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Sustainability of the Minor Irrigation Systems of the Cascades in Dry Zone of Sri Lanka: Challenges and Potentials

A Cultural Ecological Analysis

By

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Abstract

This article describes the cultural ecology of terraced tank clusters (Cascades) in the Dry Climatic Zone (DCZ) of Sri Lanka. As recognized by Julian Steward in 1950s, Cultural ecology is a theoretical approach that attempts to explain the similarities and differences in the culture in relation to the environment (Tucker 2013). The traditional settlements linked with small tanks called 'Wew gam' (Tanks villages) and the interrelationships between human activities and the natural ecosystems of the cascades are good examples of the cultural ecology in Sri Lanka. According to the study, the ecology and the and culture sustainably go together and ecology deals with patterns of relations of plants, animals, and people to each other and their surroundings, and culture deals with all products of human thoughts. There are however certain aspects of both ecology and culture that have very interesting and intimate relationships. The Sri Lankan cultural and water heritage is one of the richest and most colorful heritages in Asia. Therefore, there are much to be re-learned from our ancient hydraulic civilization. In history, the people of agricultural communities lived sustainably, respecting the environment, dealing well with wild animals, and coping with natural hazards. A village tank cascade ecosystem exemplifies a sustainable system. Concerning the historical behavior and the contribution to make a sustainable environment in drought prone areas of the DCZ of Sri Lanka, the village tank system was recognized on 19th April 2020 by FAO as one of the "Globally Important Agriculture Heritage System" in the world. It is an ancient, widely used, and unique traditional agriculture system. The system provides water for irrigation, domestic purposes, animals, and ecosystems.

Keywords; Cascades; Small Tanks; Ellanga; Sri Lanka, Minor Irrigation.

Introduction

The climate change related issues are getting worst in DCZ[1] of Sri Lanka and have endangered the sustainable livelihood of the traditional village settlers in many ways. Though, the major irrigation works which have been introduced during the last 05 decades of Sri Lanka came to the zenith, the irrigation water supply issues are still pertaining in the minor irrigation like cascades or small tank villages. The lifestyle of the small village setters of the DCZ has been worsening due to the lack of irrigation water and changing natural weather patterns. Consequently, the government and international development agencies have been turning again towards the small irrigation systems like cascades which have been malfunctioned due to inattention of all the successive governments since European colonial period. Due to the negligence of the minor irrigation system in DCZ in Sri Lanka, nearsighted encroachments and renovations for profit maximizing under modern economy, the cascade ecosystems which have been developed with indigenous knowledge have been highly damaged. The major issues of these expedite renovations are damaging the cultural ecology of the cascade settlements as a result of misunderstandings about the cascade system due to lack of cultural ecological indigenous knowledge. This article provides a cultural ecological interpretation of the cascade settlements using the traditional indigenous knowledge of settlers and folklore of DCZ of Sri Lanka.

Methodology

The main objective of the study is to reveal the significance of cascade ecosystems under the cultural ecological analysis. Consequently, this study is based on mixed method including inductive approach with cultural ecological interpretations. The author has paid attention on 35 cascades (Terraced Tank Clusters, TTC) which are located in the districts of Anuradhapura, Trincomalee, Kurunegala, and Puttalam of the DCZ of Sri Lanka. Field observations, transact walks, focused group discussions, key informant discussions, seasonal calendar, resource mapping are the major data collecting methods under the Participatory Rural Appraisal which have been done in different periods within the last 03 years by the author. The life historical method has specially been applied for collecting the historical information on cultural ecology in the TTC. This article provides different appropriate evidences from different cascades in the DCZ.

Morphology of TTC (Ellanga)

The size and shape of TTC (Cascades) or locally called *Helmalu wew pokuru or Ellangava* depend on a topography determined by geology and subsequent geomorphic changes in that topography. In the flat plains closer to the coast, the Ellanga density is low and in the prominently undulating north and north central peneplain of the DCZ, the density is very high.

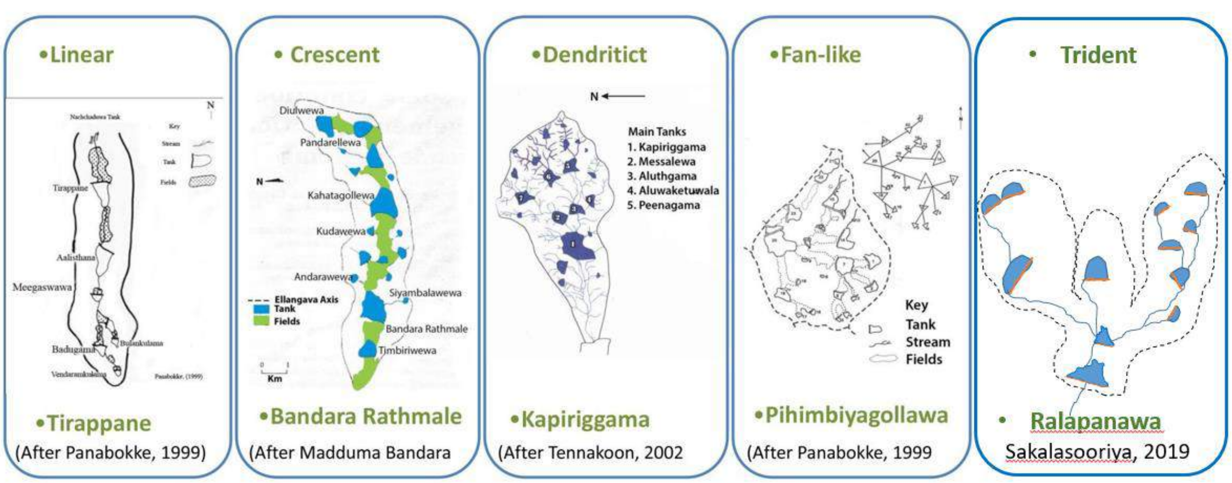
[1] The DCZ covers 63.6% (41, 717 km^2) of the total land area of Sri Lanka. the major natural hazards of the DCZ is frequent floods and droughts. Each year, the DCZ faces two monsoons and two inter-monsoonal periods. Four months of period from November to February are the normal rainy season of the DCZ and March to November, evaporation exceeds the monthly annual rainfall (Report of the Land Commission of Sri Lanka 1990).

According to the morphology, 05 types of Ellanga have been identified – linear, crescent-shaped, dendritic, fan-like, trident. Different shapes and morphology of the cascades have been visualized in Figure 01.

The foundation for the largest part of the country's agricultural production, the village tanks host a remarkable heritage of agro-biodiversity and wild biodiversity and constitute a unique buffer against natural disasters and climate change. As explained by Ranathunga (1970), the village settlements of the cascade ecosystems are 'ecovillages'. The global significance of this system is high due to the practical solutions it provides to absorb shocks of natural disasters such as flood and drought by storing water and reducing the water loss from tanks respectively. The Cascaded Tank-Village System also contributes to efficient water management with water from one tank flowing to another, through a network of tanks and streams (Thennakoon, 2005; Maddumabandara, 1985; Sakalasooriya, 2019).

However, the continuation of the Cascaded Tank-Village System is threatened by the poor income of farmers, rural-urban migration of the youth, deforestation, and the degradation of the tank eco-system. Its protection is integral to ensure the continuity and improvement of the country's food and livelihood security, as well as for sustainable rural development. Some of the significant tank components have been encroached by current profit seeking farmers in market economy and the cascade systems have been collapsing and their future is endangered. Some of the projects which run under the foreign loans or aids, have identified the most vulnerable river basins with minor irrigation systems. Figure 02 shows the most vulnerable river basins which must be renovated under the Climate Smart Irrigated Agriculture Project (CSIAP) funded by the World Bank.

Figure 01 Types of Morphology of Cascade, Helmalu Wew Pokuru, Ellanga



Source: Thennakoon, 2015, Modified by Sakalasooriya 2019

The total identified area by the CSIAP covers nearly 375,000 ha of land in 12 river basins of Yan Oya, Heda Oya, Kala Oya, Kirindi Oya, Menik Ganga, Mandekal Aru, Per Aru, Mundeni Aru, Karanda Oya, Mee Oya, Maduru Oya. These areas fall into 47 agrarian Service Divisions of 35 divisional secretariats in 11 districts namely Kilinochchi, Mulative, Anuradhapura, Puttalam, Polonnaruwa, Kurunegala, Trincomalee, Batticaloa, Ampara, Moneragala and Hambantota. Despite the fact of climate vulnerability, hotspot areas that cut across different administrative boundaries, that involve central, provincial, and district-level stakeholders, and straddle different ministries and departments adding further complexity to the operational management of the area.

Baseline study which was conducted by the CSIAP in these hotspot areas reveals many facts about the identified areas and table 1 shows the present baseline status of the hotspot areas in the 11 districts.

Table 1; Some salient features of the district in DCZ of Sri Lanka

District	% of Households			Average Monthly Income (Rs)	Rice yield t/ha
	Age < 60 years	Education above OL	Farmers		
Kurunegala	67.6	42.7	69.7	21,564	2.98
Puttlam	67.4	35.5	79.0	23,536	2.94
A'pura	75.2	49.1	79.9	38,498	3.40
Polonnaruwa	62.9	29.0	65.8	27,495	4.30
Monaragala	58.1	36.2	79.2	19,414	4.50
Mulative	77.7	43.9	91.2	22,088	4.25
Kilinochchi	72.6	19.2	100	16,911	2.24
Hambantota	60.7	45.8	92.5	19,420	4.00
Trincomalee	78.7	49.2	71.3	19,500	3.5
Batticaloa	77.1	18.8	81.3	13,771	3.3
Ampara	72.3	47.9	68.5	27,911	3.1

*National poverty line in 2019 December is Rs 4939 per person per month according to the Department of Census and Statistics.

NR – Not recorded

Figure 02 Respective river basins and identified Hotspot areas for the CSIAP project

Source: The Proposal of Climate Smart Irrigated Agriculture Project 2020-

Climate-Resilient Integrated Water Management Project CRIWMP) is another ongoing cascade development project. This project proceeds on 03 major river basins which are considered to be the most vulnerable river basins in the DCZ of Sri Lanka as per the climate change impact analysis namely, Yan Oya, Malwathu Oya, and Mi Oya. The project has been implemented over 325 tanks and anicuts of the traditional cascade areas under the Village Irrigation Systems (VIS). This project component, VIS, has been implemented in 05 districts of the DCZ namely, Anuradhapura, Trincomalee, Vavuniya, Kurunegala, and Mannar by UNDP, and 2,400 small tanks have been affiliated to be renovated under the '*Wew Gam Pubuduwa'* program and another Presidential Secretariat sponsored-program which is supported by the Green Climate Fund and UN Development Program (Ceylon Daily News, 2019).

Type of Tanks in TTC and their significant Roles

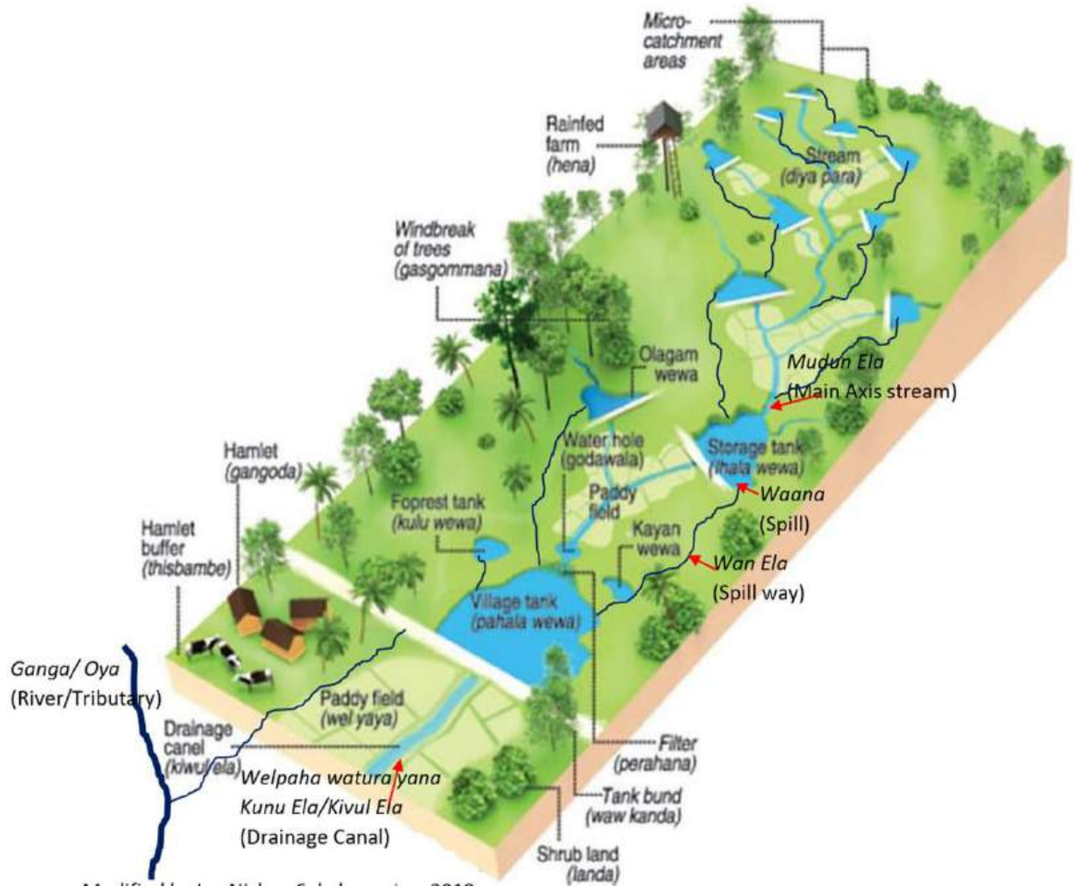
There are different types of tanks in a cascade and they play different roles to sustain the whole cascade system. In case of any damage to any part of the cascade directly malfunctions the whole system of the cascade. Most of the cascades in Sri Lanka have been malfunctioned due to collapsing of different components of the cascades. The PRAs have identified different types tanks in terms of their roles in the cascade ecosystem. All the tanks possess an endemic cultural ecology for sustaining the social-ecological system of the cascades. These tanks have been categorized by the folklore which has been revealed through FGDs, KIDs, and the information verified by the FGDs under life historical method. Some of these tanks habe been difned by eminent researchers of Sri Lanka (Mendis, 2002; Thennakoon, 2012; Maddumabandara, 1985; Panabokke, 1999, 2002, 2009; Dharmasena, 2015).

1. Forest tanks for wildlife, fauna, and flora (*Kulu wew*)
2. The first tank with a sluice after the forest tanks (*Sorrow Wewa*[2])
3. Tanks of Buddhist temple and devotees (*Pin wew*)
4. Tanks for drinking water (*Wathura Bona Wewa*)
5. Tanks for bathing (*Nana wew*)
6. Tanks for Protecting siltation, *(Kayan wew*)
7. Supplementary tanks, (*Olagam Wew, Biso wew)*
8. *Storage Tanks (Gabada wew)*
9. Safeguard tanks (Kalingu wew)
10. The main tank (Maha Wewa)

Figures 03 and 04 illustrate the geographic locations of different tanks in a cascade.

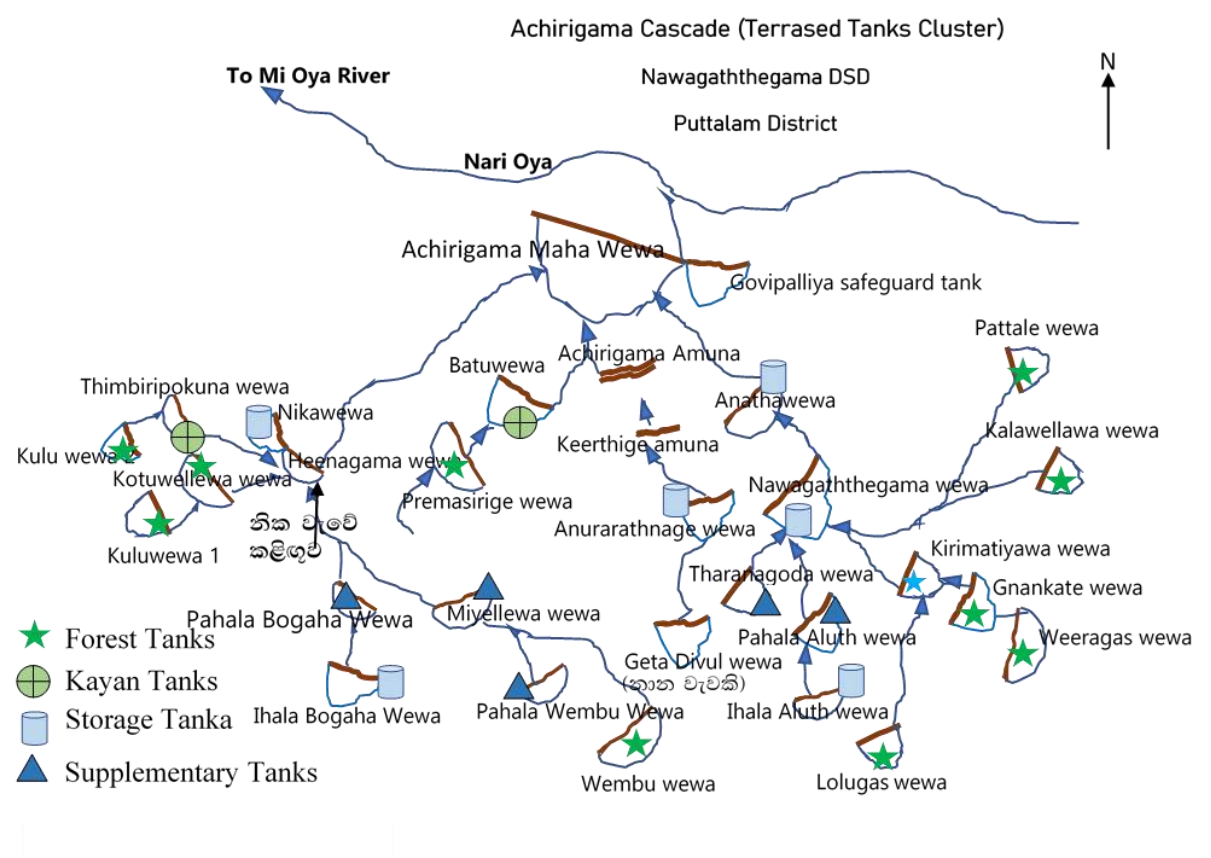
[2] This is defined by Nishan Sakalasooriya, and Lional Thilakarathna in 2020

Figure 03; Major components of a Cascade, (*Ellanga*, *Helmalu Wew Pokuru*)



Source: Modified by Sakalasooriya, 2019

Figure 04; Different tanks of a Cascade; Archirigama Cascade in Puttalam District



Source: Sakalasooriya, N. (2020), Samaja Sameeksha 05, in Vitharana, L.D.S. (ed) (In Sinhala), "Ellanga Hewath Helmalu Wew Pokuru" Samaja Parisarika Paddhathiyak Lesa, (Cascade or Terraced Tanks Clusters as a Social Ecological System, Department of Sociology, University of Kelaniya

In 2016, with the active participation of the village communities, the Ministry of Environment, and the Ministry of Agriculture, over 3,000 forest plants were replanted in the upstream section *(Gasgommana)* and the downstream reservation, interceptor *(Kattakaduwa)* of the Palugaswewa cascade system in Anuradhapura. Globally Important Agricultural Heritage Systems such as the Cascaded Tank-Village System in the DCZ of Sri Lanka have long played, and continue to play a crucial role at the global, regional, and national levels for food security and sustainable development in the context of climate change. Figure 05 and o6 respectively show the nature of forest tanks for wildlife and Kayan Tank for siltation, and figure 07 provides the nature of supplementary tanks.

Figure 05, A forest Tank, *Kuluwewa*, Koon wewa, in Ralapanawa cascade, Karuwalagas Wewa DSD in Puttalam District

Photo Credit: Lional Thilakarathna

Figure 6, A Kayan Tank in Ihala Govi Palliya wewa, Rambewa cascade

Photo Credit: Lional Thilakarathna

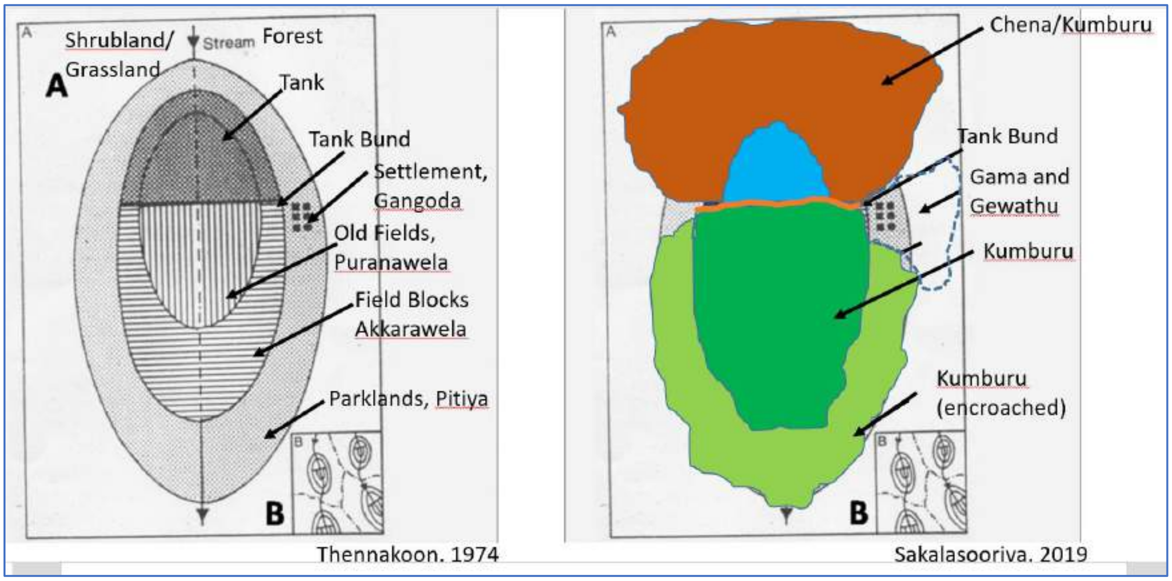
Figure 07, An Olagam Wewa, Ihala Dangas wewa in Rambawewa Cascade in Karuwalagaswewa DSD in Puttalam District

Photo Credit: Lional Thilakarathna 2020

Therefore, it is an essential factor to rehabilitate the physical and biological infrastructure of cascaded tanks to ensure the future existence of tank ecosystems and for the benefit of the communities, animals above and below the ground environments. The village tank is an ecosystem that functions as a unit to provide a range of ecosystem services that are extremely beneficial to humans and other living beings. (See box overleaf for more detail.)

A village tank cascade is a centuries-old ecosystem that has provided villagers living in its surroundings with a suite of life-sustaining ecosystem services for their daily needs such as foods, medicine, and fuelwood; absorption of carbon; purification of water; control of erosion; and stabilization of stream banks. A range of human-induced activities such as deforestation, exploitation of tank catchment & reservation areas, pollution due to agricultural activities, and the spread of invasive alien species have affected to cause damages to the cascaded tank ecosystems. Figure 08 show the transformation of cascade ecosystem during the last 45 years, 1974-2019. Due to the population growth and lack of income sources, cascade villagers have encroached the interceptors, tree belts, filters and catchments areas of the tanks and cascades.

Figure 08, Old and new cultural ecological system of the cascades, Ellanga



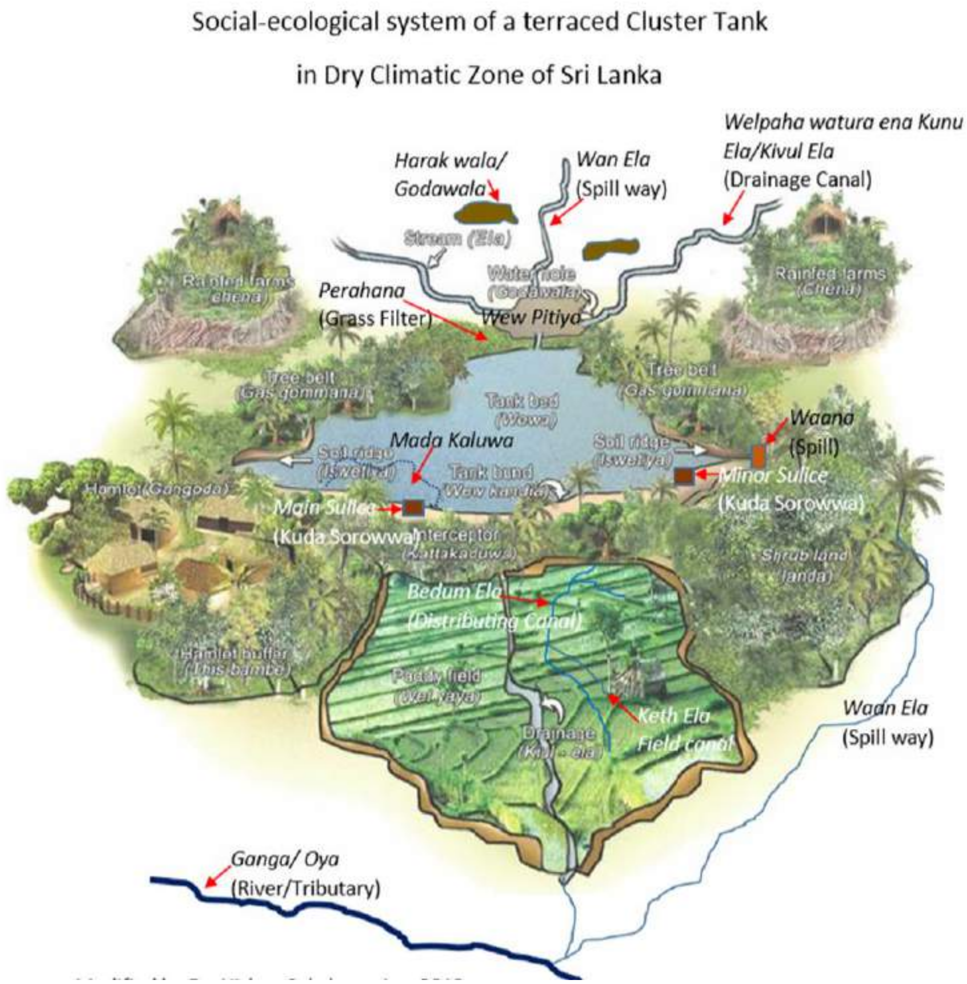
It is urgent to rehabilitate these tanks and restore the cascade ecosystems to a considerable extent to ensure the livelihood of tank villagers, as most of the tanks are abandoned or highly damaged by encroachers.

During the PRAs, the study has identified 42 components of the cascade ecosystems and every component of the ecosystem was well planned for a diverse range of benefits for the people and the environment linking the culture and ecology.

A tank ecosystem includes the following components.

- Tank bed
- Tank bund
- Upstream reservation
- Upstream water hole to trap sediment.
- Upstream earth ridges to prevent sediment inflow
- Downstream reservation
- Command area drainage
- Downstream sanitary cordon

Figure 09, Main components of a traditional Tank Villages of a Cascade



Dharmasena 2010, Modified by Sakalasooriya, N. 2021,

The tank beds, and Dead storage phase (*Mada Kaluwa*)

The tank bed consists of four storing phases of water mass as dead storage, deep phase, shallow phase, and the high flood phase. Water in the dead storage cannot be used to irrigate paddy fields. When the tank gains its full supply level, this phase lies in the deepest water column. During the dry period, this small water body supports the surrounding vegetation by maintaining the groundwater level for the survival of the fish population, water for cattle, and even for wildlife.

Figure 10, Dead storage phase (Mada Kaluwa) of Udakadawala Tank in Pulugaswewa Cas cde

Photo Credit; Mihiri Wijesinghe 2020

Deep phase (*Diya Giluma*)

This is the central part of the tank bed. Water lilies and lotus grow in this area. In the traditional system, people conserved this water mass for Yala cultivation by making maximum use of rainwater for Maha cultivation. The largest amount of sediment is found in this phase. In partial de-siltation, this sediment mass is removed and heaped up as mounds in the upstream area (shallow phase).

Shallow phase (*Wew Thavula*)

This is the upper part of the tank bed. Water spreads as a shallow layer. Aquatic plants grow in this area. Birds roam in this area for catching fish. In the traditional system, people practiced tank bed cultivation (*Thavulu Govithena*) during low rainfall seasons by constructing a soil bund along the lower boundary of the shallow phase. When they needed to use the tank water for the Maha season, they used this water mass, which would anyway disappear during the first inter-monsoon (January – March) period. Sediment removed is heaped up in this area making habitats for many birds — such as egrets, herons (*Koka*), jacanas (*Diyasaana*) and coots (*Kithala*) as well as for the other aquatic species. Swamp barb (*Puntius thermalis*; *Kota* pethiya), Tic tac-toe barb (*Pethia melanomaculata*; *Tithpethiya*), and juveniles of various Rasbora and Devario species are found in the water volume of the shallow phase.

Figure 11, Shallow Phase, Wew Thavulla

Location: Palugaswewa, Palugaswewa Cascade, Habarana

High flood phase (*Waan Gilma / Mattama*)

This is the area between full supply level (FSL) and high flood level (HFL). This area is the Upstream of the tank bed. When tank spills, various floating seeds move to this area and sink in the mud when the water level depletes. Ultimately a strip of trees and bushes emerges in this area. This is called tree belt (*Gasgommana*) which acts as a windbreak and reduce the water evaporation of the tankas. The undergrowth becomes a meadow called 'filter' (*Perahana*). During the high flood phase fish species such as Shark catfish (*walaya*), Butter catfish (*Walapoththa* or *Kokussa*), and eels (Aandha) live in this habitat.

Figure 12, The tree belt that grows in the high flood phase

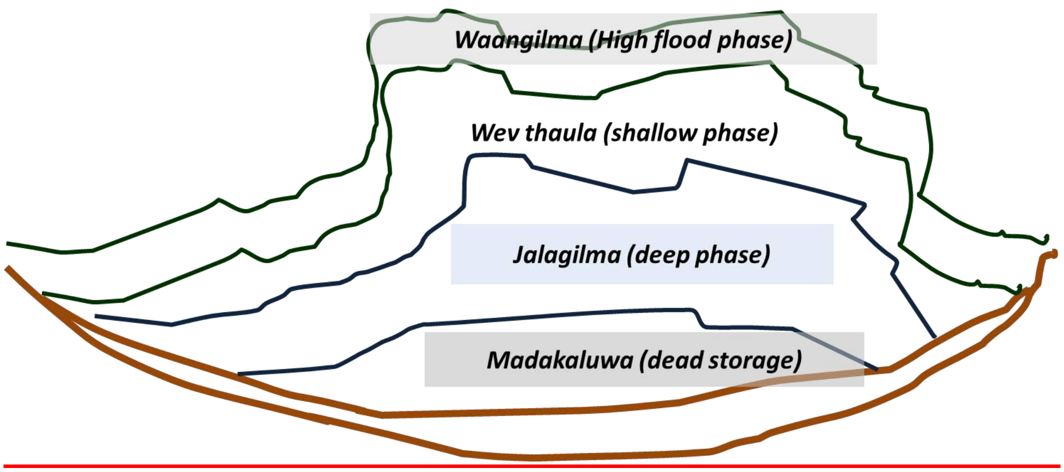


Figure 13; Four phases of the traditional tank

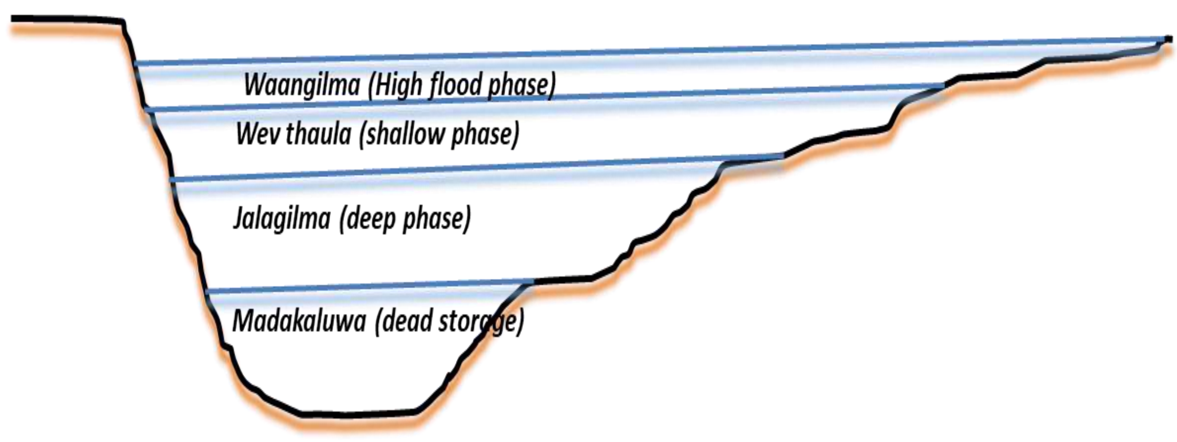


Figure 14, High flood phase (Waan Gilma/ Mattama), Pahala Ralapanawa Wewa, Ralapanawa cascade, Puttalama District,

Photo Credit: Lional Thilakarathna, October 16, 2019

Tank bund

Minor irrigation tanks are constructed by placing an earth bund across a suitable location of a natural waterway. The bund is strengthened through compaction of the soil. The community maintains the bund by clearing the vegetation and repairing any damaged places annually. To prevent the bund from breaching, villagers traditionally planted *Pandanus odoratissimus* (*Wetakeyiya*) at the toe of the bund, where the breaching risk is high because of accelerated seepage from a weak point. Cattle herds are not allowed to cross the bund. *Borassus flabellifer* (*Thal*) is planted along the bund. Elephants are reluctant to cross the bund due to Pandanus and *Borassus* growing on the tank bund.

Many plant species which are used by the villagers as fruits, vegetables and medicine are found on the tank bund, including *Ziziphus oenoplia* (*Eraminiya*); *Aerva lanata* (*Polpala*); *Acalyphaindica* (*Kuppameniya*); and *Calotropis gigantea* (*Wara*).

Upstream reservation, Tree belt and Filter

The tree belt, buffer zone for winds called *Gasgommana* possesses a naturally grown vegetation in the upstream land strip *(Waan gilma)* above the tank bed, accommodating water when it spills. The tree belt acts as a wind barrier reducing evaporation from the tank and lowering the water temperature. The roots of large trees make water cages on either side of the bund, creating breeding and living spaces for some fish species. This strip of trees demarcates the territory between humans and wild animals.

Large water-tolerant trees such as *Terminalia arjuna* (*Kumbuk*), *Vitex leucoxylon* (*Nabada*, *Bauhinia racemosa* (*MailaSyzygium gardneri* (*Damba*), and climbers such as *Phyllanthus reticulatus* (*Kaila*), *Caesalpinia bonduc* (*Katukeliya*), *Derris parviflora* (*Kalawel*;) and *Derris scandens* (*Bokalawel*) are found in this area. Barking deer (*Vali muva*), wild boar (*Wal oora*), sambur (Gona), wild buffalo (Mee haraka) are also found here, and elephants also roam in this area. The filter or *Perahana* is the meadow developed under the tree belt which filters the sediment which flow from upstream chena lands.

Figure 15; Filter, (Perahana), Koon wewa, Ralapanawa Cascade

Figure 16, Gasgommana (Tree Belt) and Perahana (Filter) of Kadapaslapu Wewa

Photo Credit: Lional Thilakarathna 2019

Upstream water hole to trap sediment (*Goda wala*)

Villagers construct a water hole above the tank bed area located at the entry point of the main inflow stream. This human-made water hole aims to trap sediment and it also provides water to wild animals. This might have been used as a strategy to evade human-animal conflict. During the periods of dry weather, any rainfall does not generate much runoff, but some water can be collected in this water hole to benefit wild animals. The sediment filtering action of this structure is of particular importance and keeps the tank free of sedimentation.

Upstream

Upstream earth ridges to prevent sediment inflow is called *Iswetiya.* Tanks are generally constructed at a confluence of the stream network to reduce the bund length. For the same reason, the land slope of both sides of the upstream area is relatively high. There is, therefore, a risk of sediment inflow from these areas into the tank. In the past, soil ridges known as *Iswetiya* or *Pota Wetiya* were constructed to minimize this sediment inflow. In present tank systems, *Isweti* are hard to be found. The importance of having this structure is evident as many tanks have been heavily silted up because of the absence of *Perahana, Godawala, and Iswetiya*.

Figure 17; An Olagam tank with damaged filter and Iswetiya of Ihala Wewa in Rambawewa Cascade in Karuwalagaswewa DSD

Photo Credit: Lional Thilakarathna 2020

Downstream reservation or interceptor (*Kattakaduwa*)

This is the reserved land below the tank bund. It consists of four micro-climatic environments:

1) Water hole (Pond)

2) Marshy land

3) Moist land

4) Dry upland

And therefore, diverse vegetation is developed. The interceptor forest is a natural bio-filter that traps impurities such as salts and metal ions in the water before it irrigates in to the low-lying Paddy tracts. The thick root system of trees and shrubs act as a protective cushion for the sloping land. Well-developed interceptor forests provide convenient resting sites for birds, bats, reptiles, and amphibians.

Common tree species in this patch of the small forest include; *Barringtonia acutangula* (*Midella*), *Borassus flabellifer* (*Thal*); *Diospyros malabarica* (*Thimbiri*); *Ficus benghalensis* (*Nuga*); *Ficus racemosa*, (*Aththikka*); *Hibiscus tiliaceus* (*Belipatta*); *Madhuca longifolia* (*Mee*); *Margaritaria indicus* (*Karau*), *Nauclea orientalis*, *Milletia pinnata* (*Karanda*) and *Terminalia arjuna* (*Kumbuk*). The bund seepage by raising the groundwater table. Villagers plant *Pandanus odoratissimus* along the toe of the bund to strengthen the bund stability.

It appears to be a village garden, where people use various parts of the vegetation for numerous purposes such as to obtain food, fruits, vegetables, firewood, medicine, timber, fencing materials, household, and farm implements. Specifically, they harvest raw materials from this vegetation for cottage industries.

Table 02, List of plants species in the Kattakaduwa and products derived from them

Scientific name	Sinhala name	Product(s)
Phoenix pusilla	Indi	Product(s)
Pandanus odoratissimus	Wetakeiya	Bags, baskets, mats
Bambusa vulgaris	Katu-Una	Wood carvings, flower vases, building materials
Calamus rotang	Heen-wewel	Baskets, furniture
Borassus flabellifer	Thal	Mats, bags, baskets, sweets, toddy
Hibiscus tiliaceus	Beli-patta	Ropes, strings

Figure 18, Tank Embarkment, (*Wew Bemma*), and Interceptor (*Kattakaduwa*) Location:

Wetiya wewa cascade, Katapaththa wewa, Puttalam District

Photo Credit: Lional Thilakarathna 2019

Note: Part of the interceptor has been encroached by the farmers in this tank

Command area drainage (*Kiwul ela*)

The Kiwul ela removes impurities such as salts and ions and improves the drainage of the paddy tract. Tree species such as *Milletia pinnata; Madhuca longifolia, Cyperus pangorei, Hygrophila schulli* (Katu Ikiri), Pandanus and a few species of small fish such as the Malabar danio, *Devario malabaricus*, (*Rath kailaya*), *Carverii Rasbora*, *Rasbora microcephalus* (dandiya), *Rasbora dandia* (*Kehel Dandiya*) and the Common spiny loach (*Lepidocephalichthys thermalis* (*Thith Ahirawa*) are also found in the water holes along the main drainage of the command area called *kiwul ela*.

In water management, drainage is as important as irrigation. The absence of proper drainage facilities in many irrigation schemes in Sri Lanka has led to the development of salinity in Paddy fields. At present, it is hard to find drainage in minor irrigation schemes to dispose the excess runoff from the command area. During the period of cultivation, any excess water in the field should be removed at a safe velocity but rapidly. Thus, the presence of common drainage is essential for irrigable paddy fields.

Traditional Sluice gates (*Keta Horowwa*)

The Chronic Kidney Disease (CKD) is very common in the DCZ of Sri Lanka. Some of the scientists refer it as Chronic Kidney Disease of unknown etiology (CKD). Alternate suggested names for this condition include Chronic Agricultural Nephropathy (CAN) and CKD of multifactorial origin (CKD-mfo). Similar entities with unknown cause for CKD exist in other parts of the world. Environmental agents and conditions such as heavy metals and industrial chemicals, have been linked to the development of CKD in the other parts of the world (Soderland P, Lovekar S, Weiner DE, Brooks DR, Kaufman JS., 2010). In the cascade villages, there were two traps in the tanks as interceptor and sluice gates to filter the heavy metals present in water. As explained earlier in this article, interceptor is swampy as the seepage of the tank's bottom water deposits in the interceptor while blocking the heavy metals from entering the paddy fields. The second trap is the traditional sluice which is difficult to be seen currently due to replacing it with modern sluice gates. These traditional sluices discharge water from upper areas of water body of the tanks. When water level goes down, one piece of the sluice can be removed (Figure 19). Hence it works as filter for heavy metals. Anyhow, the modern engineers have introduced a new sluice which discharge water from the bottom of the tank.

Figure 19; Traditional Sluice of small tanks in Cascades called *Kete Horowwa*

Photo Credit; Nishan Sakalasooriya 2020

Figure 20; Place of Village Gods and problem-solving or conflict resolution place of the village called *Sanhinda* Ralapanawa Maha Wewa, Ralapanawa Cascade, Puttlam District

Photo Credit; Lional Thilakarathna 2020

Small temple of Gods of Village (*Sanhida*)

The tanks village settlers of the DCZ believe that the nature and Gods protect the village and sustain their livelihood and harvest. They believe that all the specific activities of the village run under the wishes of nature and Gods. The villagers select one of the largest trees on the tank bund as Tree God (*Vrucksha Deviyo*) because they believe that trees protect the village life and livelihood, and they build a small place for other Gods who protects the village and livelihoods under this tree (Figure 20). Before starting all the common works of the village or command area, all the farmers usually gather to this place and discuss. Sometimes this place works as the village's court of law. Everyone who seek justice for private or common issues complain the issue to the village headman and he command all the settlers to meet at *Sanhinda* and find the justice.

Conclusions

According to the study, it is very clear that the relationship between the culture and ecology of the cascade systems has significantly collapsed and majority of the components of the cascades are malfunctioned or destroyed. Due to this divorce between ecology and culture of the cascade systems, both the settlers and the cascade ecosystems are malfunctioned. Consequently, the settlers have been suffering in different ways. On the other hand, as the study discloses that the successive renovations which have been done by different authorities including farmer organization, have continuously damaged the original functions of the cascade ecosystems and cultural integrity of the cascade settlers. One of the major issues of the cascade renovations is renovating individual tanks instead of cascade system renovations.

All the tanks, inside and the outside of the cascades should be renovated as a system because it is one of the answers for the drought, flood, animal invasions, elephant and other wild animal attacks and economic resilience of venerable settlers. Elephant attacks significantly damage to the livelihood and the social system of cascades. Therefore, without controlling elephant attacks and other wild animal invasions, it is difficult to expect to make a resilient society from cascade renovations as the elephants destroy the crops. Without renovating the forest tanks, it very difficult to provide water and food inside the forests for wild animals. This study recommends renovating the cascade system under the system approaches and with good enough understanding about the indigenous knowledge, skills, techniques, and philosophy behind the traditional cascade systems in DCZ of Sri Lanka.

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