation programmes at present, the tank bund is strengthened, structures repaired or replaced, and the capacity lost due to deposition of sediment is regained by raising the spill and the tank bund. This has come out with the common belief that the desiltation of minor tanks would result in very low economic returns. However, scientists, planners and engineers cannot escape from the challenge of disappearing minor tanks from the dry zone landscape during next few decades. Desiltation of small tanks should aim not only at increasing storage potential and reducing tank water loss but also at protecting the tank ecosystem. The partial desiltation concept was first introduced a decade ago (Dharmasena, 1994) with lot of ambitions, but adoption of it is progressing very slowly.

The process of desiltation in this concept is not essentially aimed at expanding the present capacity of tank. The main objective of the concept is to reduce tank water losses by manipulating tank bed geometry through desiltation. It is clear that the said objective cannot be successfully achieved by a complete desiltation, which would not much alter the area: height ratio of the tank storage. Sedimentation studies (Dharmasena, 1992) indicated that half of the sediment deposited in small tanks is found within one third of the tank bed area closer to bund. Thus, the same capacity can be maintained by removing sediment in this area and heap up in the upstream area. These soil heaps must be formed at safe gradient and stabilized with trees and grasses to prevent washing down to the tank. These mounds would appear as micro-islands, where productive plant species could be grown. These soil mounds must not block the natural drainage, which supply water to the tank. An illustration of the desilting technique is given in Fig. 4. Further, there is a need to construct a soil bund along the periphery of the desilted area except in places where natural streams enter into the tank.

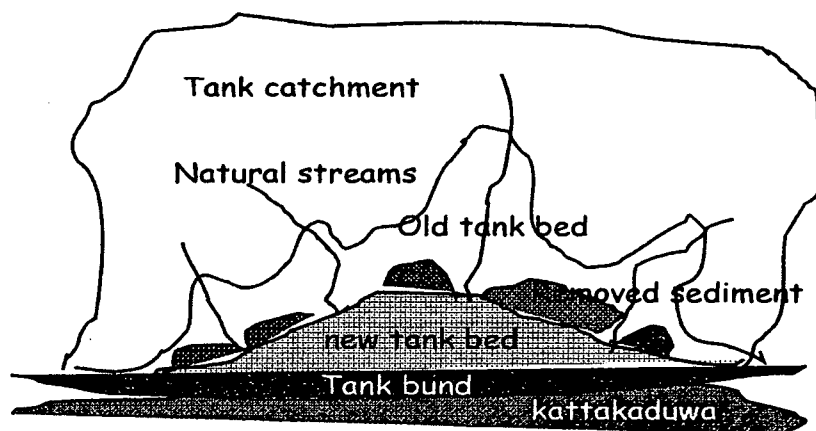


Fig. 4 Partial Desilting Concept

Partial desiltation technique consists of preliminary field surveys, preparation of plans, designs and estimates, removal of sediments, making soil mounds, establishment of upstream reservation (*Gasgommana*) with soil mounds and natural streams, renovation of tank bund and sluices, establishment of downstream reservations (*Kattakaduwa*) and main drainage of the command area (*Kiul-ela*). The technique should consist of all these activities without which the impact of partial desiltation would not be much effective. However, before commencement of technical planning a Participatory Rapid Appraisal or

a similar exercise must be carried out to obtain farmers' views on tank rehabilitation, and to consider their suggestions for incorporating in the subsequent planning and implementation programme.

A tank bed engineering survey has to be carried out to understand the present tank bed geometry, storage capacity and area-capacity-elevation relationship. A sediment depth survey is also to be carried out to prepare original (prior to sedimentation) contour map and area-capacity-elevation curves, which would later be super-imposed to the existing tank bed perspectives. The depth to original tank bed can be determined by field experience. It is identified as the depth at which the sand/(silt+clay) ratio shows a sudden contrasting higher value (Dharmasena, 1992).

Excavation of soil needs the support of machinery. However, the associated farming community can do shaping up of soil mounds and upstream bund. Most important components in this programme are stabilization of bunds with vegetative cover, establishment of *Gasgommana* (upstream vegetation) and *Kattakaduwa* (downstream reservation) area. Farmers must be aware right at the inception of the programme of how they are supposed to contribute in this exercise. Total work should be undertaken by farmer organization.

Partial desiltation of a tank would provide various benefits to the community some of which cannot be assessed by an economic analysis. It is quite obvious that the return to investment from desiltation is not economical if the purpose of desiltation is to increase the storage. The concept of partial desiltation is not meant merely to increase the storage unless there is a demand from the community or an additional storage potential in the system. The economic analysis should therefore, be based on consideration of following benefits in order to determine the return to investment of partial desiltation.

Even though the asweddumized lands are available in plenty for cultivation in most of the command areas, availability of water in the tank limits the cultivable extent. Reduction of tank water losses from partial desiltation would lead to improve the water availability in minor tanks providing more opportunities for cultivating relatively a larger extent.

Partial desiltation reduces the water-spread area. More than half the land inundated with tank water would be free of surface water after a successful desiltation. Water body would be confined to the portion closer to tank bund. The land area freed from water spread can be covered with perennial vegetation. This soil is fertile with nutrients and high level of organic matter (5 - 8 %) and also has an easy access to groundwater. In a cottage industry improvement programme, this land may best be utilized to grow Bamboo (*Bambusa* spp.), Rattan (*Calamus* spp.), Mat grass (*Cyperus pangorei*), Vetakeya (*Pandanus* spp.), Patabeli (*Hibiscus tiliaceus*), Palmaira (*Borassus flabellifer*), Kithul (*Caryota urens*) etc. all of which provide various raw materials for cottage industries.

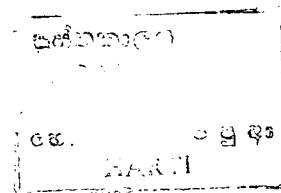
Water storing efficiency of the tank would be increased with improvements on tank geometry by partial desiltation. Any water remaining in the tank after *maha* cultivation can be kept without many losses for *yala* cultivation. Further, this tank storage can raise the groundwater in the command area and *yala* cultivation can be supplemented by well water with a great assurance. Both these reasons could lead to increase the cropping intensity of the command area.

Minor tanks are seasonal reservoirs. These can be utilized for raising fish species of short duration or harvesting half matured fish stock. An adequate dead storage of a tank with favourable geometry can improve this situation for rearing long duration fish species. The other advantage of having a good dead storage during dry periods is that these tanks can be utilized for raising fingerlings in protected areas. Nevertheless, dead storage is the only live storage during dry period for the survival of surrounding vegetation, wild animals, cattle and domestic purposes of the community.

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Discussion on Session One

Discussant

Eng. A.D.S. Gunawardena

Director (Special Projects) Ministry of Irrigation

I have 10 minutes to sum up the proceedings in the morning session. I am not going to take paper by paper. What I am going to say may mostly contains what registered in my mind from the presentations made. Mr. Lakshman Jayakody, Presidential Advisor, although is about 85 years of age, spoke quite clearly about the current shift in policy to rehabilitate small irrigation tanks. One of the points that he brought out was that scientists should advise policy makers correctly. I think from Hon. D. S. Senanayaka downwards that has been said. But scientists found it impossible to give proper advice to politicians, because these two groups had two sets of rules and there was always a conflict between the two. Then there were also conflicts between fellow scientists having contradictory views on the policies. Therefore your advice is hardly heard at the higher quarters. I have observed this for the past 30 - 35 years.

Going back to the real subject, someone mentioned that simple engineering upgrading alone can't improve the cropping intensity. Even the former Minister said that we have done VIRP, NIRP and so many other things like that, but all these have been investments in engineering upgrading of the system. But they have not improved the cropping intensity of these systems. Take for example the TIMP, which was done, in early 70s. Although Rs. 200 million was spend for it under a World Bank Project the benefits were meagre. Then recently a group of experts examined a project proposal for funding in the same manner to the tune of Rs. 6000 million. They found that benefits accrue to the man-on-the street is only Rs. 1000 million. Now discussions are going on with the funding agency to carryout required modifications to change this situation.

As you know the cascades are in the upper reaches of the waterways. There are many people living in these areas and they are demanding that rehabilitation of small irrigation system be carried out in those areas as well. An example would be Lunugamwehera. When we went to ADB for funding, an agreement was made with them not to exploit anything in the upstreams. Now this is not fair by these people, who are living in the upstream. Even under the 10,000 tank programme, people of the upstream of Lunugamwehera are demanding to rehabilitate at least 3 tanks, but, under the agreement with ADB we cannot do that.

For the last 15-20 years, the debate on the small systems vs big systems in irrigation was highly explosive. Some scientists are on one side and the others on the other side. People have gone to the extreme of castigating top engineers on one side or the other. Now look at the ground realities. The Kurunegala District has the highest density or number of small tanks. During last 15 years or so we have been spending about 10-15 million rupees to rehabilitate them. Organizations like World Bank, ADB, EEC and Sri Lanka Government provided funds for this. However, the present Deputy Minister on several occasions has stated that not more than 60 tanks have been properly rehabilitated. Now here we have to consider the significance of Deduru Oya. Every year more than 1000 mcm of water just goes down to the sea. Unless we store this water we do not have water to feed most of those small tanks in the Kurunegala District. Take for example Malala Oya basin. Here the small tanks spill with just 2-3 rains, as their storage capacity is small. A further 2-3 rain also falls during the season. Unless you have big tanks here, you cannot store that water. You may inundate houses, tea plantation, other lands but that is the price the country has to pay to store precious water. In the Kurunegala District, unless you store Deduru Oya water, you will not be able to do anything, especially with regard to the rehabilitation of small tanks at a cost of Rs. 400,000 each. Because these efforts will not bear fruit unless you feed water to these tanks.

About 20-30 years ago there was a discussion that no more big reservoirs are required for the country. Nevertheless, during the last regime an expert team has found that there are 22 sites for new large tanks where rainwater could be stored. There was a proposal to divert Menik ganga water to Lunugamwehera. People laughed at it. But last year when the Irrigation Department completed an anicut at Sellakatharagama, it was found that during a two months period around 6000 cubic feet of water just flowed to the sea. This is the water that was proposed to be diverted to Lunugamwehera. This is the quantum of water that falls into the catchments during the rainy season with 6-7 rains. Then if you take Kirindi Oya, the total volume of water that would be stored in the small tanks is less than 1% of the rainfall. I can provide you the statistics. Here planners will have to rethink to get their perspectives right.

It has often been highlighted that due to foreign loan, country is indebted Rs 90,000 per person. This amounting to Rs. 1800 billion or US \$ 18 billion. We have to map out how best, we could utilize these funds for the country's integrated development. In the project I referred earlier in the presentation with regard to the benefits. Accrue to the ordinary areas, we were offered experts at a cost of Rs. 3.3 million per month per person. Now there are senior chartered engineers with 5-6 years experience. We have to address our minds how best we could utilize out talents. Without getting indebted, we have to use our resources wherever possible.

Another aspect mentioned by Hon. Jayakody was the need to get down a World Bank team to look at the drainage problem in the Western areas. Although we got independence in 1948, our politicians assisted by our unscrupulous professionals, have not got the feeling that our own people can analyse some of these problems and come up with solutions. For example, if you take the drainage problem of Colombo and all, a Japanese loan of Rs. 4,000 million was spent on it, some 20 years ago by the Low-line Reclamation Board. Then they took another Rs. 6,000 million. This was followed up with another Rs. 10,000 million to be spent on the same subject. Has it improved the drainage flooding of the city? No! We only have the bunds built on sides of the Kelani River during 50s to be seen. We had a debate on this at the Institute of Engineers, and we found that the structures required for the purpose need only Rs. 500 million.

Getting back to 10,000 tanks programme, we have to analyse in depth the problems before hand and spend the least amount of money. We have to look at how we could augment these systems. The way we are moving is not exactly that, slightly away from the ideal.

Discussant

Mr. Nanda Abeywickrama

Chair Lanka Jalani and Senior Advisor to the Director General IWMI

Thank you Mr. Chairman. You have really put me in the deep end. I didn't bargain to come here as a discussant.

The topic that is being discussed today is Village Tanks; hence I will try to confine my comments to that topic. I am not very much into village tanks. But I find the presentations very interesting; they try to answer a number of questions and issues that had been mingling intriguing me for a long time with regard to the potential, usefulness and relevance of village tanks. Indeed the way Dr. Tennakoon and Dr. Dharmasena presented it, we find that village tanks cannot be treated in isolation; they are part of the technical system, ecological system, and the social system. I find the analysis of Dr. Tennakoon very interesting. Even as a Sri Lankan couldn't have got into this depth of analysis unless one has been really living in that environment.

When we prepared the Sri Lanka Water Vision 2025 in 1999 – 2000, we were faced with a dilemma. We have bundled "irrigation" into one i.e. large multi – purpose projects, major-major, major with one season only, medium and small systems, and kept on investing with one goal ie "self – sufficiency in rice". Very large investments have been made in these systems. The large systems have a yield potential of 7-8 metric tons or more but small village tanks were never able to achieve that. Even their cropping intensity was 1.2 or 1.3. Hence, our economic evaluations cannot justify village tanks on economic grounds alone. But, they have an immense value both socially and environmentally. They show how to create a different eco-system in an otherwise hostile environment. So the Sri Lanka Water Vision came out with the proposition that village tanks are an essential part of our landscape or (social scape!) and that we need to find a way of justifying them not only on economic grounds but on social and environmental criteria as well. Both Dr. Tennakoon and Dr. Dharmasena presented their cases in a very scientific manner.

I have two questions to raise here. One is how much water do we lose by evaporation in small tanks as well as elsewhere? This is a tropical country with a high rate of evaporation, hence the effectiveness of the actual rainfall could be much less than assumed. The second question is village tanks, even if nurtured and looked after, to what extent could they provide adequate livelihoods for the people living there?. Whether the rising aspirations of societies could be satisfied through a tank based economy alone? It may need other investments that have to come from elsewhere to fill the gap..

Then in this sphere, we always have been moving along sectorally. For example the investments in the forestry sector stops at the Forest Departments and R.F.O. Although we talk of consultation and participation it occurs vertically. It is the same with irrigation and other sectors. How could we move horizontally? How do we get investments directly into the areas concerned, the Provincial Councils, Districts, Local Authorities, Divisional Secretariat Divisions, etc? How do we involve communities for common action in planning, implementation and monitoring? How do we make them more transparent, more demand based, problem solving and sustainable? Not merely how the people could be sustained but also how to provide ways for them to prosper?

Another issue looming on the horizon is that once our income levels reach US \$ 1000 per capita, we are not entitled to the type of concessionary funding we are accustomed to. Then investments have to come from our budget, our taxes and our own resources. Village irrigation tanks are excellent eco systems, where planning can be done to involve local people to make use of these resources in a more effective manner.

Mr. Chairman, I had no intention of getting into the politics of water management, yet since some statements have been made by one of the speakers regarding global partnerships and various other global institutions some of which I am associated with, I would like to mention that Sri Lanka cannot live in isolation from developments that are taking place in the rest of the world. It doesn't mean that we have to take instructions coming from global forums in toto.

Then the perception that Sri Lanka has enough water was argued and advanced. We may have enough water in the aggregate, but seasonal and regional variations are very high. People in some areas are going through difficulties in getting required amount of clean water for drinking and for domestic purposes. Water pollution is very high in this country. In NCP even if you have ground water, it is not good enough for drinking purposes. So one has to be careful in coming to conclusions on these matters.

Having said that, I want to reiterate that, whatever we do with global partnerships, we keep in mind the national interests of this country. We do not do that with the intention of selling the interests of this country!

Thank you Mr. Chairman

Technical Session Two

SMALL TANK CASCADE SYSTEMS: THEIR RELEVANCE FOR MINOR IRRIGATION REHABILITATION

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Abstract

Current interest in rehabilitating minor irrigation systems at an unprecedented scale is undoubtedly commendable in view of the fact that, such irrigation works have remained relatively neglected and the communities inhabiting associated settlements belong to the 'poorest of the poor' in the country. At the same time, it has to be recognized that, there is an accumulated body of knowledge and experience in small tank rehabilitation particularly during the last few decades. It is argued that, in the long-term interest of the country, this wealth of knowledge must be harnessed in any large-scale rehabilitation or development of small tank systems. It is also stressed that small tank rehabilitation alone may not prove to be an effective means of combating the impact of droughts, since experience suggests that, historically the drought damage had been highest in small tank settlements areas. Tank de-siltation will not last long, if the tank catchment areas are not adequately protected. It is therefore, suggested that a properly planned 'cascade-based' approach to development of small irrigation systems, fed and nurtured by large scale irrigation projects would prove to be a more enduring solution to the acute water stress in such areas. A fundamental change in land use towards less water consuming and more economically attractive crop and livestock combinations, has a better chance of assuring stability in these rural areas.

Some Early Studies

As a student of geography in the early 1960s, an interesting reference to village tank settlements in Brohier's (1935) monumental work on ancient irrigation, kindled an academic interest in tank irrigation settlements. This was compounded by an impressive map in the equally impressive book on the Geography of Ceylon by Elsie Cook (1931) - an inspiring scholar who fired the imagination of many generations of students. In a lighter vein, the books by Devendra on 'Tanks and Rice' and Brohier on 'Food for the People', gave us much insights to the subject of minor irrigation and impressed upon our minds that the *purana* village with its tank, temple and the paddy field is a gold mine for social-anthropological and water resources research. We have also come across cotemporary intellectual giants such as Leach (1961 & 1980) who universalized 'Pul Eliya', and Farmer (1956) who wrote on Rainfall and Water Supply and Dry Zone Colonization. Subsequently, the contributions made by Ratnatunge (1979) in cataloging the small tanks, and in promoting institutional development and community participation in the form of "wew sabha" (or reservoir councils) deserves special mentioning. These writings were however, only a few leading lights on this fascinating subject.

The thrust of my argument here is that, there is a sizeable body of knowledge on the nature and functioning of small tank systems that, rapidly grew particularly during the last two to three decades. In the long-term interest of the country, this wealth of knowledge and experience must be harnessed for any large-scale rehabilitation or development of small tank systems. Thus, Van der Molen (2001) has listed some 14 tank rehabilitation projects during the last two decades, and some 23 national and international NGOs involved in such activities. Small tanks taken in isolation certainly have their intrinsic social anthropological and other unique characteristics. However, their ecological, institutional, cascading and clustering characteristics are of utmost importance in water resources planning in general, and in any attempt towards their renovation or rehabilitation.

Nature and Distribution of Small Tank Systems

A total of nearly 18,000 small tanks, both operational and abandoned are found distributed across the dry and intermediate zones of Sri Lanka. Around 40% of them are located in the North Western Province, while 26% are in the North Central Province. Southern and Northern Provinces account approximately 10% respectively while the balance is in other provinces. *About half a million people live in these village tank settlements and represent some of the 'poorest of the poor' in Sri Lanka. They are remote from towns, and their health and educational conditions are poorer than other areas.*

In recent years a village irrigation rehabilitation programme renovated and rehabilitated around one thousand tanks. This was predominantly an exercise in tank de-silting and technical improvements to buds, sluices and spillways. At present, the government has launched a 'Thousand Tanks' programme that would eventually expanded to cover some ten thousand tanks or nearly 60% of the total number of tanks in the country.

Number of Operational and Abandoned Tanks

<u>Name of Province</u>	<u>Operational</u>	<u>Abandoned</u>	<u>Total</u>
Northern	608	816	1,424
North Central	2,095	1,922	4,017
North Western	4,200	2,273	6,473
Southern	653	757	1,410
Uva	16	543	559
Eastern	48	1,442	1,490
Total	7,260	7,753	15,373

Source : Panabokke, et.al. 2002

(Note: Inclusion of small tanks in other Provinces increase the total number of tanks to about 18,000; It had been estimated that a population of around 400,000 is dependent on presently operational tanks)

There is a wide variation in the size class and the geometry of these small tank systems. Those in the intermediate climatic zone are generally smaller than those in the dry zone proper.

It is not proper to assume that all these small tanks numbering nearly 18,000 were operational at the same time in history. At any given time in history it likely that less than two-third of them would have been functioning, depending on the needs of their time. It may also be mentioned that not all small tanks have been used for irrigated agriculture. Some of them have been there to support downstream tanks, or merely for the use of animals and ecological purposes. Therefore, any attempt towards renovating all abandoned tanks may not be a wise option. This is further complicated by more recent developments where a large number of major tanks have been renovated particularly during the first half of the last century. These major tanks are likely to affect adversely if unplanned attempts are made to renovate abandoned small tanks in their catchments.

A delicate combination of rainfed *chena* farming, lowland rice cultivation, homestead mixed garden farming, cattle grazing and herding, tank-fish harvesting and food gathering, led to a traditionally self-sufficient livelihood pattern under small tank irrigation systems. The situation has undergone much change over the last century, during which the main productions systems were linked to external supplies and market forces. In consequence, the earlier self-sufficient equilibrium no longer prevails and many imbalances are now visible.

Land tenure and water management practices have been changed. *Chena* lands were increasingly converted to rainfed settlements resulting in accelerated land degradation, soil erosion and tank siltation. The earlier equilibrium maintained between tank capacity, irrigated area and the forested catchment area had been seriously disturbed.

Traditional production systems have now to be responsive to the emerging challenges of open market forces. This makes it difficult to determine any realistic production thresholds. The changing climatic pattern has added more confusion and uncertainty

Small Tank Cascade Systems

The most interesting aspect of these small tank systems is that over 90% of them are clustered into cascades. The cascading systems that evolved through long periods of history indicate their adjustment to the landscape, soils, climatic and hydrological conditions of the dry zone. It had been shown that cascades also show some sociological gradation in village settlements located down their valleys.

The writer had the occasion (1985) to introduce the concept of 'cascading systems' to characterize the chains of small tanks found in the dry zone landscape. At that time, *I defined a cascade as a "connected series of tanks organized within the micro-catchments of the dry zone landscape, storing, conveying and utilizing water from an ephemeral rivulet"*. Further refinements to the above definition, were adopted by Panabokke and Shaktivadivel et.al. (1996), who preferred the use of the term 'meso catchment' in the place of 'micro-catchment' and also substituted the 'ephemeral rivulet' with 'first order or second order ephemeral stream'. Since my paper in 1985, it is with some academic satisfaction that, one may note the rapid growth of writings on cascades that followed, particularly by scholars such as Panabokke, Mendis, Tennakone (1986), Somasiri (1992), Itakura and Abernathy (1993), Dharmasena, Gangodawila, Dhanasekera and Aheeyar etc. Today the concept of cascade systems is increasingly used in rehabilitation planning (Shakthivadivel et.al, 1996 & 1997).

The local people who depended on village tanks referred to the chain of reservoirs as *wew panthi* or as *ellangawa* in some areas. The number of operational tanks in a cascade seems to have expanded or contracted depending on the changes in rural populations, their economic conditions and varying vicissitudes of history.

It had been argued that, cascading systems and their characteristic land use assemblages reflect a time-tested system of land and water management (Madduma Bandara, 1985). Each tank in a cascade had to be maintained optimally to ensure the health of the whole system. Thus in exceptionally heavy rainy seasons, if the bund of the topmost tank in the cascade got breached, the tank bunds downstream can collapse one after another like a set of dominoes due to the piling up of the progressively increasing volume of water downstream. This has happened at the time of 1957 floods in the North Central Region. During normal times, water from an upstream tank after irrigating its command area sends its drainage water to the downstream tank through the *wagala* or the *bashawa* reflecting a remarkable degree of recycling. It was contended that, this type of small tank cascade systems gave a better expression to the well-known dictum of King Prakramabahu, than some of the major systems. Cascading principle may also be applied to larger systems as in the case of the present Mahaweli Cascade of major reservoirs, with appropriate scale modifications.

Some Past Experiences

The need to exercise some care and caution in handling small irrigation tanks could be illustrated with a few examples from water resources development efforts in the recent past. The first was *the destruction caused to many small tank systems in the Rajarata area during the initial period of the Mahaweli Project*. The massive conversion and transformation of land for Mahaweli development in that area based on the land use planning concepts of that time required the breaching of bunds of small tanks and 'reclaiming' or bull dozing the land in the tank-beds and adjacent areas. The planning concept was based on the notion that small tanks evaporate and waste too much water and the traditional land use patterns associated with them were inefficient. Subsequently, however, the value of small tank systems were beginning to be felt with the build up of salinity in some areas and the enhanced flow of excessive water out of the system due to lack of storage, during heavy rains. Other traditional functions associated with village tanks such as those for human and animal uses, were also ceased along with their reclamation. The ecological impacts on aquatic life and tank-based avi-fauna had also been devastating. Some even perceived it as a 'bulls in a china-shop' exercise.

The second example is the *reported impact of small tank development in the catchment areas of major reservoirs without due regard to their inflow patterns. The case of Mahakanadarawa scheme in the Anuradhapura is one of the most well known.* The Moratuwa University study under the auspices of the ARTI had shown that over 100 small tanks were renovated and rehabilitated in the catchment area of the Mahakanadarawa reservoir resulting in reducing its inflows up to 40% of the total estimated volume. The spilling of the tank had subsequently become a rare phenomenon, and the farmers had to fall back on the traditional *bethma* system in a major irrigation setting in some years. The designed irrigable area under this scheme thus declined, leaving some farmers to resort to chena cultivation in land allotted to them. Mahakanadarawa, thus provides a clear example of haphazard development of small tank systems without fully comprehending their implications downstream.

There is now evidence to indicate that, the majority of small tanks in the dry and intermediate zones are heavily silted and lost over 60% of their capacity in some cases (Dharmasena, 1992). This was the inevitable result of heavy deforestation in their catchment areas, particularly during the latter half of the last century. Thus while the capacity of the small tanks to contain water gradually reduced, the irrigated area under the tank increased with additional lands being *asweddumized* as *akkarawel* or as illicit encroachments that were often regularized subsequently, around and below the *puranawela* fields. The net effect was spreading a diminishing amount of tank water thinly over a larger and ever expanding command area. The fragmented tenurial systems that developed originally as a risk minimizing strategy in time of drought, contributed in leaving out large areas without any cultivation (Water Resources Board Survey of Toruwe Tulana, 1967). Small tank farmers, without any scientific forecasting support, had to gamble with the arrival of *maha* rains and often proving it to their disadvantage.

An analysis of drought damage during the last century would indicate that, the damage caused by drought had been highest in the areas served by small tanks (Madduma Bandara, 1982). *This indicates that renovating and rehabilitating of small tank systems without addressing a host of surrounding issues, that ranged from cascade hydrology, to catchment conservation and downstream impacts to name a few, may even contribute to increase drought damage, defeating the very purpose of the whole exercise.* It must be emphasized that, this does not mean in any way that, small tanks need not be renovated or rehabilitated; Let it be done with a sound understanding of all their implications.

The Way Ahead

Considering the changing climatic conditions in the dry zone, a doubt arises as to whether small tank irrigation systems can indeed continue to survive in the future. There are signs of some desiccation in the dry zone, while the forest cover in the catchment areas had been diminishing rapidly. Economics of particularly rice cultivation, under small village tanks do not appear to be promising. *Crop diversification supported by some form of agro-wells may stabilize village settlements in which a trend of out-migration is noticeable.*

Economically viable land use systems with greater emphasis on animal husbandry built on traditional roots may prove to be a more promising path for the future. *There is potential for growing less water consuming and drought resistant crops both in the lowlands as well as in the highlands. With an understanding of the demographic changes that are taking place in which there are increasing trends of rural out-migration, land use adjustments in the future have to be more towards extensive types than intensive.* In some villages labour shortages are already affecting cultivation practices.

A de-siltation and technical improvement approach, alone may not answer the problem of recurrent droughts in the dry and intermediate zones. The past experience suggests that drought damage is highest in the areas served by small tank systems. Therefore, any unplanned tank renovation exercises may result in increased drought damage contrary to all good intentioned expectations. *If the tank catchments are not protected, de-silted tanks may become silted again within a few years requiring a repetition of the same exercise.*

Small tanks have to be managed as integrated systems and not as singular entities. The traditional forms of management such as *Rajakariya* cannot be recreated in its ancient form. The *Vel Vidane* system, the *Kelekorala* (who looked after the village forests in the tank catchments) and *Vew Lekama* (who looked after the tanks) cannot be easily re-commissioned in the modern context. Even the *Bethma* system still practiced some villages cannot be managed without strong leadership. Therefore *new and effective institutions have to take the role of managing small tanks, without which technical improvements alone will not prove sustainable.*

Long-term stability of small irrigation systems in the North West and the eastern part of the north central regions as well as in some other parts of the dry zone, may only be assured through the development of major irrigation. Such development however, should be designed to nurture and support minor systems than destroying them as attempted earlier in the Mahaweli Project area. *"Feeding the cascade systems" through major irrigation projects may prove to be a more enduring strategy for prevailing ground realities of the dry zone.*

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UNDERSTANDING RAINFALL AS FIRST PREREQUISITE TO TANK MANAGEMENT AND REHABILITATION

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Abstract

In the dry zone of Sri Lanka, rainfall is substantial (at the site studied, annual low of 700 mm and high of 1500 mm). Yet the tank village communities are in the grip of poverty, suffer water scarcity for farming in dry years and for community use in dry months of dry years.

This seeming paradox can be at least partly attributed to misunderstanding of the rainfall as too poorly distributed for direct use for farming and hence using it for irrigation after conversion into runoff. But this is possible only in times and years of high (intensity) rainfall. This misunderstanding of rainfall has been due to total reliance on the volume of rainfall to characterize rainfall, which between rains shows wide variation in intensity and hence in the effectiveness as a water resource. For this reason the total volume of rain computed by adding such rains is of little meaning. For example the effectiveness of the water from 10 rains of 10 mm per day is not of the same value for human use as water from 2 rains 50 mm each coming on two days. But the convention has been to add these non-additives without considering intensity, which makes them non-additive.

When intensity is looked at, it becomes clear that much of the total volume of rainfall in dry years is made up of relatively lower intensity, which generates little runoff and hence little water for irrigation. Advancing from dry years to wet years, the same volume of low intensity rain as in dry years is repeated. The wetness in these years is due to increasing volumes of high intensity rain, which generates runoff and makes irrigation tanks functional.

Therefore the present day system of watershed management lacks a response mechanism for the dry years. But the traditional Wewa system had measures such Wetiya, Wala, Wila suitably distributed above the Wewa to help manage the low intensity rainfall for rainfed farming (farming when it rains and where it rains devoid of loss of wet weather time, conveyance loss, storage loss etc). In times of high intensity rain too they supported rainfed farming and buffered the Wewa from flash flood shock.

Therefore access to rainfall intensity enlightens us better. It enables the resolution of the paradox of poverty amidst plenty (of water). Most importantly it justifies and even legitimizes the tank villagers engaging in rainfed farming, which the Government has failed to control by law.

Thus it is becoming increasingly clear that Wewa needs rehabilitation in its true form, not only as a tank for irrigation.

Introduction

The manmade water body called tank in English is the *Wewa* of the local communities. Its significance is as the nucleus of the eco-strategy adopted by their ancestors to help them overcome the twin problems of floods and droughts that are so characteristic of the dry zone climate. This eco-strategy appears to have been a smart response to the distribution pattern and the composition of local rainfall for controlling and regulating runoff flow and conserving the held up water for drought mitigation, and is valid even today. The origin or the specific meaning of the word *Wewa* is not clear, but its, Tamil equivalent *Kulam*, which is derived from the word *Kuli* (bathe) may mean what bathes/soothes (the land). So *Wewa* could be a *Kulam* that enables and sustains growth (*Wewima*, *Vardhanaya* in Sinhala), by moderating floods and droughts and thereby satisfying the most important requirement – water security for human settlement in a dry landscape. This has made *Wewa* a monument symbolic of material well being of the dry zone civilization. The other significant monument being the *Dagoba*, which symbolizes spiritual well being.

Wewa began to be called by the term tank around 1890 when the then colonial government started to use it as mere water storage for paddy irrigation. Along with this transformation of *Wewa* to tank, rainfed farming

was discouraged on the uplands above the tank, which area was reserved as tank "catchment" to catch rainwater for exclusive delivery to the tank below, denying the upland users their share of water for farming. There is no local data to assess the impact of this denial but its seriousness can be guessed from the fact that in India about 70% of even the present day food production comes from outside the irrigation sector. The water stored in the tank has been so rigidly reserved for paddy irrigation that the tank operation and maintenance policy has opposed deepening of the tanks because such deepening below the sill level would only increase the "dead storage" which is of no avail to gravity irrigation, though it represents the water on which the dry zone communities live through the rainless months.

While sheer ignorance of the significance of the traditional *Wewa* and the associated eco-strategy may have caused this transformation of *Wewa* to tank, there is reason to suspect that it has been done as a masqueraded political agenda of the then colonial government. Hidden agendas have been the pressures to stop shifting cultivation as a farming practice, and to promote paddy irrigation not only to produce rice but also to settle peasantry on Government settlements (with irrigation) as political necessity and strategy. The following observations justify such suspicion. After the 1818 Uva rebellion, the government is reported to have stated the need to destabilize the rural self-sufficient economy in order to gain full control over the people. A tank committee declaration in 1936 compared traditional *Wew* (tanks) with village cattle possibly implying that they were too many to manage. In 1940's *Wew* (tanks) were called mere evaporating pans. Thus the *Wewa* may have been not only misunderstood but also derided.

Even after independence, gained in 1948, the same anti *Wewa* and pro tank policy has continued, though with less derision. Paddy farming and rainfed farming have continued to be de-linked and treated with bias and prejudice respectively. Thus the organic and dynamic *Wewa* of the traditional eco-strategy became a tank for one way traffic of water caught from the "catchment", through the tank to the paddy fields which constituted less than 15% of the total watershed, virtually denying the upland farmers access to rain and alienating them from the tank. To this day the tank village communities remain trapped in poverty despite tank rehabilitation over the past three decades under many projects: national programmes such as VIRP, MIRP, NIRP, and provincial and district wise ones, some tanks many times over under different projects.

When the rainfall drops below the average, most rehabilitated tanks turn dry, as is the case right now. Crop production under them has little improved over and above what is due to seed and fertilizer technology. Consequently the overall national food production remains so low that for every 2kg of locally grown rice one kg of wheat/rice has to be imported. Rural poverty and unemployment have not eased forcing the rural youth to turn to garment factories and the Middle East for employment. Drought is becoming a recurring headache. All these problems despite the relatively good rainfall the country is blessed with. This casts doubts whether tank rehabilitation has ever benefited from a good understanding of the rainfall as the primary source of water for human use.

Problem Diagnosis

Observed tank performance shows that it is highly dependent on rainfall: good in years with near average rainfall and poor in dry years with far below average rainfall. In those years of very high rainfall the surplus water, which the tanks cannot cope with, ends up in flood and causes damage to life and property and results in waste of water. Thus the range of the level of tank village performance varies widely. In worst years there is almost no water for community use and no crop to produce food. In best years water is abundant and food is in plenty. This is far too wide a range to be explained with annual total rainfall, which shows a relatively narrow 1:2.6 range of distribution between the lowest and the highest values (Figure 1 and Table 1). The data are for Angunakolapelessa rain gauging station.

Table 1. Intensity-wise composition of rainfall arranged according to increasing annual rainfall for Angunakolapelessa							
Year	Total rain mm	rain mm >25mm/d (H.I. Rain)	rain mm <25mm/d (basic rain)	rain mm 25-10 mm/d	rain mm <10 mm/d	d/y with rain >25mm/d	H.I. Rain/basic rain
86/87	653.3	176.391	476.909	241.721	235.188	4	37%
89/90	708.3	233.739	474.561	269.154	205.407	7	49%
91/92	783.9	290.043	493.857	282.204	211.653	9	61%
2001/02	788.3	275.905	512.395	291.671	220.724	7	58%
75/76	816	318.24	497.76	252.96	244.8	7	67%
71/72	821.75	205.4375	616.3125	427.31	189.0025	6	43%
00/01	854.8	401.756	453.044	179.508	273.536	8	85%
95/96	891.5	401.175	490.325	240.705	249.62	9	85%
84/85	909.2	245.484	663.716	354.588	309.128	7	52%
96/97	947.7	416.988	530.712	274.833	255.879	10	88%
82/83	956.5	373.035	583.465	382.6	200.865	9	79%
80/81	964.95	443.877	521.073	289.485	231.588	11	94%
78/79	1024.49	502.0001	522.4899	266.3674	256.1225	11	106%
79/80	1112.18	478.2374	633.9426	378.1412	255.8014	12	101%
77/78	1149.16	609.0548	540.1052	298.7816	241.3236	13	128%
76/77	1151.75	541.3225	610.4275	334.0075	276.42	12	114%
85/86	1202.3	541.035	661.265	432.828	228.437	13	114%
87/88	1203.3	661.815	541.485	336.924	204.561	14	139%
98/99	1208.9	423.115	785.785	507.738	278.047	11	89%
90/91	1264.55	518.4655	746.0845	455.238	290.8465	9	109%
72/73	1268.75	697.8125	570.9375	329.875	241.0625	19	147%
99/00	1281.5	474.155	807.345	551.045	256.3	11	100%
92/93	1307.1	862.686	444.414	274.491	169.923	16	182%
81/82	1313.8	788.28	525.52	249.622	275.898	15	166%
83/84	1318.3	593.235	725.065	395.49	329.575	14	125%
93/94	1320.1	660.05	660.05	382.829	277.221	14	139%
73/74	1333.25	559.965	773.285	479.97	293.315	14	118%
94/95	1337.6	601.92	735.68	387.904	347.776	16	127%
74/75	1519.25	759.625	759.625	319.0425	440.5825	18	160%
97/98	1708.6	1178.934	529.666	290.462	239.204	21	248%

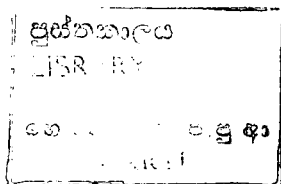


Figure No. 1: Range of distribution of rainfall intensity classes according to increasing annual total rain for Angunakolapelessa

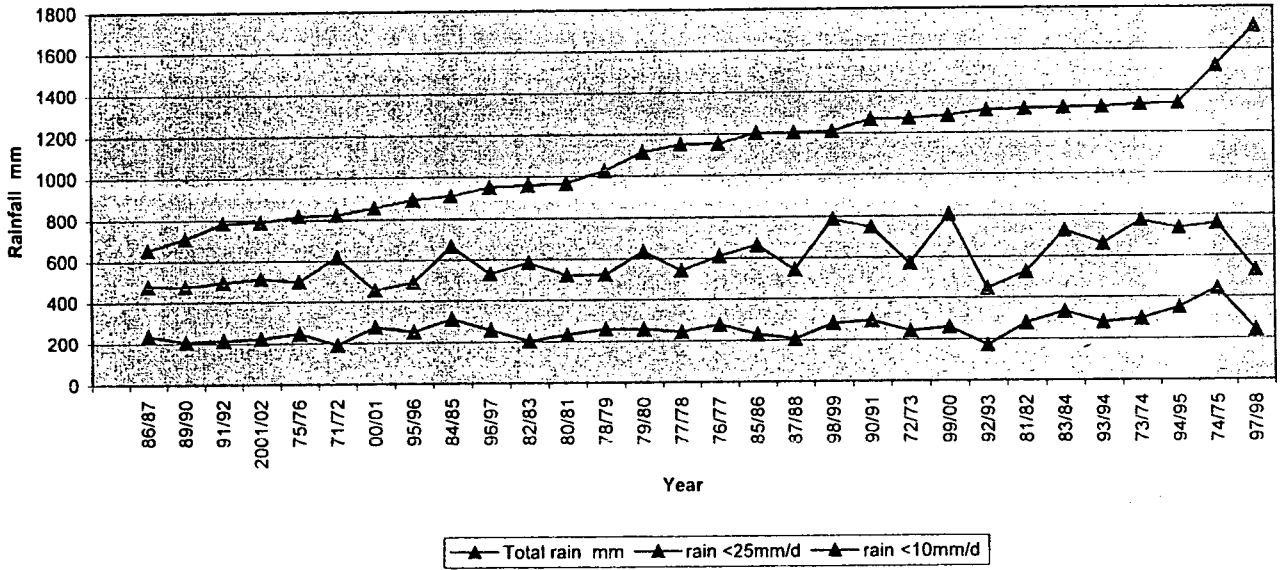
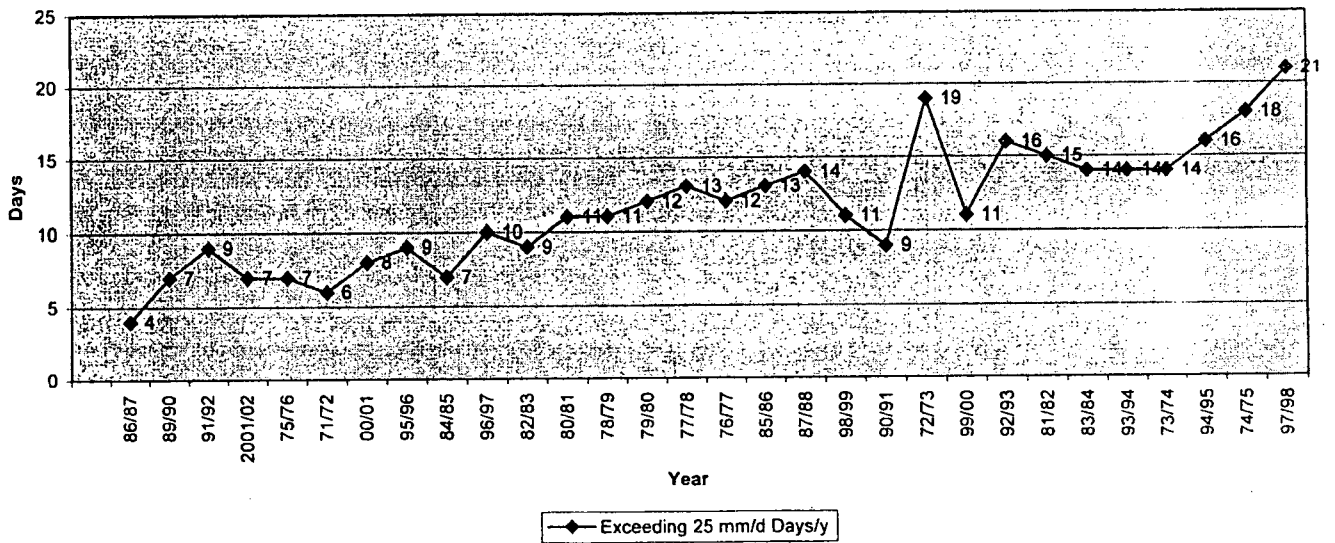


Figure No. 2: Range of number of days with rain exceeding 25 mm/day for Angunakolapelessa with increasing annual total rain



Despite total (volume of) rainfall bearing little relationship with production it is the parameter that has been conventionally used to understand the rainfall as a resource. It has been computed by adding the daily volumes of rainfalls recorded by the rain gauge reader. Not much "data improvement or value addition" has been done to it to develop a rainfall parameter that is more reflective of (rain water based) production.

In statistics the total of a set of data items has meaning only if the items added up are comparable. The daily rainfall values differ widely in intensity from less than 3mm/d to more than 100 mm/day. How does intensity alter the meaning of the volume of rainfall? While it is true that in a rain measuring station there are no trees above the rain gauge and the water is collected in a sealed container, in the field some rain never reaches the ground because of canopy interception, and not all the rain that falls on the ground goes into the soil beneath or to the tank below. It flows in many directions, and the proportion that goes into the soil or tank varies with the intensity, that too not consistently.

Farmers in the field know that the impact from 10 rains of 10mm per day intensity is not the same as that from a single rain of 100 mm per day, though the two total volumes are the same. They would welcome the former and curse the latter for obvious reasons. In a utility context the above rainfall data cannot be compared with two consignments of bricks (from the same stock), each 100 in number, one of them delivered in lots of 10 each on 10 different days, and the other delivered in one go, which despite the difference in the mode of delivery have the same effectiveness as material for building a 100 brick wall. Therefore volume data on rainfall needs value addition by referring to its intensity to make it more useful as rainfall information.

Unfortunately today's land use planning in the dry zone, if any, rests on this poor parameter of total volume of rainfall. Therefore the use of this inappropriate or incomplete data to assess rainfall can be a major technical reason for poor performance of tank village agriculture. And this deserves analysis and resolution.

Problem Analysis

Daily rainfall (volume) data for recent 30year period for Angunakolapelessa was disaggregated according to daily rainfall intensity into three intensity classes. Figure 1 shows that total rainfall in any given year consists of two broad intensity categories. Rain falling at intensities below 25mm/d appears constant for all years with little variation between years. Rain falling at intensities exceeding 25 mm per day increases sharply from dry years to wet years at a rate faster than the total rainfall.

As discussed under problem diagnosis the sharp rise in community water sufficiency and economic production in tank villages from dry years to wet years is too high to be explained from total rainfall the range of which from low to high for the 30 year period is only 1:2.6. It appears to be more in keeping with the wider range of 1:6.6 within which the volume of high intensity rain varies (in the same direction). Therefore tank village performance under present day management depends more on the volume of high intensity rain than on the volume of total rain at a ratio of 6.6: 2.6.

To illustrate it further, it can be said that while the total rainfall in the lowest rainfall year (653mm) is only 2.6 times as bad (water scarce) as in the best rainfall year (1708 mm), between the same two extreme years the availability of high intensity rain is 6.6 times as bad (176 mm vs 1178 mm). In other words access to rainfall intensity data enables a better understanding of how rainfall could affect the performance of tank villages under a given management.

For this reason it becomes clear that (under the present system of management) the rainfall of lower intensity than 25 mm per day contributes little to tank village performance. It is interesting to note that the volume of rain that falls at intensities less than 25 mm per day is somewhat constant around 500 mm per year (range 444 mm to 807 mm) showing little or no change with total rainfall or high intensity rainfall. Hence it can be called the basic rain, which is there in all years. In dry years even the availability of some high intensity rain, about 200 mm falling in about 7 days is of little avail. This negative result in dry years, which is generally brushed aside as inevitable owing to low rainfall may well be due to the current system being unable to utilize an annual total rainfall of about 700 mm despite the inclusion within it about 200 mm of high intensity rain falling in about 7 days. In the data list such years (September - August) are 1986/87, 1989/90, 1991/92, 2001/02, 1975/76, 1971/72, 2000/01 (Table 1).

This makes us assume that the present system of dry zone small watershed management is mainly focusing on years with high intensity rain falling on more than about 10 days, out of a range of 4 to 21 such days (Figure 2), when generation of substantial runoff, which is the key hydrological process that has been relied upon for modern day tank village management is more likely.

In the very high rainfall years the high intensity rainfall far exceeds basic rainfall, contributing to the water security and hence to crop cultivation, both as direct rainfall and via runoff generated. In such years: 1981/82, 1983/84, 1993/94, 1973/74, 1994/95, 1974/75, 1997/98 (Table 1) the tank becomes effective in two ways, (1) provision of flood protection to the land below the tank (by containing floodwaters within its bounds) and (2) holding surplus water as a reserve for drought mitigation. In these high rainfall years the experience in the field is that the tank village settlers can farm with rainfall alone, with little need for tank water for irrigation, but their dependence on the tank for flood control is substantial.

The above analysis enable us understand that:

- Volumes of rainfall from rainfalls of different intensities are not additive and hence total volume from rainfalls that differ in intensity is not a good parameter to understand rainfall.
- Total volume of rainfall needs data improvement or value addition by paying attention to intensity of individual rains for understanding the effectiveness of rainfall as a resource.
- Production being negative or near zero in dry years the currently applied system of tank village development and management has no strategies to make use of dry year rainfall which is made up of mainly low intensity rainfalls.
- Production in the wet years is largely based on runoff generating high intensity rains.

Let us see how we can put the above findings into use in the field in order to help solve the problem.

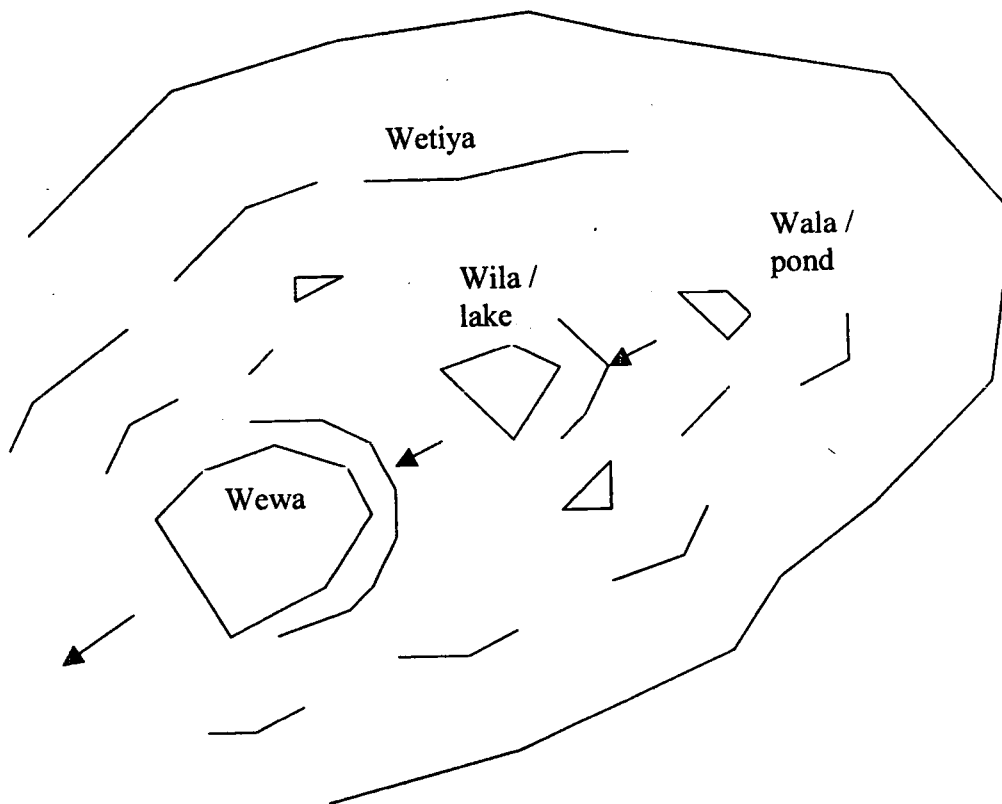
Solving the Problem

Figures 1 and 2 and Table 1 show that years of low, moderate and high rainfall do not come as separate sets, but are mixed up. It is seldom that three consecutive years are continuously dry or wet. There has been two dry years in succession eg 2000/2001 and 2001/2002, and the adjacent years 1999/2000 and 2002/2003 (not given in the data) have been wet. What this implies is that rain sourced water management in tank villages has to be formulated on a long term, on a three to four year running basis, instead of the currently applied annual approach of transferring the Maha season surplus to meet the deficit in the Yala season of the same hydrological year. For such a long term strategy to be effective, it has to have answers for managing water over at least four different time periods: at or during individual rains, during (rainy) seasons, during the year made of the two seasons - Maha and Yala, and over consecutive years, the success or failure at early stage progressively and cumulatively contributing to that in the later stages. Therefore how well individual rains are managed is crucial and for good management of individual rains the management measures applied must address their intensity aspects which tells us what measures are necessary to respond to them and make the water more effective.

As the intensity of an expected rain cannot be accurately known in advance, and even if known appropriate management measures cannot be fixed in a hurry, it is necessary for such measures, rather a broad spectrum of them (to respond to a wide range of intensities) to be on the ground ready and functional, in appropriate places within the watershed at all times, so that what ever the intensity of the rain that falls there is a measure ready to respond to take care of it.

Tradition offers lessons on what measures to apply. If we take a walk through a dry zone landscape that has not been tampered by modern development and see the relicts of the variety and multiplicity of the devices that have been constructed by the ancient people to detain runoff, enhance infiltration and regulate surplus runoff flow and thus directly respond to rain as a process and to manage the water it brings. They include contour earth bunds (*Wetiya*), isolated pits dug behind them to form ponds (*Pokuna*), small lakes (*Wila*) that have formed at the points where the contour earth bunds cross small drainage lines and tank (*Wewa*) which is basically such a lake sited on a larger stream and has a larger capacity and a larger bund (Figure 3).

Figure No. 3: Traditional rainwater conservation measures in small watershed



The four measures in that order have tackled rain of increasing intensities. The *Wetiya*, *Wala* and *Wila* were mostly in the present day "catchment" responding to rain and making rainfed farming possible there in dry years, and cushioning the *Wewa* from the shock of flash flooding in the wet years. The *Wewa* has been most likely for runoff regulation and safe disposal when runoff reached flood proportions in wet years and conserving water for use in the dry years. In the wet years, flood protection enabled paddy farming in the lowlands, while rainfed farming was possible in the uplands. From the above reasoning it becomes clear that the watershed management package to be effective has to have answers not only for wet years but also for dry years, which can be accomplished by promoting both rainfed farming and irrigated paddy farming, with provision to change their relative proportions, depending on the rainfall.

The above comprehensive system of responding to rain and managing rainwater becomes possible only if the people value water for community use more than gravity irrigation of paddy. For this to be possible we have to appreciate that upland rice (El Wi), *Kurakkan*, *Meneri*, yams etc. are also wholesome staples. In India even today where vast strides in food production have been made in recent years, gravity irrigated cropland constitutes only about 30% of the total cropland. Such enlightenment on food ethics and values will also ease the pressure for sacrificing the environment for production of more environment unfriendly food under monoculture.

Maintenance of a network of measures (*Wetiya*, *Wala*, *Wila*, *Wewa*) on the ground spread through the watershed and functional and ready at all times to withstand the pressures of up to 21 days of high intensity rain is a challenge that requires frequent, detailed and consistent management attention, which is only possible from close at hand, and with immense stakeholder commitment. Therefore as in the past (prior to vesting the tanks in the GAs) the need for a community level institution with authority and responsibility to make almost daily observations, take decisions and to implement them is obvious.

Conclusion

In the final analysis it appears that the shortcomings of the prevailing system of land use in the tank villages result from incomplete understanding of the rainfall as a poorly distributed and unreliable resource, which has led to the false conclusion that the only way to use it is to resort to runoff farming (transform rain to runoff, accumulate it in tanks and use it for irrigation). In the local context runoff farming is not an efficient system for many reasons: direct rain is not used, only a fraction of the substantial rain can be converted to runoff, from low intensity rains there is little runoff, and lot of land has to be spared for mere run off generation. This is why the tank villagers are poor, destitute and often vulnerable to drought hazards. To emerge out of this sad situation, rainfall has to be better understood than now, and better responded to and used for farming as enabled by such understanding. It requires total watershed management with the application of a variety of management measures to respond to rain and utilize all forms of rain derived water for all potential forms of farming, including the use of direct rain for farming when it rains and where it rains.

SMALL TANK SETTLEMENTS IN SRI LANKA

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Water Resources Board

Abstract

The small village tank marks the beginning of organized human settlement in this country. By the second century BC the North Central region had, for very cogent reasons, become the more favoured area for the evolution and spread of the small tank settlements. By the 5th to 6th century AD, a full development of both small and big tanks had taken place across several selected areas of the dry zone landscape.

It should, however, be recognized that in these small tank settlements the more reliable and stable food supply had come from the 'chena' or 'hena' which always received priority over wetland rice in the cultivation cycle of each maha season. Even up to the mid-seventies the main cash income of the settlers came from the chena component; this was clearly revealed in the well-known Valagambahuwa small tank cropping systems study conducted by the DOA in 1975-77. The often quoted symbol of 'wewa and dagaba' should therefore rightly be altered to read as 'wewa, hena and dagaba'; although there is now little or no 'hena' left because of population increases within the village settlements and other encroachments that have taken place.

In a recently conducted study across 70 river basins situated across four provinces of the dry zone it was observed that there was at present a total of around 7000 functioning small tanks as compared with around 5000 abandoned small tanks. Among the main reasons for the prevalence of so many abandoned small tanks as proposed by several workers, are the lack of sufficient catchment area, poor quality soils and remote locations far away from other settlements.

It is also now clearly recognized, from several studies carried out in recent times, that these small tanks themselves are not randomly located, but rather occur in the form of distinct cascades situated within well defined meso-catchment basins of varying size, with a modal value of 8 sq. miles in the Anuradhapura district.

In a clinical study that was made of five representative cascade settlements located within four of the principal agro-ecological sub-regions of the dry zone it was possible to identify some of the principal constraints facing the small tank settlements today; chief among these were (a) the population pressure – a ten fold increase in population over a 100 year period (b) fragmentation of land holdings and (c) hydrological instability – both changing rainfall patterns and catchment degradation, and (d) diminishing chena land. Measures for the partial relaxation of some of the foregoing constraints had also been proposed in the above study. The needs for creating off-farm employment and income generating activities have also been highlighted.

The main national issue facing us today, however, is that of making a choice between allocating the limited financial resources available to the Government towards the rehabilitation of some of these 5000 abandoned tanks versus improving the present quality of life of the settlers presently living within the 7000 functioning small tank settlements.

Introduction

A renewed interest in Small Tank Settlements has been observed in South Asia over the last 18 – 20 years. According to DHAN foundation's recent publication titled "Village Tanks of South Asia" (2002), there is a total of around 140,000 village tanks of varying type and size distributed across the three states of Andhra Pradesh (65,000) Tamil Nadu (39,000) and Karnataka (36,000). Some special attributes of village tanks according to the DHAN foundation are as follows:

1. Now considered one of the oldest man-made ecosystems.
2. As an engineering system it is historically one of the oldest in engineering design.
3. As a social system it benefits all sections of the village community, specially women.

4. They are also considered as being eco-friendly; they ensure groundwater recharge in the more arid environments; they are considered both as flood moderators and drought mitigators, and they are more easily managed.

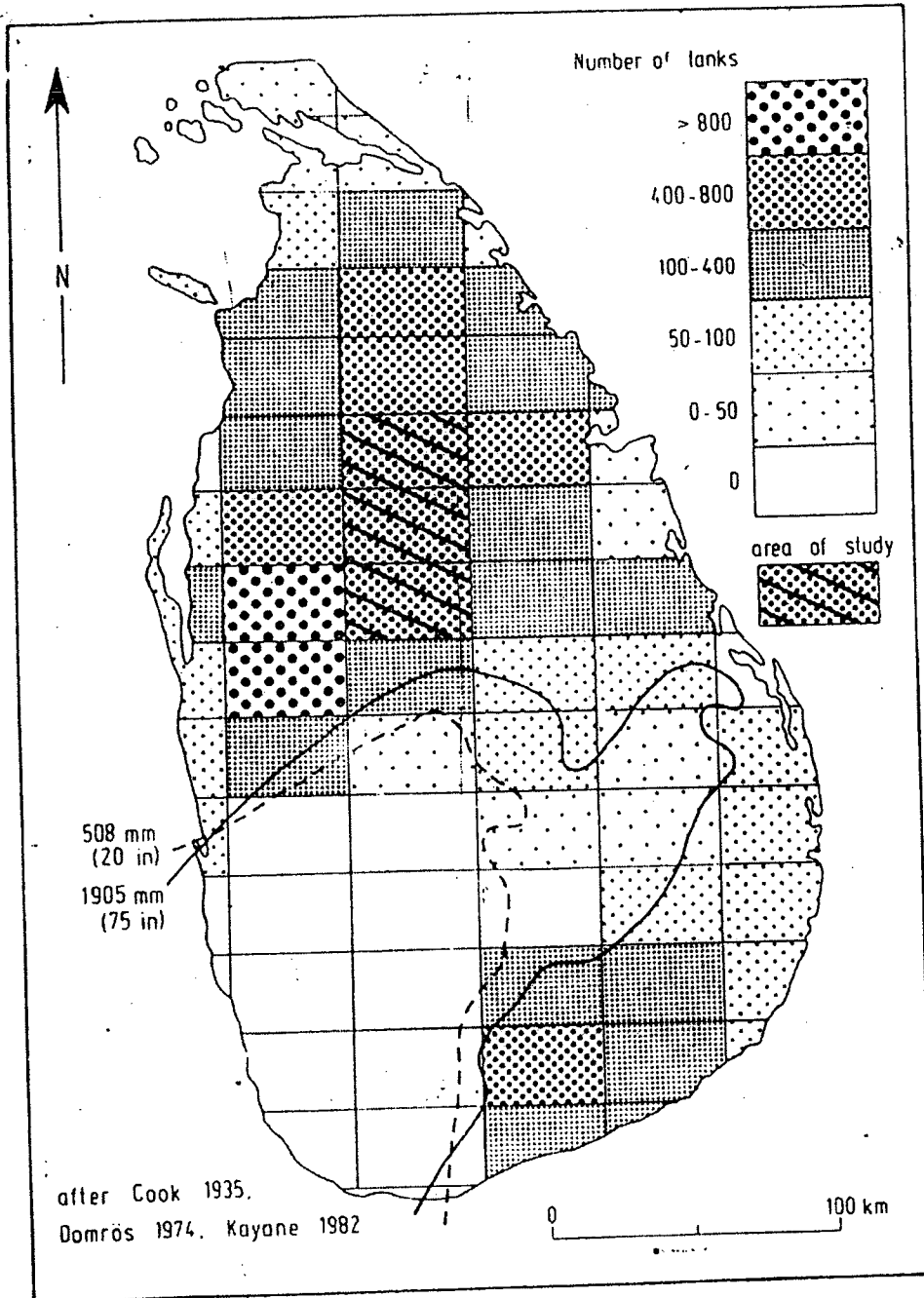
In Sri Lanka, both functioning and abandoned tanks amount to around 18,000 (Ratnatunaga, 1979). These small tank systems, which were mostly constructed during the Early and Middle Historic periods, were the centres of human settlement.

National Setting Within Sri Lanka

The earliest map showing tank distribution across the whole country was that compiled by John Keane in his Report on Irrigation in Ceylon, in Seasonal Paper No. XIV of 1905. This map shows the existing, restored and un-restored small and big tanks in relation to the Restoration of Irrigation Works 1855-1904. Even by present day standards, this map produced 100 years ago depicts the tank distribution pattern of the country in a very reliable manner.

The next rational depiction of tanks in the country was by Elsie Cook, Reader in Geography in the then University College in 1935. As shown in Figure 1, it shows the number of tanks of all sizes occurring within each of the 1 inch to 1 mile topographic sheets covering the whole country. As could be seen in Figure 1, the highest tank density is found in the Wariyapola and Galgamuwa topo sheets, followed by the Medawachchiya and Anuradhapura topo sheets.

Figure 1: Tank Density in Sri Lanka



The most comprehensive and accurate depiction of tank distribution in this country in recent times was that by Ratnatunga (1979) in his three-volume publication of *Wewas and Reservoirs in Sri Lanka*. In these three volumes, which cover the North, North Central, North Western and Southern regions, the tanks appearing in the one-inch topographical sheets of the Survey Department have been numbered serially within each river basin. According to figures given in this three-volume document, the total number of

tanks (big and small) and which include both functioning and abandoned tanks is 18,387; and this could be taken as the most reliable and acceptable figure for this country.

In a more recent study by Panabokke et al (2002) a count was made of presently functioning and abandoned small tanks in each of 70 river basins covering the North Central (NCP), North Western (NWP), Southern (SP) and Northern (NP) provinces. Both small and big tank distribution is shown in Figure 2. It should also be noted that the NWP represents a sub-humid agro-climate in the IL3 agro-ecological region; while the NCP represents a semi-humid agro-climate in the DL1 agro-ecological region, and the SP represents a semi-arid agro-climate in the DL5 agro-ecological region.

The number of functioning and abandoned tanks in respect of each of these province study areas is shown in Table 1.

Table 1: Number of Functioning and Abandoned Small Tanks within each province.

Province	Functioning	Abandoned	Percentage Abandoned
NP	605	876	57
NCP	2000	1900	48
NWP	3800	1800	35
SP	655	750	54
	7000	5266	

A more detailed depiction of small tank systems on a cascade basis is given in the 'The Small Tank Cascade Systems of the Rajarata (Panabokke 1999). It depicts the boundaries of the 457 small tank cascade systems that cover nine river basins of the NCP, which constitute the ancient Rajarata.

In general, it could be observed that the average tank density is one tank per 2.6 km² for the NCP, and one tank per 1.2 Km² for the NWP.

The size class distribution of small tanks for four districts, which is based on the command area for each size class, is shown in Figure 3. This figure shows that the dominant size class of tanks within the Anuradhapura district falls within the 10 – 20 ha size command area, while the dominant size class for the Kurunegala district is less than 6 ha size command area.

In order to get a clearer picture of the locations and distribution patterns of both functioning and abandoned tanks across the landscapes, a set of maps was prepared which cover the nine river basins that make up the whole of the Rajarata. This includes the whole of the Anuradhapura district and extends up to eastern and western shores. A set of three figures, which shows (a) Tanks working and rivers (b) tanks working and (c) abandoned tanks is shown in Figures 5 to 8.

Figure 2: Distribution of Small and Big-tanks in Semi-humid, Sub-humid and Semi Arid Agri-climatic

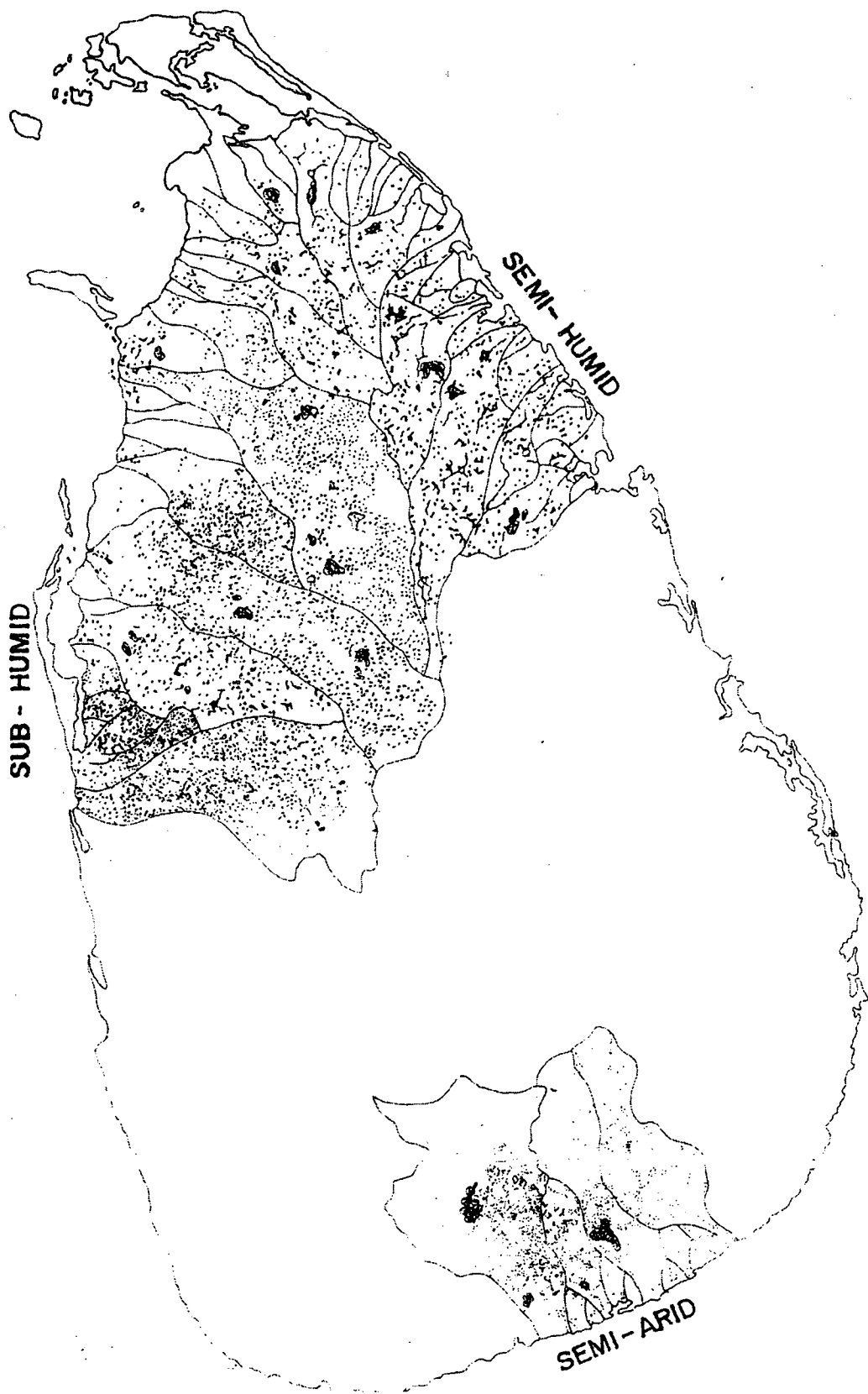
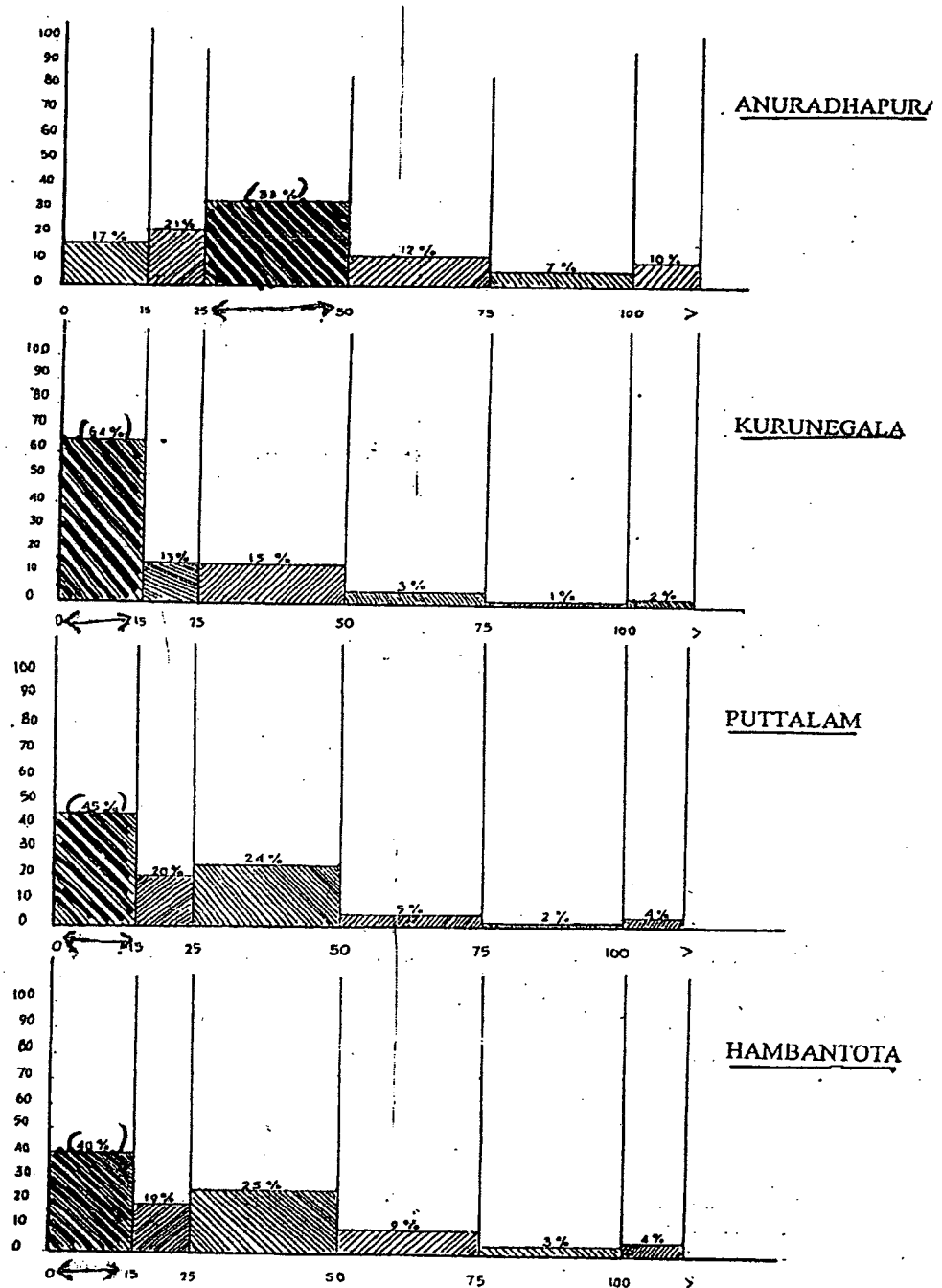


Figure 3: Size Class Distribution of Tanks (in 4 districts)



As could be observed from the foregoing figures, the highest numbers as well as the highest density of small tanks are found to occur within the Malwathu Oya basin. It is also now known that the small tank cascade systems that are located in the upper aspects of the Malwathu Oya and its sub-watersheds of Kadahathu Oya and Kandara Oya, have been in continuous and unbroken use since the Middle Historic Period. Hence the long-term stability of these small tank cascades located within these upper watershed regions.

As could also be seen in figure 6, the highest proportion of small tanks is situated within the central core areas of this province. At the same time, it could also be observed that the highest number and density of

abandoned tanks occur around the mid aspects of the Moderagam Aru which is in the western segment of the province, and also in the mid aspects of the Yan Oya which is in the eastern segment of the province.

Reasons for the occurrence of abandoned tanks in this manner have been discussed by Panabokke in a presentation made at IFS-SLAAS lecture series (1998).

It is now clearly recognized that the large number of small tanks that are distributed across the undulating landscape of the dry zone are not randomly located and distributed as commonly perceived; rather they are found to occur in the form of distinct cascades that are positioned within well defined small watersheds or meso-catchment basins. A cascade of tanks is made up of 4 to 10 individual small tanks, with each tank having its own meso-catchment, but where all of the tanks are situated within a single meso-catchment basin. These meso-catchment basins could vary in extent from 6 to 10 sq. miles, with a modal value of 8 sq. miles in the North Central region. A more detailed description and the merits of considering tank cascade systems over individual tanks have been described and discussed by Panabokke 2002.

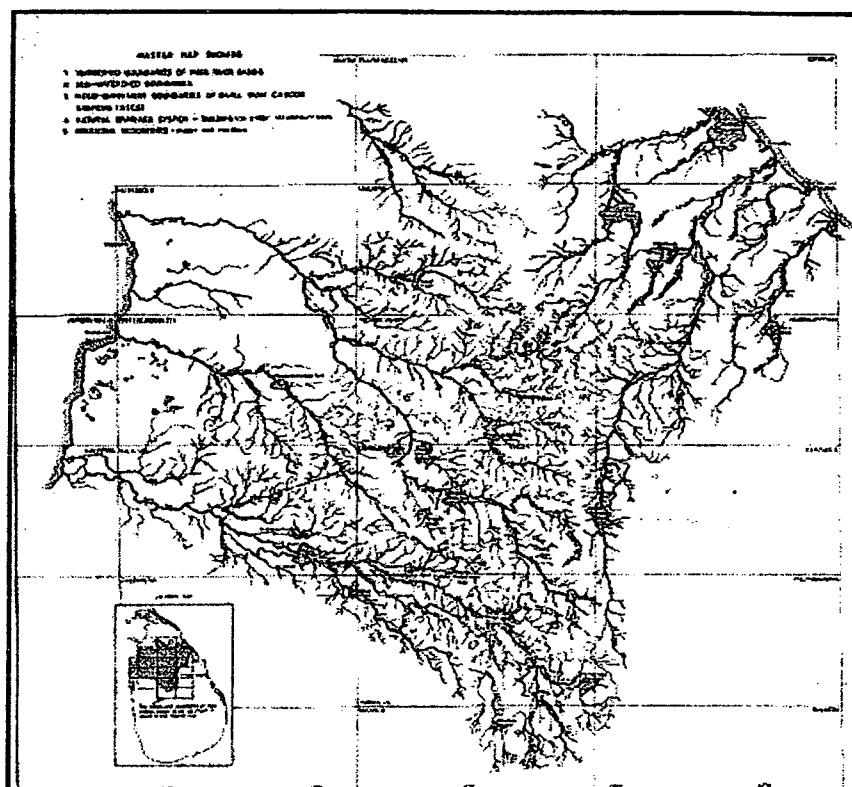
Past and Recent History of Small Tank Settlements

The small village tank marks the beginning of organized human settlement in this country, According to that reputed period authority Nicholas (1959), "the village tank was a well established feature of the dry zone by the first century B.C. By the beginning of the second century B.C. if not earlier, the entire dry zone was populated, more thickly in the North Central Region, and the construction of tanks and other irrigation works had begun". As discussed elsewhere by Panabokke (2003), because of the very high density of small linear inland valleys that occur in their natural state in this North Central region as shown in Figure 4, it became the more favoured area of for the evolution of the small tanks from the man-made rudimentary ponds.

By the second century B.C., stable human settlements had become well established around these early prototypes of the small village tank. The size or storage volume of these small village tanks at their early stages were just about sufficient to meet the domestic needs of the family settlers around these small tanks. It should be very clearly recognized that at this stage the main source of food supply came from the 'Swidden' or rainfed *chena* cultivation.

Once the early settlements had advanced to a stage that the settlers were able to construct village tanks with a larger storage capacity, the cultivation of rice became possible. In order to get beyond the stage of pure subsistence agriculture to a more advanced stage of 'Subsistence affluence'. Irrigation became a necessity. The origins of irrigation in its elemental form in this country had taken place at this stage and the cultivation of wetland rice in this country was a purely indigenous development and not one introduced by early Aryan settlers as considered by some historians.

Figure 4: The Hydrography of the Rajarata



The more extensive cultivation of wetland rice had to await the advance from the village tank to the major tank. This advance took place around the first century AD with Vasabha being the first of these tank-building kings. At the same time, village tank construction proceeded apace as the population increased and spread to other regions in the dry zone. From all available accounts it is clear that the spread of these small village tanks would have taken place concurrently with the construction of the well-known major irrigation works especially those of king Mahasen during the later second and early third century A.D.

By the 5th to 6th Century AD, a full development of both small and big tanks had taken place, and according to Nicholas (1959), the 8th and 9th centuries were a period of affluence for the Sinhalese people. This was followed by the *Chola* intrusions from the 12th century onwards, and a period of decline took place between the 12th and 19th centuries. While the management institutions for the large irrigation systems collapsed during this period, the institutions supporting the village tank systems were able to survive in some measure. Wanigaratne (1999) has very clearly argued the case for the survival of the management institutions of the small village tank up to the colonial intervention in the nineteenth century.

The disastrous effect of the abolition of 'Rajakariya' by the British administration in 1825 was a major cause for the degradation of village irrigation works from 1832 – 1887. Various attempts made for the revival of the provincial irrigation works have been adequately discussed by Madduma Bandara and Gunaratne (1990).

Problems of Presently Functioning Small Tank Settlements

A clinical study of five representative modal small tank cascade systems in the dominant agro-ecological sub-regions of the dry zone which covered the Anuradhapura, Kurunegala and Hambantota districts was reported by Panabokke, Sakthivadivel, and Weerasinghe (2002). In this study it was possible to identify some of the more important present and future issues facing small tank settlements in this country. These

from the tank village homestead. The well known cropping systems study conducted by the Department of Agriculture from 1975 at Walagambahuwa small tank very clearly showed that the main cash income of the settlers came from the *chena* land which was then adequate in extent for each family. These conditions do not obtain any more in the village tank settlements of the present day. However, recent studies show that in this same tank settlement, farmer settlers been able to find several sources of ex-farm and non-farm income avenues.

There are, however, increasing indications today that the tank based settlements are now becoming acceptable habitats for people on account of the clean environment and improved infrastructure facilities provided by the state. They also constitute an important part of the rural landscape together with its ecosystem, and there is therefore a rationale for ensuring the sustainability of these settlements for social and environmental reasons.

Figure 5: Tank Working and Rivers

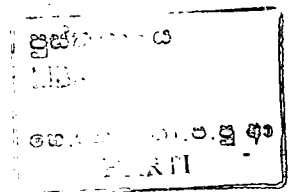
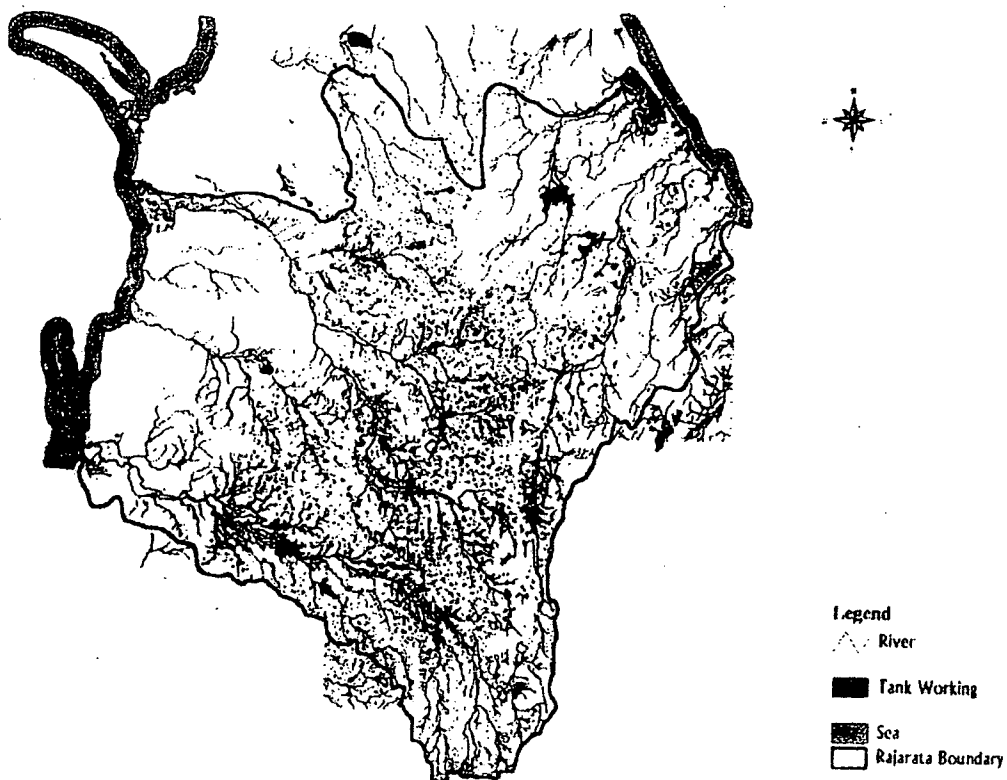


Figure 6: Tank Working

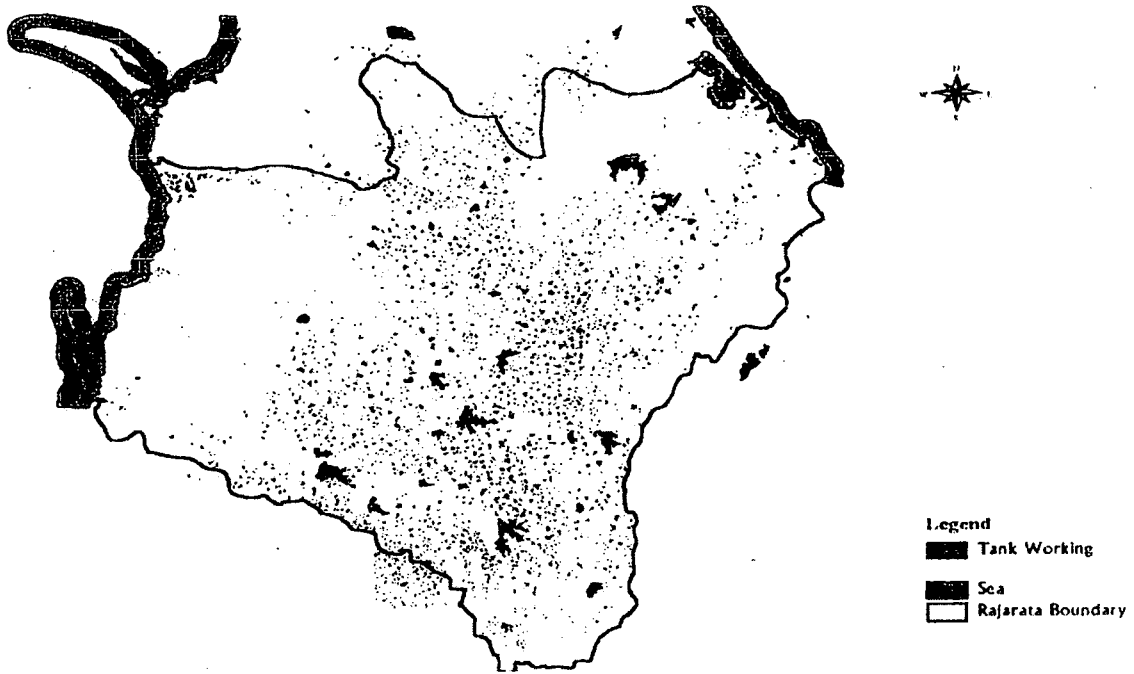


Figure 7: Abandoned Tanks

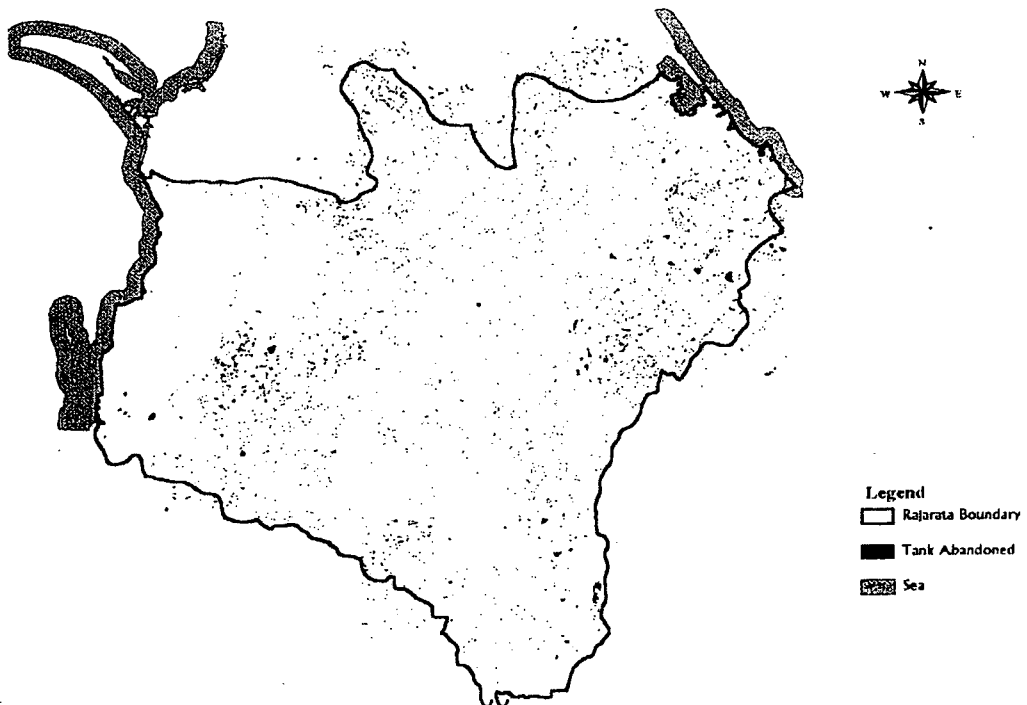
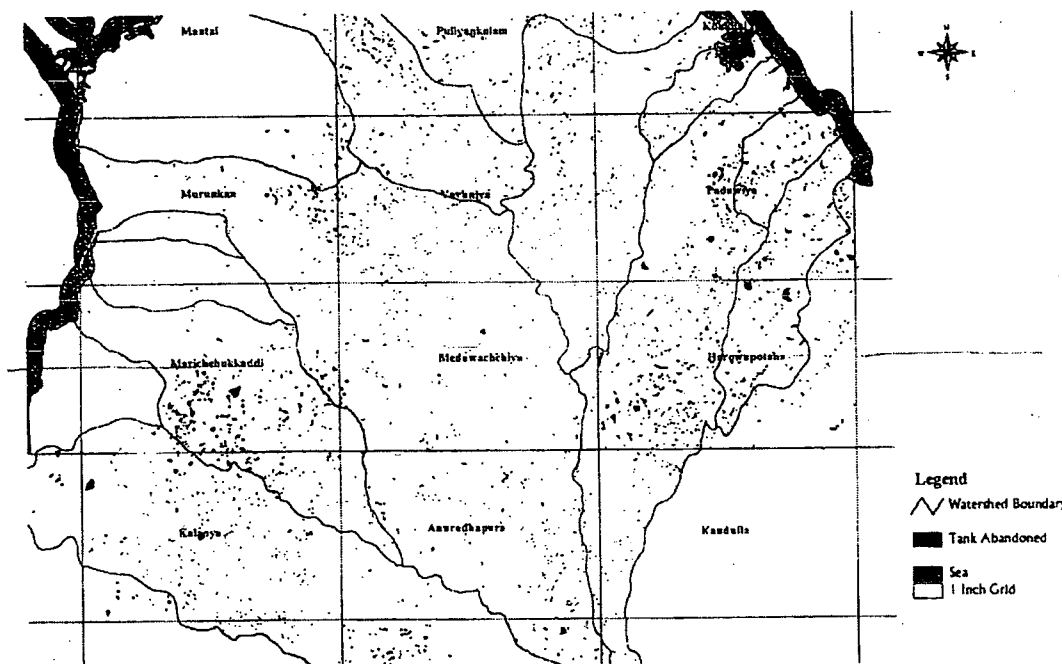


Figure 8: Abandoned Tanks and Watersheds



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Discussion on Session Two

Discussant

**Dr. R.D. Wanigaratne, Consultant, Land Titling Project
Ministry of Agriculture, Livestock, Lands and Irrigation**

What I propose to do is to bring out differences in different papers and also try to synthesis three papers and to come out with some generalizations.

First I would like to take-up Dr. Panabokke's historical thesis. The small tanks systems in Sri Lanka are represented by him as an appendage of ingenuity to similar systems found in Andhra Pradesh, Tamil Nadu and Karnataka. From modest beginnings around 300 BC the village systems of Sri Lanka expanded and developed complexities to meet different physical, economic and socio-institutional challenges and needs of an expanding population over a period of nearly 2000 years until the 12th century AD. During this period small village tanks were systematically linked to large tanks and anicut systems within and across micro and meso basin systems for both water control and supplementary irrigation water supplies along systems of tank cascades.

Central government maintained the larger tanks and canal systems while village level institutions maintained the small tanks, with the former maintaining a supervisory oversight over the entire system through a complex irrigation bureaucracy. With repeated invasions from South India in the 11th and 12th centuries the central government and its control over the management of the interlinked small and large irrigation systems broke down. Large tanks, anicuts and channel systems required a higher level of technical sophistication for their operation and maintenance. In their absence most tanks breached, and covered with forest until restored in post 19th century.

The small tank system de-linked from the central government and the larger systems underwent a centuries long decline, neglect and isolation. In these systems it was the strength of the small tank based institutions, its *Wev Lekam*, *Wel Vidane* and the village based committees such as *Variga Sabha*, legends, customs, norms and rules which governed rights as well as the allocation of water and land resources in an equitable manner to maintain production and village populations in a subsistence maintaining balance over the centuries until they were supplanted by the centrally government supervised and cultivation committee managed system, following the Paddy Lands Act of 1959.

The other related issue is the abandoned tanks. When I was at ARTI under the Dry zone Agriculture Project at Anuradhapura 300 tanks were selected from about 5000 tanks. Of the 5000 tanks, 2000 tanks were abandoned tanks. People have various reasons for leaving these tanks abandoned. We also have identified little cycles in the movement of villages. People have abandoned some of these due to soil mining and other related factors. Some of these tanks were rehabilitated and people were settled there, but people were like prisoners in those conditions. We have to be careful when we select these tanks by taking all other factors into consideration.

Then there is another factor how these interventions should take place. State is trying to bring back these systems. Here what I am trying to think is that you have to learn from the past. May not be very far past, but near past, and also learn from the people themselves. Rehabilitation process itself from the recent evaluation of NIRP I was involved in that. It is a failure. People themselves were not fully involved in that and the village organization itself has broken down in the process. Because outside contractors have come in and villagers are not properly consulted. There are some of the considerations that need in bringing these tanks back.

It was mentioned by the speakers today, that during the times tanks were functioning very well, a responsible management was there. That system was changed by the cultivation committee system, with political will also coming into the picture. What strategies do we evolve in this context? Can we go back? For example can we initiate a *Gamarala*? Is *Wew-lekam* or *Vel-vidane* possible? If not possible what new institutional mechanisms should we evolve to maintain the tanks? Since the cultivation committees have been in vogue for nearly 50 years since 1958 Paddy lands Act should not we develop upon it? Should we intervene and create problems or is there some other way to do these things? Or allow small tank communities to do it on their own. But own experience is that small tank communities as with the rest of

the society is fragmented along political party and access to centers of power and influence lines besides other traditional criteria. Yet at a recent OED project performance reassessment of the NIRP I have encountered situations where young groups had removed the chairmen of cultivation committees and taken over the management, on account of their failings to deliver the goods to the community. Such changes have to be accommodated to maintain and improve upon institutional continuity and change in small tank system management

Villagers in the small tank country usually have very valid reasons, besides cash and material costs, why they on their own volition have not attempted before to effect some rehabilitation in nearby tanks. Many of the past rehabilitations involving substantial donor investments such as the ADB funded Anuradhapura Dry Zone Agricultural Project (ADZAP), the World bank funded Kurunegala IRD Project (KIRDP) and the National Irrigation Rehabilitation Project (NIRP) have had their fair share of failings (with moderate to unsatisfactory ratings in subsequent project performance assessments) having expended enormous amount of funds over their project periods. Most of the failings have arisen due to inadequate attention to problem identification by existing small tank communities. What is to be rehabilitated? What is the social worth of such rehabilitation to tank communities and other relevant questions are not often adequately probed at the problem identification stage, amidst urgencies to meet time targets to develop rehabilitation plans.

Since each small tank system has its own unique characteristics, these must be properly understood prior to considering suitable choices for rehabilitation. If some of the small tank systems to be rehabilitated are linked tanks in a tank cascade system the entire tank cascade need to be considered, the views of all tank communities along the cascade need to be taken into account, besides opinion of the technical staff prior to final choice of the tank as "worth" for rehabilitation.

In this effort the need for a carefully selected set of objective criteria, that goes beyond what is normally adopted into estimations of the possible social and institutional impacts is considered an urgent prerequisite, to reduce the incidence of realized failings at the end of costly rehabilitations.

Dr. Handawala's presentation is based on the intensity of rainfall as a criterion. He observes that with an increase in the number of days of high intensity rainfall per year there is a phenomenal increase in water availability and crop production. He contends that the volume of such high intensity rain received in any given year may be a key determinant of present day tank village performance.

He makes an observation that the traditional small tank system had its own strategies and technologies to detain runoff, enhance infiltration and regulate surplus runoff flow and thus directly responded to rain as a process and manage the water it brought. It include contour earth bunds (wetiya), pits dug behind them to form ponds (pokuna), small lakes (Wila) formed on natural landscape above constructed bunds and tank (Wewa). In this way it provided a complete system of water management with a full range of water management measures positioned across the entire cascade. It provided flood protection during the wet season and water security during the dry periods—a perfectly adapted system.

In the context of such a system Dr. Handawela argues that "tank alone" rehabilitation is insufficient, but that the scope of tank rehabilitation must be expanded to focus on the overall tank landscape water management system. He also argues for a relaxation of the "irrigated rice" bias, by inducing small tank residents to move into water saving upland rice, kurakkan, meneri, and such other crops grown without irrigation. To get back the water security during the dry period that was a high point of the traditional small tank system.

Dr. Madduma Bandara discussed about how to bring back management of the tank system. He expressed an opinion about the need to make public the criteria under which the tanks were selected under the 10,000 tank programme, and forewarned that isolated attempts to tackle one could upset the cascade system generating a concurrent problem chain. He however, recommended that effort should be taken to reduce and prevent encroachment on the cascade system to at least maintain a semblance of its past performance.

Evidence of some desiccation in the Dry Zone, with a diminishing forest cover coupled with changing climatic conditions in the Dry Zone raises some doubts as to whether small tank systems could survive in the future. Feeding the cascade system through major irrigation projects may be a more enduring strategy. It will help to re-link in a limited way the small tank system with large irrigation works as it was in the

past. However, such a step must also accompany what Dr. Handawela mentions of in readjusting the water management landscape of the small tank system.

Discussant

Eng. S. Selvarajah

Advisor to Hon. Minister of Agriculture, Livestock, Lands and Irrigation

Let me take up first the understanding of rainfall aspect for tank management and rehabilitation. This is in regard to rainfall intensities. If you are going to measure these intensities, you need automatic gauges and automatic flow gauges. They are very expensive. We have to consider whether it is worthwhile to have these in small tank catchment. Further to measure and get accurate figure, it takes a longtime. Hence, to my opinion intensities are not that important.

Another speaker raised the question of having so much water on the land, yet we are still poor. There is a political reason for this. That is because we are continuously being exploited. We need not be poor if not for the exploitation.

With regard to point raised on differences in inflows to tanks. This again requires good rainfall gauges. Say for example, IL₁ and IL₂ have different conditions, but again we have to consider whether it is worthwhile for small tanks.

Several questions were asked with regard to tank cascade system in the dry and intermediate zones and their applicability. They are;

- (1) Whether the rehabilitations work is carried out scientifically as in good old days. I think so.
- (2) Is drought affecting village tanks were then the major tanks? In village tanks, water duty is low. In major tanks farmers tend to use excess water. Crops can be saved if water is used efficiently in both these systems. Hence, discipline in water use is a common factor to mitigate drought.
- (3) Water scarcity map - We must use water according to land use pattern. In order to instill and discipline, many acts have been enacted. For example 1948 State Land Ordinance, Agrarian Services Ordinance etc. Hence the regulations are there, but the problem is we are not implementing them.
- (4) It was mentioned that people in the Mahaweli areas are better off compared to other systems. But, Mahaweli scheme is only 25 years old. That is roughly about one generation's lifetime. Is it possible to draw this conclusion within a such a short period. Furthermore, the Mahaweli settlers are given 2 ½ acres of land, where as in other areas farmers own about 1 acre on the average.
- (5) About politics and development, we just can't separate politics from our life. People are living under those systems and they need water. We have to find some scientific way in doing it.

Finally what I want to say is that if authors of papers raise questions they also must suggest remedial measures or answers. Then it would be more fruitful.

Discussant

**Dr. M. Samad, Team Leader, Water Resources Institutions and Policies
International Water Management Institute**

I was asked to comment on the last session. I am honoured to do so because the papers were presented by these eminent scholars who have spent lifetime conducting research on small tank systems.

There are two issues raised by Professor Madduma Bandara and Dr. C. R. Panabokke. One was that during the recent drought biggest damage was experienced in the small tank system. That was certified by the newspaper clippings showed by Dr. P.B. Dharmasena. According to rainfall charts presented by Dr. Dharmasena drought is not a new phenomena. We have seen drought in the past, even more severe one. Due to some reason or other it has affected small tanks system much more. My argument is that in the past there were more drought coping mechanisms that were built into the farming system. And among those were, as Professor Madduma Bandara stated were, tank itself responded to water scarcity. Then he referred to Karahankota, the technological response to salinity management. There were also agronomic responses such as *Kekulam* cultivation and so on. Still there were other kinds of institutional responses such as *Bethma* cultivation. What has happened was all kinds of traditional drought coping strategies have eroded.

We talked about *chena*. *Chena* was a central component in small tank system. The tank or *wewa*, *kumbura*, *hena*, *watte* combination provided the much needed economic viability of these systems. That kept the system going. In such a system there was the elasticity. If one component facted, others were activated and so on. Economy may be fixed on to the paddy land, but other components sustained the system. Thus there was the food security, nourishment etc.

The other issue was multi-functionality of small tanks put forward by Dr. Tennakoon. They are not only multi-function, but also consist of multiple enterprises. This combination again help the system keeps it going.

Nobody is against rehabilitations. Some kind of intervention is necessary. Quite rightly Mr. Seneviratne pointed out in the morning that with our focus on large-scale system we tend to forget small tank systems. These are the locations that some of our poorest sections of the society live. They need interventions. The message that comes across is that rehabilitation alone wont do. It is necessary, but not sufficient condition. The other interventions that are necessarily includes institutional, sociological, community, economic, pricing subsidies etc. There are also internal pressures created by the demographic process, different land tenures systems etc. Hence, rehabilitation is necessary, but there are other interventions that have to go simultaneously. Total synergy of these interventions can enhance performance of these systems and provide better livelihood to the people who are dependent on the system.

Open Forum

Eng. G.T. Dharmasena

I would like to clarify some of the issues raised and also to make a few comments. Soon after I made my presentation here, I attended another meeting where over 200 irrigation personnel were present. They also raised the same questions such as how the 10,000 tanks figure come, how the tanks are selected, what are the criteria for selection etc. May be most people do not know what is going on. As we are aware, when we look at the geographical map and maps and documents prepared by FFHC and Agrarian Services Department roughly we talk about 30,000 tanks and anicuits or *amunas*. Then there is an understanding that we have already developed about 20,000 of these existing tanks. So these are a balance of 10,000. These figures are not given by me. It was in the election manifesto. I am just trying to give an explanation. But, my concern is whether we can get 10,000. We did a survey by going to the grass-root level unofficially requesting people to propose tanks for rehabilitation. We got only about 525 requests. Agrarian Services Department got about 200 requests. Roughly there are 750 requests and they are mostly existing tanks. There was a discussion here not to neglect the existing tanks. The breached tanks are in the jungle. People are not living there. This year will not go to the jungle, hence you need not worry about that aspect this year. That is also the most convenient way to start.

The sustainability of village tanks is another important issue raised by Dr. Handawela. This is a serious matter. The combination of tank and *chena* should be there. Today *chena* is not there. Under the circumstances it is our duty to come up with some proposal to make the system sustainable. That aspect we have not really discussed.

Why small tanks are more prone to vagaries of climate and other factors. Larger systems are more flexible than a small system. The storage level of small tank is small hence more sensitive to changes.

Finally, I am a person who believes that we have enough number of tanks; but the real issue is we do not have enough water to fill all these tanks, hence, the need for argumentation. For this we have to merge these small systems with larges systems. For example in the *Deduru Oya* basin there are over 100 small tanks. If they are to be augment we have to regulate *Deduru Oya* water and feed the tanks.

Dr. J. Handawela

When I mentioned intensity, I did not mean intensity that you measure from hydrograph. It is quite expensive. What I wanted was to look at daily rainfall. Today it many be 5 mm, tomorrow 10 mm and so on. Based on this, develop a diagram.

Dr. Madduma Bandara and others raised the question that, why the small tanks fail. This is because we do the wrong thing with it. We use it to do only one thing. That is grow paddy. The small tank doesn't exist in isolation. It enriches the surroundings. Upland rainfed farmers can continue to live using tank water for bathing, drinking and few similar purposes. If you can develop an eco-farming type of a thing in the watershed that would be ideal. Let them farm, but not paddy. Thereby it need not fail.

Eng. G.T. Dharmasena

In most of the western countries, Japan and America only 5 percent of the population are doing farming. It is highly machinery and they are rich people with children are at Cambridge, and so on. But, we still have a large number of farm families under the small tanks. They are subsistence farmers. They sometimes cannot cultivate even one season per year. They are the people who are asking for the 10,000 tanks rehabilitation. They believe with some improvement, more water can be stored there, which would help them to increase cropping intensity above its present value.

Several speakers also mentioned about *Vel-vidane* and others. They were there but, they have collected their B.A.s, B.Sc.s, Ph.D.s and gone away. They are living in a different land of economic system with higher per capita incomes and higher aspiration and values. They are holding higher position who got Rs. 50,000 million for the rehabilitation of irrigation in the purse, with no benefit for the economic upliftment of the people.

Mr. Widanapathirana

Mr. Chairman, there is no proper English word that carry the correct meaning of the word '*wewa*'. The word tank is inadequate to carry the full connotation.

We recognize that, they are multi functional. But how did we do NIRD, VIRP etc. How did they look at the multi-functional aspect? What was their investment package? It was based on the magic word cropping intensity. If the cropping intensity is low or if they do not get the expected cropping intensity, that tank will not get selected for rehabilitation. But we are talking of multi-functionality.

The tank is linked to the entire village resource system. The speakers here mentioned that *chena* is a missing component of village resource system. Hence, we need to find something else. A new value is to be added to the livelihood focus. This is linked to the outside world through the market process and so many other things. Hence, what is required is the holistic approach. That is what we are doing under the Sri Lanka-Australia Natural Resources Management Project. Mr. Nanda Abeywickrama also mentioned this aspect.

How did the '*wewa*' system sustain over two millenniums? Was it the *rajakariya* or social responsibility as some others mentioned? We do not have a clear idea. We do not have good Social Scientists of the caliber of Dr. Panabokke in the technical aspects. We need to look at social, technical and institutional mechanism and their links to each other. Perhaps we should have a special symposium on institutional aspects. That aspect is vital to sustain '*wewa*' system.

Mr. D.S. Pattiarachchi

There is a misunderstanding about the 10,000 tanks rehabilitation project. There are several objectives under this project. Tanks physical rehabilitation is just one of it. These are to be done by a "*wewa* committee". These are to be formed in collaboration with the "Farmer Organizations". This is the most challenging part of it. Since a cross section of the masses is included in it, all segments of the society are represented there. It is the responsibility of this committee to prepare the sustainable operation and maintenance plan, eco-system plan, dairy farm etc. all included in the package. In this symposium our attention was focused on one component only.

Mr. D.G.P. Seneviratne
Director/HARTI

I think we have had a very useful discussion and I wish the last intervention had been made much earlier in the proceedings. There are a number of things that were said with which I would not agree. For instance Ranjith Wanigaratne said that the small tanks were fed by major systems and therefore survived. I don't know the evidence for that. He also surmised that in the post-Chola invasion period, the development of the village tank was a response to human settlement: that too is a kind of chicken or egg question. Our officers have gone out and seen how these tanks have been selected for rehabilitation. Although Mr. Selvaraja said that we can't ignore politics, there seems to have been very little of that in the selections that were made. When we look at the Kurunegala district in the Yapahuwa area, there may have been some cases of a response to what particular a hamlet suffered during the "*bheeshanaya*" period when young people were taken to the bund of the tank and shot or burned. There would be a reaction to that, and maybe a tank was selected in response to that kind of thing. But even in such cases, from what our officers have seen, on the other criteria that have been set out that particular tank would have merited selection. It was not an aberration.

So let's hope that we can put all these thoughts together and get a publication out as quickly as possible, so that it would open further discussion at policy-making level. As Mr. Selvaraja suggested we could call on the help of the Irrigation Department, people in the field, to carry out a kind of survey and study of the various elements that have come up for comment today over a small sample.

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