Plan for restoration of cascading tank systems in Anuradhapura district, Sri Lanka

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Introduction

Tanjore in Tamil Nadu, Cambodia and Sri Lanka (dry zone) are the three civilisations in Asia which had well managed tank systems for rice production. The first two civilisations were destructed in due course of time. The dry zone of Sri Lanka is the only ancient irrigation civilisation which still continue its system. The tanks in this area ensured that the water was stored and the soil could be cultivated despite of dry and arid climate. Tanks were constructed mainly in two ways, either by impounding a river or by diverting the river through canals. In early days villages were built around tanks to allow easy access to water for agricultural purposes. Tanks were also important for cultural, spiritual and religious reasons, as water is a symbol of life and purity. There are nearly 12,000 small tanks and 13, 000 anicuts which irrigate around 246, 000 ha of land in Sri Lanka and produce around 191, 000 metric ton of rice which is approximately 20 per cent of the national production. For administrative purposes irrigation reservoirs in Sri Lanka are classified according to the size of their command area. Major systems (with command area >600 ha), medium (with command area 80-600 ha) are the responsibility of the Irrigation Department, whilst minor tanks (with command area <80 ha) come under the jurisdiction of the Department of Agrarian Services (DAS). Only the smallest tanks (with command area <5-10 ha) are privately owned and managed (1). The North Central Province of the island country which is marked as dry zone has number of small and large tanks. In the year 2002, it was seen that in North Central Province there were about 4, 017 minor tanks out of which only 52.2 per cent of the tanks were operating (2).

Anuradhapura district (Fig 1), located in the dry sub- humid North Central Province of the island country is dotted all over by large and small tanks (Photographs 1 and 2). Even today the ancient tanks of this district play a major role in the lives of the people. Not only are the tanks used for irrigation purposes but also for freshwater fishing, washing, bathing and replenishing the flora and fauna that surround it. The first man-made tank in Sri Lanka can be found in the city of Anuradhapura. Approximately 89, 041 ha of the district have been developed for paddy out of which 36 per cent is cultivated under minor irrigation (3). These tanks are generally interconnected forming a cascade system where extra runoff from the upper cascades reach the lower ones. There are 315 such tank cascades wholly or partially within the district, which include over 4,000 small tanks. Centred on these small tanks, a whole pattern of agriculture and living have developed (4,5,6). Over the past few decades the cascading tanks of Anuradhapura district have fallen into despair gradually. The tanks in this cascading system remain abandoned due to reasons like non availability of adequate water, drought conditions, delayed rain, loss of interest by the villagers. This has affected the communities, economy and the ecosystem which depend heavily on these cascading systems. Tank rehabilitation strategies of the country have not been able to systematically revive the traditional knowledge and social organisation that sustained the cascade systems. According to the researchers, the ancient tank irrigation technology reflects technically sophisticated attempts towards optimising the use of scarce water resources in small catchments in the Dry Zone (DZ) area. The previous tank rehabilitation projects did not take care of this.

To ensure a long term sustainability of these cascading tank systems, in the dry district of Anuradhapura, CSE tried to analyse the problems which has led to the poor condition of these cascading tanks. CSE has formulated a scheme for restoration of these cascading systems which are both policy driven and technical.

Cascading tank systems of Anuradhapura

The tanks of Anuradhapura are interconnected in series or parallel links (Fig 2, 3). Under this layout, water is continuously recycled. Excess water from the upstream tank are captured in the downstream tanks. This water is used in the irrigation in the command area of the second tank. Thus the tank is fed by direct rainfall and run-off from the catchment areas. This system helps to tackle any irregularity of rainfall. This traditional system also takes care of non-availability of large catchments and the difficulty of construction of large tanks. Most of the tanks are shallow and have a high ratio of water spread area to the area irrigated.

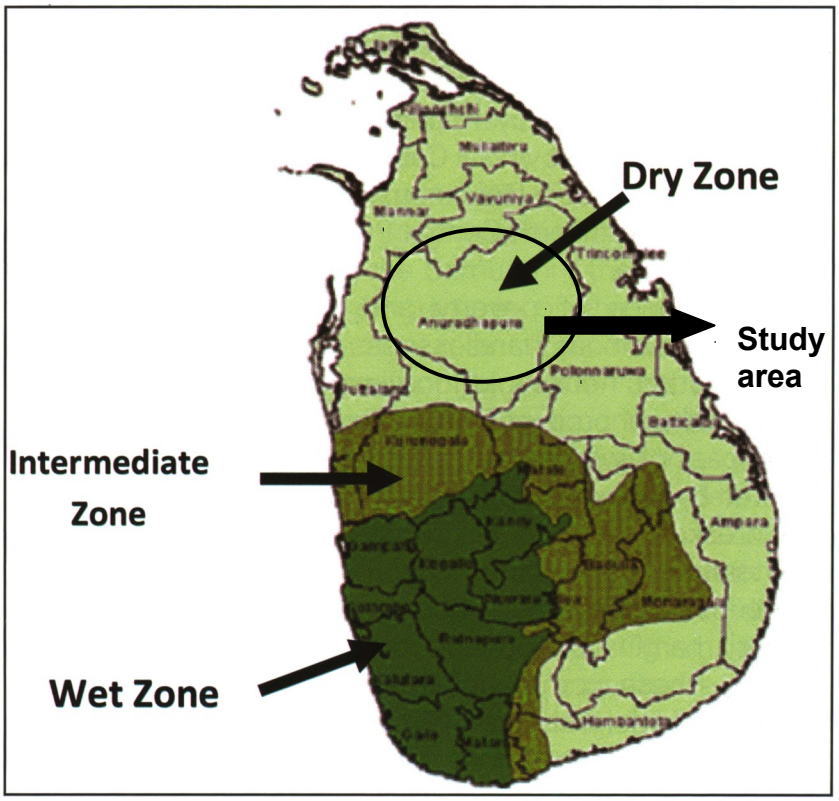


Fig 1: Map of climatic zones of Sri Lanka (Study area-Anuradhapura district marked) Source: Anon 2010, Cascade Irrigation Systems for Rural Sustainability, Experience of Plan Sri Lanka's Cascade Systems Development Project in the North Central Province of Sri Lanka 2004-2010 . Plan India. 183 p.

A single tank system in the cascade comprises the dam (bund), the tank body (*wewa*) and the upper periphery (*thaulla*) as major elements (Fig 4) (7). The *thaulla* is an artificial wetland area of aquatic plants through which the upstream drainage water from the paddy fields has to pass to reduce pollutants. Fines deposited in the *thaulla* are used for pottery; tall grasses and softwood from this area are used for crafts. Downstream of most of the dams, paddy fields are located. Artificial swamp area is located near to the dam for the treatment of the sewage.

A typical tank system (Fig 5) consists of the following:

Tank bund: A tank *bund* is an earthen dam, which is made out of several layers of compacted earth to barricade and store water within a depression of existing topography.
Sluices: These are masonry structures utilised in providing orifices to irrigation canals and are comprised of water stopping and regulating mechanism such as sluice gates.
Spill: This is a structure which allows excess of water of an irrigation tank to drain off in order to prevent earthen tank *bund* from getting washed off.
Kattakaduwa: A strip of land downstream and adjacent to tank *bund* as a barrier against salinity. The seepage water coming from the tank through the bottom of the *bund* has high concentration of residues which enhances the salinity of water. This is harmful for paddy cultivation. *Kattakaduwa* allows the water to filter through it and hence helps in reduction of salinity.
Kurulapaluwa: A cultivated strip of land where crop is consumed by birds and other animals. This helps to prevent the crops from direct damage by birds and animals.
Mookalana: A forest patch above the tank. This prevents soil erosion in the catchment and also helps in providing a constant supply of water to the tank in a controlled way.

The cascade system which is formed by the interlinked tanks are generally managed by tank

based communities. These communities collectively look into tank rehabilitation, fisheries development and reforestation. The activities were implemented through participatory methodologies. Whenever the communities across various villages in a cascading system worked together it gave positive outcomes for addressing social and economic issues. Cohesions among the different community groups across same cascade system due to social and religious issues caused the failure of community management system. In the rehabilitation projects Cascade Management Committees (CMCs) were created following traditional system to manage the system. The system did not sustain as CMCs were unofficial in nature and they were not supported by national government policy or legislation. The present evaluation study showed that more than 35 per cent of the cases did not believe that CMCS are advantageous. The issues and the threats faced by these tanks and the related socio-economic conditions of the related communities involve lowering of cropping index, siltation of tanks, water losses from the tanks and low resource productivity. In order to increase the cropping index, a large number of rehabilitation projects have been launched to restore the tanks but very little change could be made to increase the cropping index. Negligence of these tanks which caused high siltation of the tanks has reduced the capacity of the tanks. Siltation of tanks not only causes reduction of storage capacity but also leads to alter the tank geometry.

In many rehabilitation works, the capacity of the tanks has been increased by raising the spill and tank *bund.* These steps made the situation more complicated creating several other problems (7).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*)
e) Disappearance of some indigenous fish species, which cannot survive in shallow water or do not find a favourable breeding environment

It has been also seen that the water losses from the tanks due to evaporation take place at high rate after the seasonal rains. In the dry seasons the tanks turn nearly to cess pools. Water losses are higher from tanks with shallow water bodies than those with deep water. The poor condition of the tanks also effect the resource productivity of the area. Apart from these threats there is also encroachment of the catchment area.

The policies on these minor irrigation tanks first shifted the ownership of these tanks to the government department and then again the communities got back the ownership but this time political appointments influenced the system (Box 1) . The insufficient capacity of the communities to maintain the tanks and the catchment areas also caused the failure of rehabilitation programmes.

Photograph 1: Kurunegala tank, a man made reservoir in North West Province. Source: Nitya Jacob, Water Team, CSE

Photograph 2: Traditional tank in Anuradhapura city. Source: Nitya Jacob, Water Team, CSE

Fig 2: A Satellite image of the area of tank cascade systems around Anuradhapura, in North Central Sri Lanka. Source: Bandara, CM.M, ' Village Tank Cascade Systems of Srilanka. A Traditional Technology of water and Drought Management' < http: //drh.edm.bosai.go.jp/Project/ Phase 2/ 1 Documents/ 8.../8_TIK6_P.pdf >

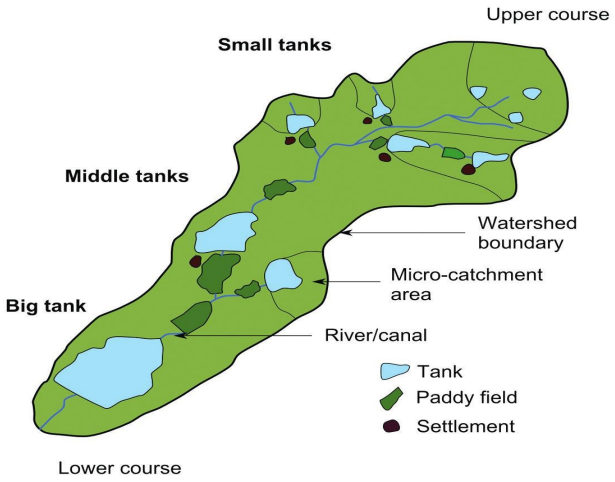


Fig 3: A typical cascade system. Source: Schutt, B *et. al.,* 2013, ' Characterisation of the Rota Wewa tank cascade system in the vicinity of Anuradhapura, Srilanka' , J. Geographical Society of Berlin, Volume 144, No. 1, pp 51-68

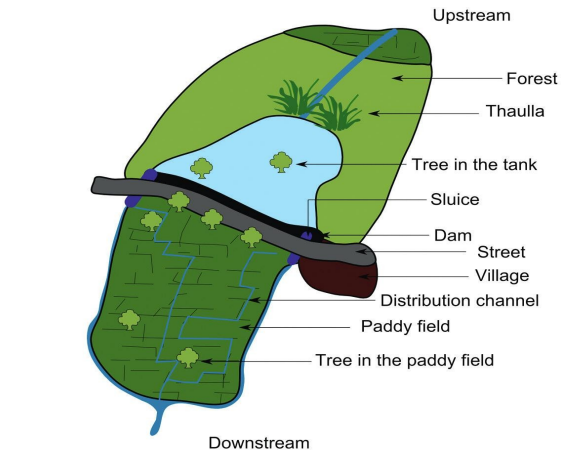


Fig 4: Components of *wewa.* Source: Schutt, B *et. al.,* 2013, ' Characterisation of the Rota Wewa tank cascade system in the vicinity of Anuradhapura, Srilanka' , J. Geographical Society of Berlin, Volume 144, No. 1, pp 51-68

Photograph 3: One of the tanks in the cascading system in Anuradhapura district. Source: Nitya Jacob, Water Team, CSE

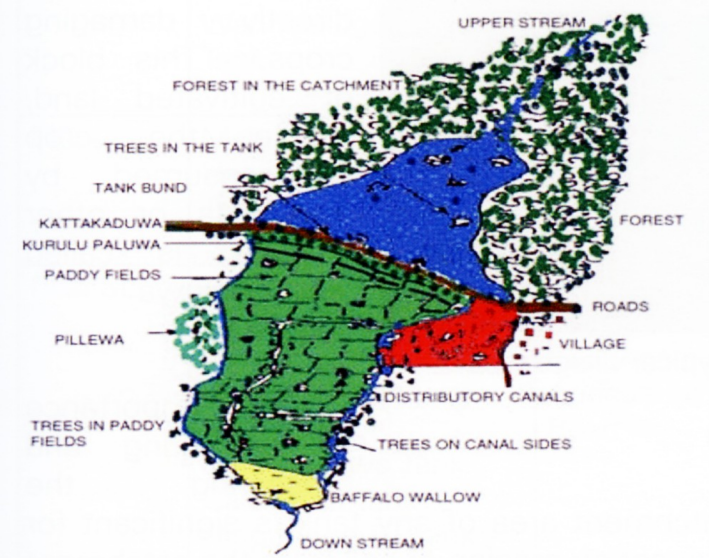


Fig 5: A typical tank system. Source: Anon 2010, Cascade Irrigation Systems for Rural Sustainability, Experience of Plan Sri Lanka's Cascade Systems Development Project in the North Central Province of Sri Lanka 2004-2010 . Plan India. 183 p.

Box 1: Sri Lankan policies and projects/programmes and its influence on the ownership of the cascading tanks

Pre 1958.Tanks were communally managed by farmer associations under the leadership of an elected *Velvidane* or the irrigation headman. Maintenance responsibilities were based on command holdings. Communities were completely responsible for desiltation of the tanks and maintenance of the bunds.

1958. Paddy Land Act shifted the responsibility of maintenance of these tanks to the Department of Agrarian Services. Farmers lost the ownership and they were not interested in the maintenance and operation of the tanks. The responsibility of water management shifted from *Velvidane* to the Cultivation Committees.

1972. Agricultural Productivity Act replaced the Cultivation Committees with Agricultural Productivity Committees with representatives from farmer as well as lack of understanding of socio-economic condition of the communities also contributed to the failure of some programmes.

1979. *Velvidane* were again brought in but this time they were politically appointed and hence most of the time of no use.

1980. Major investments were made under Integrated Rural Development Programs for the rehabilitation of the cascading tanks. Farmer organisations were encouraged to manage the system but this did not bring much impact. The Village Irrigation Rehabilitation Project (VIRP) also commenced in this year. This was the largest tank rehabilitation scheme in terms of area covered and cost involved. The scheme targeted 1200 minor tanks in the entire dry zone and benefited about 25000 families.

1981-1986. Anuradhapura Dry Zone Agricultural Project (ADZAP). This was done under the funding of Asian Development Bank and International Fund for Agricultural Development. The main objectives of this project were increasing agricultural production, employment and income of rural poor of Anuradhapura district.

1990. Asian Development Bank invested money in the maintenance of these tanks in North Central Province.

1999. Anuradhapura Rural Development Program, first of its kind implemented for the coordination of water management in the cascading tanks. Over 200 cascading tanks were covered under this programme.

2002-2006. World Food Programme started the minor tank rehabilitation project with an objective to improve the living standards of poor in the dry zone areas. Activities included rehabilitation of minor tanks, construction of agricultural roads, agrowells, multipurpose buildings and farmer training.

Source: Muray, F.J. and Little, D.C. 2000. The Nature of Small-Scale Farmer managed Irrigation Systems In North West Province, Sri Lanka and Potential for Aquaculture. Working Paper SL1.3. Project R7064.

Anon 2010, Cascade Irrigation Systems for Rural Sustainability, Experience of Plan Sri Lanka's Cascade Systems Development Project in the North Central Province of Sri Lanka 2004-2010 . Plan India. 183 p.

Tools and methods for the study of cascading system in Anuradhapura

All the tank rehabilitation projects in Anuradhapura and other dry areas of Sri Lanka funded by the government, international donors or NGOs mainly focussed on rehabilitation of isolated tanks in the cascade systems. While proposing strategies for the rehabilitation of the cascade systems in Anuradhapura, CSE has tried to focus on a cascade as a whole and not on individual tank system as done before. This helped to give a comprehensive strategy for the series of tanks connected longitudinally. Hence treating tanks at village level will not take care of runoff from connected tanks and catchment.

As a first step of study, evaluation of primary and secondary data were gathered and analysed. In the next step, hydrological, ecological and socio-economic relationships of the cascading systems were analysed. As a starting point, baseline survey data were collected from NGOs like PLAN, IUCN, and government departments like DAS, Irrigation Department and research centres like Universities of Perideniya and Rajarata. Topographic sheets (Scale of 1:50,000)and Google Earth maps were also collected to understand the spatial relationship of the cascade systems. Information on the rainfall of Anuradhapura district was also collected from the researchers to understand the pattern of rainfall in the district. The components like annual rainfall (Fig 6), number of rainy days and dry spell were collected between 2002 and 2009 were collected.

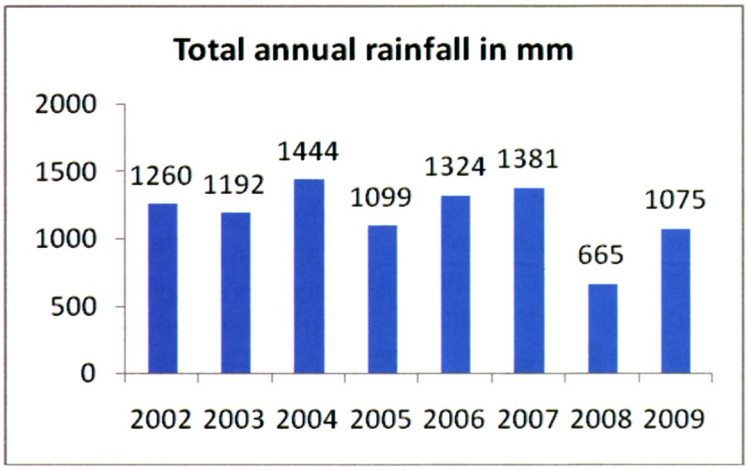


Fig 6: Annual rainfall in Anuradhapura district. Source: Anon 2010, Cascade Irrigation Systems for Rural Sustainability, Experience of Plan Sri Lanka's Cascade Systems Development Project in the North Central Province of Sri Lanka 2004-2010 . Plan India. 183 p.

As a source of important data and information gathering approach, the key officials of DAS, Irrigation Department, researchers in Peridenya, Rajarata Universities were interviewed by CSE staff members. Village leaders, women, children, farmers and Community Based Oranisations (CBOs) were also interviewed to get an understanding of the present condition of the cascading

systems and socio-economic implications. For the interviews, structured questionnaire was prepared. To understand the success and failures of the implemented rehabilitation projects, CSE staff members visited few case studies in Anuradhapura district.

To evaluate the view points of the beneficiaries of the cascade systems another questionnaire was made which included the following points:

1. Information on the house owner
2. Tank rehabilitation project if any
3. Agricultural condition and Socio-economic conditions
4. If there has been any rehabilitation project, then pre and post project conditions (social and economical)
5. Cascade management
6. Operation and Maintenance of the cascade system

The interviews brought out the problems and constraints of the existing cascading systems, levels of participation in the development work of these systems and the need of capacity building and operation and maintenance activities involved in these systems.

Box 2: Case study: The plan of restoration of Wagayakulama wewa - one of the tanks in a cascading system of Anuradhapura district

A restoration plan was formulated and implemented between 2003 to 2006 in the Wagayakulama *wewa* by the Sri Lanka Council for Agricultural Research Policy. This tank is a part of 15 tank cascading systems. Some of the tanks in the vicinity are Perkulam *wewa*, Pudukulam *wewa* and Manakulam *wewa*. The excess of water from Periakulam *wewa* flows to Pudukulam wewa and the excess of water from this tank flows to Manakulam *wewa*. The excess runoff from Manakulam wewa flows into the Wagayakulama *wewa*. An adoption of the partial desilting concept provided the benefits such that increment of tank storage, reduction of tank water loss, enhancement of command area productivity, expansion of cropping intensity, additional income from the tank command area cultivation and protection of the tank eco-system.

There was an alteration of the geometry of the tank bed in Wagayankulama *wewa* with the partial desilting work of the tank. During partial desilting, the silt that was removed from the shallower part of the tank was again added to the tank (in the deeper regions) to form mounds. Thus the tank geometry was altered to form a high capacity : area ratio as the surface area was reduced to half. Thus the moist tank soil (which was used to make the mound) was used to grow bamboo (*Bambusa spp.*), rattan (*Calamus spp.*), mat grass (*Cyperus pangorei*) etc.The development of the dead storage (water storage below the sluice level) created by removing the silt increased the water stored in this area. This extra water could be used for cultivation in the tank command area.

Thus total area of 77.3 acres was cultivated in a year in the post desiltation period which was about 90 per cent higher than the cultivated area in the pre desiltation period. The average cropping intensity in the post deepening phase of the tank has gone up by two times than the pre deepening phase. The annual income from the command area paddy cultivation was doubled than earlier (from 1.782 million SLR to Rs. 3.735 million SLR) due to the increase in the annual paddy production in the post rehabilitation period of the *wewa*. Hence, the additional income of Rs. 0.465 million was gained by 33 farmer families who were cultivating the command area of the tank. Water availability in tank was increased after the deepening activity from the height of 125 to 183 mm before and after deepening respectively. This is due to the reduction of water losses from the tank.

Drawback: Lack of fund for the management of these tanks has affected the crop yield feels the farmer group in the village. There is extra runoff from the catchment which they could not utilise due to lack of knowledge and training on management and conservation of these tanks.

Table 1: Cultivated area in *maha* and *yala* season of total command area of 59 Acres in Wgayankulama tank

Year	Cultivated land extent (Acres)	
	Maha (high rainfall period)	***Yala (low rainfall period)***
1996	43	0
1997	43	0
1998	40	0
1999	38	0
2000	37	0
2001	40	0
2002	35	0
2003	48	0
2004	39	0
2005	41	0
2006	47	27.5
2007	47	28
2008	54	29

Source: DAS

Source: Field survey by CSE staff member in November 2013

The perception and knowledge of the cascade system among those living in the communities were also determined through a questionnaire. It has been found that more than 30 per cent of the communities have been benefited directly by rehabilitation programme. It has come out from the evaluation of this questionnaire that less than 20 per cent of the people were aware about the benefit of the cascading system. A reconnaissance field investigation of the different cascading systems revealed the following:

1. Lateral as well as longitudinal connections of different tanks in the cascading systems could be observed in many cases
2. Along with water, agricultural wastes and pollutants also get circulated in the cascading systems
3. Availability of water controlled the production of the crops and sequence of agricultural activities
4. Past efforts for rehabilitation in many cases caused disputes among the beneficiaries as the role and responsibilities of different beneficiaries were not well defined
5. At many places, *kattakaduwa* were not developed or protected
6. The sociological patterns of different villages along the cascade system affected the cascade-wide institutional development or development of new roads on the tank bunds

The term rehabilitation in the island country in the previous projects meant (i) restoration of abandoned, non-working ancient tanks and the development of their command areas or (ii) taking actions in places where tanks *bunds* are breached or (iii) increase of storage capacity of the tanks together with expansion of the command area or (iv) refurbishment of the existing tank without increasing the storage capacity or expanding the command area. According to the researchers of DAS, the rehabilitation programmes of the cascading tanks emphasise more on points iii and iv and the list of tanks to be rehabilitated is prepared. According to many village communities, the priority of selection of tanks now is mostly determined by the interest of the pressure groups. The selection should be done on scientific criteria which can be cropping index. Once the list of tanks to be rehabilitated is prepared, it is to be followed by preliminary investigation survey which finds out the hydrology of the tank, spilling history, cultivation history and physical status of the tank components and irrigation system. It has been seen in the project sites that no emphasis has been given to the hydrology of the catchment area, type of the tank bed and its geometry. A survey of

whether additional area can be brought under the catchment has also been neglected. Analysis of the impact of the rehabilitation on other tanks is not at all done. Sometimes non-availability of raw materials near the site made the projects unsuccessful. Following the preliminary survey, full investigation survey has to be done which includes proper mapping and demarcation of the catchment area, survey of the topography of the tank, tank *bund* and command area. After the completion of the full investigation survey, the technical officer works on the hydrological and technical design for rehabilitation.

Way forward: Overall recommendations

The study of the cascading system showed that whatever development effort is undertaken in the DZ area including Anuradhapura district is largely centred on a single tank of the cascading system. Single tank rehabilitation will not be adequate in this region but the project should involve the whole cascade system. The rehabilitation programmes for the cascading tank systems need an improvement in survey, planning and coordination components. During the preliminary survey, a more detailed investigation of the identification of the existing institutional and technical problems, the existing land and water resources, their use and potential have to be done. While doing the detailed investigation of the topography of catchment and tank bed, the mapping should be done at 1:10,000 scale for the accuracy of the exercise. Inaccurate mapping in many sites led to wrong hydrological and technical outputs which ultimately affected the rehabilitation programme.

In many places, it has been observed that the minor tanks have been abandoned due to conflict between traditional systems and modernisation. In these cases, there is a need of long term plans whereby awareness programmes can be conducted for sustainability of these systems. As for example in most of the rehabilitation projects modern sluice systems are used in place of traditional sluice. The traditional sluice was more effective in filtering the saline water. In such cases more Research and Development work should be carried on so that the traditional wisdom can be used effectively. The traditional knowledge on soil conservation and reforestation/conservation needs to be promoted especially among young people. Ministry of Education can also help in outreach of this knowledge whereby the knowledge can be disseminated to the younger generation.

The capacity building programmes have to be designed in such a way that there is socio-economic benefit of the communities. The sustainability of these cascading systems will need strengthening of the knowledge of the user groups to carry out technical, managerial and organisational activities. This can be done through capacity building programmes and development of training manual. The There should be financial and technical investment for social development to ensure that the operation and maintenance of the tanks can be sustained. The community reforestation programmes should be done at war footage. There should be also preservation and protection of *kattakaduwa.* Evaluation of the case studies in Anuradhapura district showed that there should monitoring of the use of agrochemicals in the upper cascade areas so as to protect the lower cascade areas from the entry of pollutants (mainly agrochemicals). Planting of pollutant absorbing grass varieties along the drainage channels can be done in order to control the inflow of agrochemicals to the reservoirs. The reforestation programmes and soil conservation programmes should be taken up for the catchment areas. The Ministry of Forest can help in development of the capacity of the beneficiaries in watershed management practices in the catchment areas.

A detailed understanding of the hydrology and landuse needs to be done for sustainability of the cascade systems. Technical supports should come to the beneficiaries from consultants who should have an understanding of land and water resources in the tank based villages and change of climatic pattern in the area. Data on groundwater availability, abstraction rate and groundwater recharge rate, rainfall pattern in last fifty years, recurrence of flood, droughts and other natural calamities should be available with the CBOs so that they can be provided to the village heads whenever required. Child participation and gender mainstreaming should be prioritised in the operation and maintenance of the system.

Potograph 4: Farmer leader responsible for managing Wagayankulama *wewa in* Anuradhapura district. Source: Sushmita Sengupta, Water Team, CSE

Photograph 5: Wagayankulama *wewa* in Anuradhapura district. Source: Sushmita Sengupta, Water Team, CSE

Photograph 6: Cultivation in the command area of Wagayankulama *wewa* in Anuradhapura district. Source: Sushmita Sengupta, Water Team, CSE

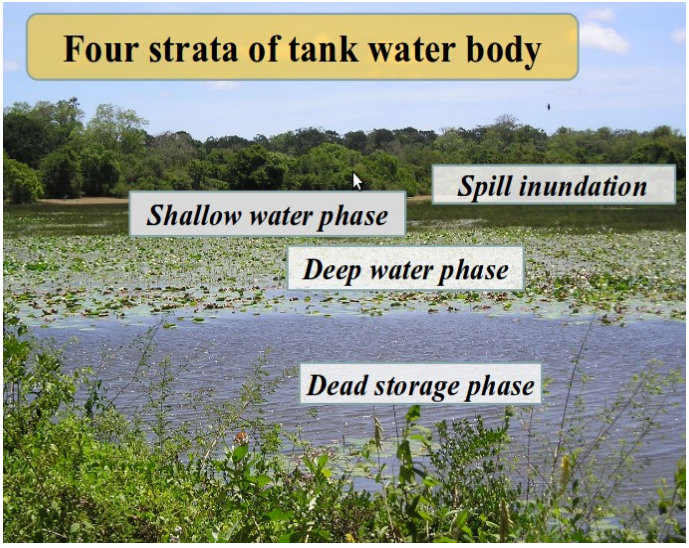
Photograph 7: Water level monitoring instrument in Wagayankulama *wewa in Anuradhapura district. Source: Sushmita Sengupta, Water Team, CSE*

Photograph 8: Sluice for tackling runoff from Periakulam *wewa to* Pudukulam *wewa* in Anuradhapura district. Source: Sushmita Sengupta, Water Team, CSE

Photograph 9: Cultivation in the upland of Manakulam *wewa* in Anuradhapura district. Source: Sushmita Sengupta, Water Team, CSE

To reduce tank water losses, partial desiltation is the best process in this case. This can be done by changing the tank bed geometry through desiltation. It is clear that the said objective cannot be successfully achieved by a complete desiltation, as desiltation does not alter the area/height ratio of the tank storage effectively (Photograph 10 and Figure 7). Thus, the same capacity can be maintained by removing sediment in this area and spread and making soil mount over the rest of the tank bed. Such partial desilting effort would reduce the area/height ratio remarkably. In order to prevent sediment moving back to the desilted area there is a need to stabilize the soil mound with a vegetative cover. Therefore, the technique of partial desiltation increases the storage potential and reducing tank water losses with protecting the ecosystem. Department of Agriculture carried on such project in one of the tanks in a cascading system and got positive results (Tables 1 and 2 and Figure 10).

Government institutions involved in tank rehabilitation project addressing the poverty reduction and income increase can be diverse including Ministry of Agriculture and Agrarian Services, Ministry of Fisheries and Aquatic Resources Development, Ministry of Plantation Industry, Ministry of Forest, Ministry of Education and Provincial Council. The evaluation of the existing rehabilitation projects do not involve coordination between these ministries. For the sustainability of the cascading systems, there should be well defined role and responsibilities of these ministries and the projects should also focus on the capacity building programmes of the officials. Ministry of Agriculture and Agrarian Services can help in developing the capacity of the beneficiary groups in the cascade systems, Ministry of Education can help in spreading awareness about the systems among young people and children, Ministry of Forest and Ministry of Plantation Industry can help in development of forest in the catchment area and on mounds created due to partial desiltation respectively. The Provincial Council can work together with the ministries for capacity building and awareness programmes, help the communities in operation and maintenance programmes and raise funds for the sustainability of the cascade systems.



Photograph 10: Different strata of tank water body. Source: Department of Agriculture

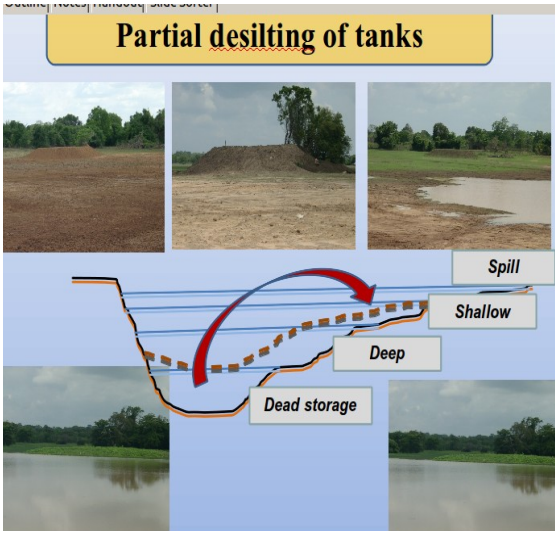


Fig 7: Partial desiltation process in tanks. Source: Department of Agriculture

Table 1. Area and capacity of the Wagayankulama tank before deepening

contour m	Area m^2	mean area m^2	Contour intervel	capacity m^3
100	8642.47		0	0
100.25	19327.53	13985	0.25	3496.25
100.5	45080.96	32204.25	0.25	11547.31
100.75	75308.53	60194.75	0.25	26596
101	115206	95257.27	0.25	50410.31
101.25	179191.54	147198.8	0.25	87210.01
101.5	190587.94	184889.7	0.25	133432.4
101.75	200450	195519	0.25	182312.2
102	222355	211402.5	0.25	235162.8
102.25	243725	233040	0.25	293422.8

Source: Department of Agriculture

Table 2. Area Capacity of the Wagayankulama tank after deepening

contour m	Area m^2	mean area m^2	Contour intervel	capacity m^3
99.25	3975	9175	0.125	1146.88
99.5	13150	8562.5	0.25	3287.50
99.75	20075	16612.5	0.25	7440.63
100	24625	22350	0.25	13028.13
100.25	30950	27787.5	0.25	19975.00
100.5	45805.96	38377.98	0.25	29569.50
100.75	75308.53	60557.25	0.25	44708.81
101	115206	95257.27	0.25	68523.12
101.25	179191.54	147198.8	0.25	105322.82
101.5	190587.94	184889.7	0.25	151545.25
101.75	200450	195519	0.25	200424.99
102	222355	211402.5	0.25	253275.62
102.25	243725	233040	0.25	311535.62

Source: Department of Agriculture

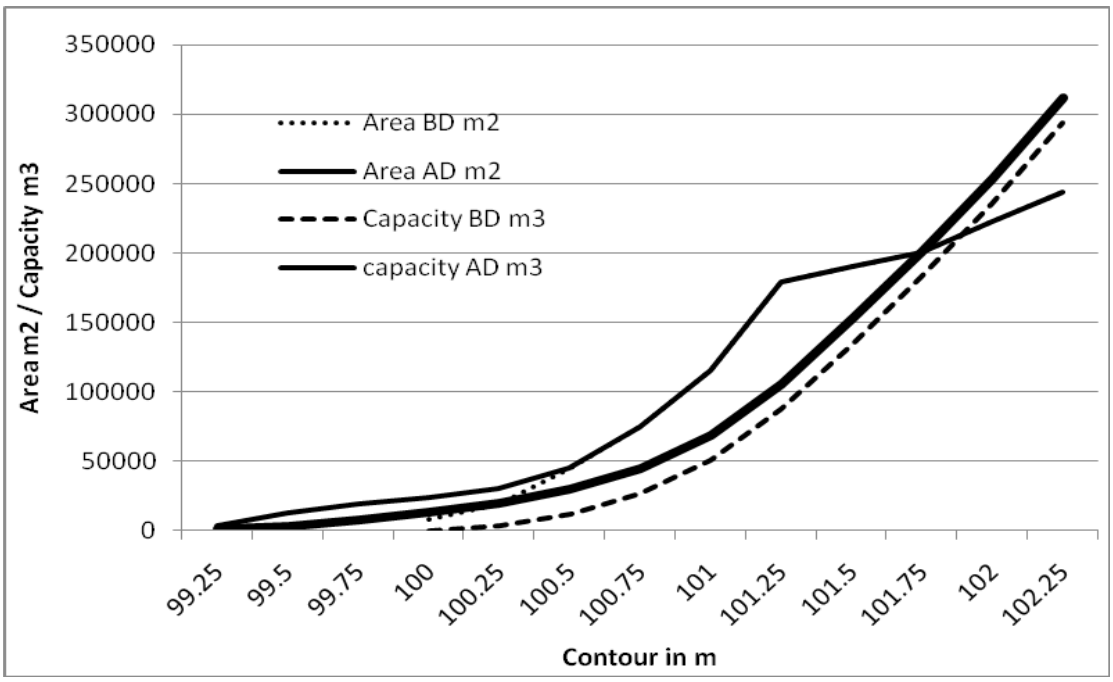


Fig 8. Area /capacity curve before and after deepening in Wagayankulama tank. Source: Department of Agriculture

The evaluation of the cascade systems showed that the cascade concept was accepted by the North Central Provincial Development Plan, but there is no required legislation and legal status for this system. The island country should also think about the legal framework for the protection and conservation of these cascading system.

Box 3: Revival strategies to be applied for Kapiriggama cascade system in Anuradhapura disstrict

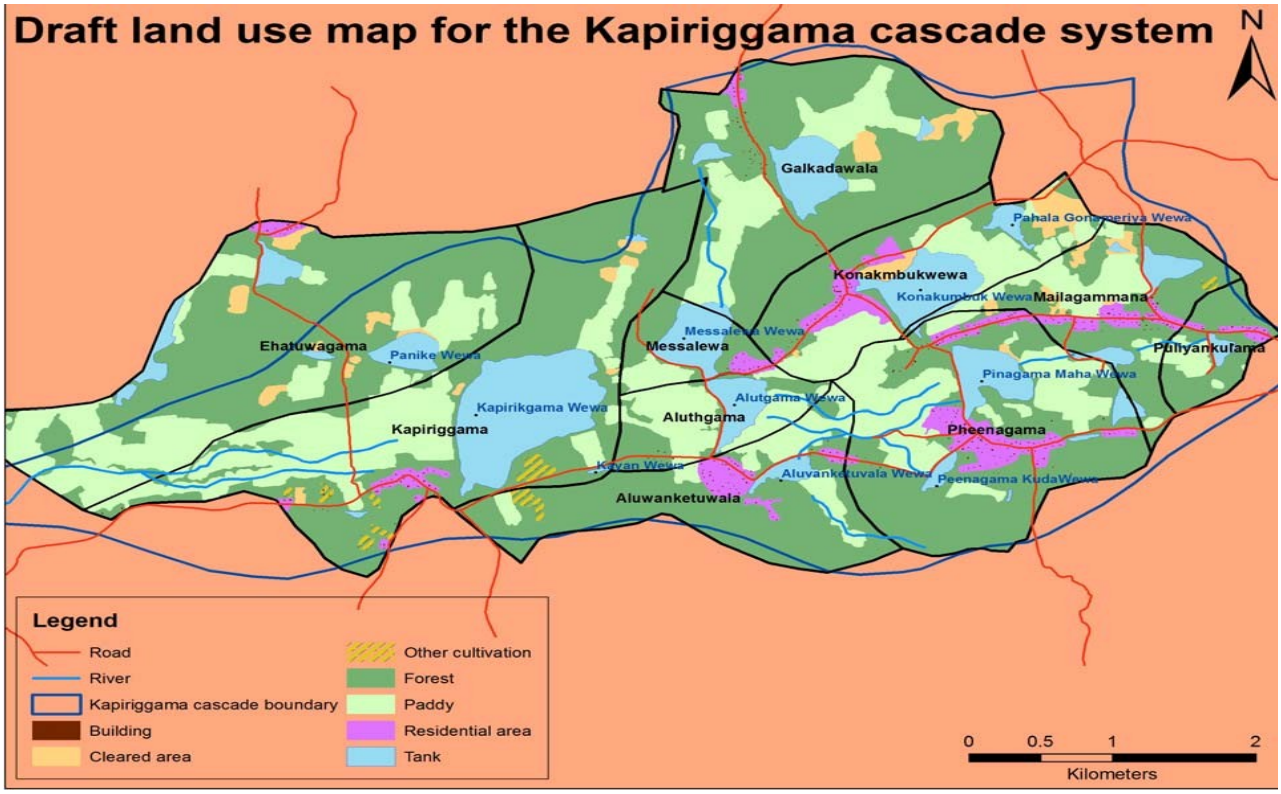


Fig 9. Draft land use map for the Kapirriggama cascade system. Source: IUCN

Previous rehabilitation programmes were designed for the restoration of Kapirriggama cascade system in Anuradhapura district. The programmes were not effective and faced many problems. The issues in the cascade systems are as follows:

a) Low cropping intensity: Between 1970 to 2003, the tanks in the cascade system always showed very low cropping index.

b) Tank sedimentation: Due to sedimentation the area of the tanks decreased and the water losses also increased proportionately. The siltation not only decreased the storage capacity of the tanks but also affected the geometry of the tank bed.

c) High tank water losses: There was huge water loss from individual tanks. During the dry period the water in the tanks was very low and the tanks almost turned into marsh land with heavy growth of weeds.

d) Low resource productivity: Due to less focus on restoration of the tank bed and its surrounding ecosystem the resource productivity of the communities decreased. The resource productivity was also affected because the programmes concentrated on single tank and its command area. The programme completely ignored the comprehensive study of the connected tanks in the cascade and the catchment. The community mobilisation, institutional development and socio-economic implications were not considered at all.

CSE is recommending the following for the restoration of the cascading tank system:

1. **Partial desiltation whereby the area/height ratio can be remarkably reduced leading to the increase of storage potential and decrease of water losses from the tank**
2. **CMCs have to be established for sustainability of the tanks and this has to be official and should have legal status**
3. **Development of database on socio-economic components, traditional knowledge, ecological components. The database should be available with CBOs**
4. **The capacity building programmes should be designed for the user groups to carry out technical, managerial and organisational activities**
5. **There should be financial and technical investments for social development to ensure that the operation and maintenance of the tanks can be sustained.**
6. **The community reforestation programmes should be done at war footage. There should be also preservation and protection of *kattakaduwa***
7. **Research and Development work should take place in order to integrate traditional knowledge in implementation of structures like sluices, *bunds* etc.**
8. **A detailed understanding of the hydrology and landuse needs to be done for sustainability of the cascade systems. Technical supports should come to the beneficiaries from consultants who should have an understanding of land and water resources in the tank based villages and change of climatic pattern in the area**
9. **Child participation and gender mainstreaming should be prioritised in the operation and maintenance of the system**
10. **Coordination should be established between Ministry of Agriculture and Agrarian Services, Ministry of Fisheries and Aquatic Resources Development, Ministry of Plantation Industry, Ministry of Forest, Ministry of Education and Provincial Council. Ministry of Agriculture and Agrarian Services can help in developing the capacity of the beneficiary groups in the cascade systems, Ministry of Education can help in spreading awareness about the systems among young people and children, Ministry of Forest and Ministry of Plantation Industry can help in development of forest in the catchment area and on mounds created due to partial desiltation respectively. The Provincial Council can work together with the ministries for capacity building and awareness programmes, help the communities in operation and maintenance programmes and raise funds for the sustainability of the cascade systems.**

Source: IUCN and CSE

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