Evolution of Cascade or Networked Small Tanks Systems in Sri Lanka and its Sustainable Water Management

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Introduction

The main reason for the formation of organized settlements in the plains and Dry zone of Sri Lanka was the small-scale rural tanks constructed using the region's landscape to overcome water scarcity and environmental challenges. Initially evolving into micro-irrigation structures, these tanks were systematically interconnected and formed into network tank systems. These networked tank systems are considered an identity factor of Dry zone irrigation water management in Sri Lanka. This paper focuses on the origins and evolution of these networked tank systems, commonly referred to as *Cascade* by scholars. It explores their contribution to dry zone microbial management sustainability in Sri Lanka.

Objective

The primary purpose of presenting this paper is to discuss the origin and evolution of networked tank systems based on rural tanks that can be considered as the heart of the dry zone of Sri Lanka. Although much research has been done on these rural tanks in various fields, little attention has been paid to their origin and evolution. The intention here is to cover that gap to some extent.

Discussion

Sustainability of networked tank systems

The dry climate associated with this region has directly impacted the settlement of the area and the socio-economic process. It can seem that the contribution of these networked tank systems to the development of a sustainable agro-economic model based on paddy cultivation has been more significant than that of the large scale irrigation industry. It has been able to meet the climate challenge in this region successfully.

The construction of small tanks in the Dry zone of Sri Lanka begins as a result of the ancients' understanding of the landscape suitability for irrigation in the area. An examination of the identifiable archaeological evidence in this regard reveals that the phenomenon dates back to the Proto-Historic Period (1000 B.C. – 100 A.D.) in Sri Lanka. Rainwater from the country's Dry zone has been collected and used since ancient times by these small network tank systems, which still operate as the leading water supply network of the region (Withanachchi, 2017).

After the dry season is the country's primary rainy season, the period between September and December is when these small networked tank systems become more active. In ancient times, these networked tanks began to function by adding rainwater that had filtered somehow (Geekiyanage, Pushpakumara, 2013: 94). At present, these tanks filled with water flowing through various fields for a short time as the tanks associated with have cleared during settlement.

There are various theories as to the origin of these networked tank systems. It is generally accepted that these tanks were created and developed during the Anuradhapura period (300 BC – 900 AD).

However, our research shows that their origins date back to the fourth century B.C.

The Kok Ebe megalithic burial site is an Iron Age site located on the banks of the Yan Oya (*Oya* means River) in the Anuradhapura District, which was excavated by a team including the author, where Carbon 14 dates were obtained (Withanachchi, 2017; Withanachchi, C.R., Mendis 2017). The RUSL/KA/EX01/2016 sample from this excavation dates back to 790 BC, and the RUSL/KA/EX03/2016 sample dates to 770 BC (Withanachchi, C.R., Mendis 2017). Assuming that the leadership and workforce found in the prehistoric megalithic culture of Sri Lanka are the same groups, it seems that a simple connection can be made to the small tanks associated with these excavation dates. Accordingly, it can be assumed that the construction of the small tanks related to this area dates back to the 8th century B.C. One of the samples excavated at this site in RUSL/KA/EX01/2016 confirms that this settlement process continued according to Order 50 (*ibid*) of the year 50 AD. In comparison, the design of small tanks is likely to continue to develop. It may have contributed to the emergence of network systems associated with these tanks.

Further, in collaboration with the author, another research team obtained an absolute chronology of silt deposits by drilling the beds of several tanks in the Rotawewa cascade system near Kahatagasdigiliya, Anuradhapura District in the year 2010/2011 (Schütt et al. 2013: 51-68). Accordingly, regulations for silt deposits in those tanks have received up to 8095± 63, 3398 ± 34, 7908 ± 92, 2985 ± 66, 7364 ± 46, 1085 ± 53 today (*ibid*). Most of these dates belong to the prehistoric cultural periods of the country. The assumption that can be made based on this information is that it gives an idea of the terrestrial fossils formed naturally during the Holocene. Natural habitats such as landslides may have gradually become tanks during human intervention.

Some documents state that in ancient Sri Lanka, there were more than 30,000 rural tanks (Mendis 2003). At present, there are about 10,000 small tanks in use in the Dry zone of Sri Lanka and (Vitharana, 2000), with a large number broken up and abandoned. Most of the water from the remaining small tanks is used primarily for agriculture but is less regularly used at present. Decades ago, the water in small tanks were widely used for daily activities, but at present have been reduced due to wells and other water supply schemes.

At present, 1,166 cascade or networked tank systems have identified in the Dry zone of Sri Lanka, with 457 of them located in the Anuradhapura District of the North Central Province alone. (Vitharana, 2000). These tank systems can be grouped as small, medium and large scale tanks, with some networked tank systems connecting up with a large-scale tank.

These networked tank systems seem to reflect the traditional knowledge of the micro-irrigation industry in the country, where the gradual development with experienced gained is explicit. Experience from the environment in particular, can be seen to have directly influenced the emergence of these irrigation schemes. The ability to establish these tanks to suit each ecosystem is a testament to the ancient people's skill; as it is evident from the ancients' ability to gradually transform the small tank into a large tank and a medium scale tank.

Focusing on the natural activities that led to the formation of the network of tank systems, it appears that the environmental and climatic problems in the Dry zone of the country may have been fundamental. Examining the river valleys' present ecological conditions such as the Deduru Oya, Mee Oya, Kala Oya, and Malwathu Oya confirms some river valleys in the Dry zone of Sri Lanka have felt this situation more severely. Among these are the lack of adequate rainfall, the scarcity of water sources, the high level of evaporation, the high temperature, the dry nature of the environment, the strong dry winds and the inadequacy of water in natural waterways. Apart from the dry conditions that arise based on such conditions, many factors, including landscaping and soil distribution, may have contributed to the Dry zone settlement in Sri Lanka from an early stage in its suitability for agriculture (Withanachchi, 2018).

The ancient people's feelings about the dry nature of the Dry zone may have existed in various forms. It is clear that the ancients' diversity of technology to minimize that condition and build life dates back to the earliest times. They seem to have adapted to society's primary economic process which has always been built on an agriculture-based on paddy cultivation. Overcoming the challenge posed by the dry and arid nature, measures have been taken to introduce artificial irrigation systems in the region. To meet the water shortage, the ancients used the Dry zone's geophysical location to prepare the primary water bodies at the beginning, store the water in them, and utilize it when needed.

The formation of networked tank systems in the Dry zone of Sri Lanka is mainly due to the lowland areas with contour diversity that naturally occur in the plains. In practice, such places are called *pathas* (natural water holes). Rainwater collects in low-lying areas associated with an undulating terrain in the natural plains, or low-lying areas associated with not-so-high natural rock ridges, or at the foot of a large rock plateau, creating natural pools. Such natural sites were utilized for water collection since the beginning of the Proto-Historic Period.

Before constructing the tank, the early historical people who lived in Anuradhapura may have built at first a small tank and used it. Commenting on the Early Historical Period, Seneviratne (1984) points out that the people who lived during that period may have built tanks with hand-made dams using the low-lying lands where natural water features met. The *Deeghapashana* (Long rocky ridge, Pre Cambrian stone ridge -The landscape formed with this continuous range from prehistoric to proto historic times was a decisive factor in settlement of the area around the ancient city Anuradhapura), which runs through the ancient city of Anuradhapura, is somewhat elevated. Part of the North-West is situated on a rocky outcrop, creating a variety of contours. It makes low-lying areas where water naturally collects.

The chronicles mention the conversion of the natural plateaus in Anuradhapura into tanks. The oldest tanks in Anuradhapura, Abaya Wewa (tank) (Basawakkulama Wewa) and Gamini Wewa (Bulankulama Wewa), can be identified as the first tanks built based on such a landscape. Accordingly, the small tanks that were the basis for creating the network tank system were developed based on natural water bodies.

Although there are not many small tanks in chronological sources, contemporary inscriptions can uncover much information. It is conceivable that these small tanks may have made a direct contribution to the later development of networked tank systems. Accordingly, the widespread use of traditional knowledge can be identified through this. It is clear that even in the present day, where large scale irrigation industries are active, the central water supply system in the Dry zone rural societies is the network of tanks based on the small tank and the large tank. It may be because the installation of those irrigation systems is well suited to the utility.

The Yan Oya valley is an example of this. Most small, large and medium scale tanks associated with this valley belong to any networked tank system. About 80 such cascade tank systems can be identified in the Yan Oya valley (Vitharana, 2000). Focusing on the distribution of networked rural small tanks in the valley, it is clear that it had developed to find a sustainable solution to the prolonged drought that lasts from May to about the end of September each year. It is a well-known fact that the water in the Yan Oya vicinity is not sufficient for use in such times. Accordingly, although farming was not done during this period, it was essential to find solutions for this valley's people's other water needs. This background may have contributed to the development of networked tank systems in the valley.

As shown by Panabokke (2009), the ancients used advanced iron tools to excavate upto 1.5m to 2m of the dry rock layer of the natural lowlands in the Dry zone. The small natural water holes associated with the Dry zone may have been converted into tanks. Groundwater levels rise due to the constant circulation of surface water during the maintenance of network tank systems over a long period. It completely changed the environment in those areas. By the middle of the Anuradhapura period, when these networked irrigation systems were in good working order, the period's milder wet climates may have been better than they are today in the country's Dry zone. However, due to proper maintenance, many networked small tank systems' efficiency gradually deteriorated. As a result, people were increasingly turning to groundwater, which in turn depleted the groundwater resources (Withanachchi, 2017). It affected the vegetation of the region and the long-term crop growth, resulting in the formation of nature in the terrestrial environment.

Sustainable management of natural resources is essential, especially for striking a balance between urban and rural areas (Senavirathna, 1996). Contemporary inscriptions confirm that the sustainable management of natural resources was better done in ancient Sri Lankan society than at present. Inscriptional evidence shows that the iron industry and the gem industry had spread to various parts of the island. From the chronicles, it is clear that the political authorities took steps to manage the Dry zone's water and natural resources in a balanced manner up to to the Polonnaruwa period. It enabled the large scale irrigation industries built from the Inter-zone to the Dry zone to ensure fair access to water resources in all areas. By the middle of the Anuradhapura period (600 AD – 900 AD), an organized programme was underway to divert water from the valleys with more water to the valleys with less water by building inter-valley connections.

It is conceivable that the contribution of these large-scale irrigation schemes to the nutrition of networked small tank systems may have been significant. Although it does not apply to all networked tank systems, this activity is high in networked mini-tank systems associated with large-scale tanks that can supply water to small tanks and areas where natural waterways have completely activated due to large-scale irrigation. May exist. Small networked tank systems adjacent to the extensive irrigation canals, especially in the Deduru Oya, Kala Oya and Malwathu Oya valleys, may have been activated in this manner. Such networked small tank systems supply water through active irrigation canals in the Mahaweli movement found in several farming areas in the Mahaweli movement.

The collected water through small tank systems contributed to all water-related activities in the rural society. If small tanks had not been built in ancient times in the Dry zone ecosystem of Sri Lanka, the environment associated with those areas would still be very dry today. With the construction of small tanks and over time, they become networked systems, thereby improving water security and efficiency. Due to this network of tank systems, it is possible to build an aquatic ecosystem in the country's Dry zone. It can seem that this situation has contributed significantly to the formation of organized human settlement in this region. It has led to the activation of micro-watersheds in dry regional landscapes. These small tank systems, mainly based on small waterways activated by the northeast monsoon rains and based on natural landslides, have been active in the past and in the present, in stabilizing the rural settlements in the Dry zone of the country and developing their sustainable livelihoods.

When closely examining these small networked tanks, it is clear that they weren't built at one point in history. The country's Early Historical Period has been identified as the initial stage of these tanks (Withanachchi, 2017), and they have been subjected to various levels before. Some tanks may have been abandoned during specific periods, during which time other tanks may have been built at different locations. Nevertheless, over time, the tank has become an active part of its integration with the ecosystem (Madduma Bandara and etal., 2010).

About 18,500 of the 22,000 tanks and reservoirs in the Dry zone cover about 2/3 of the island's total land area. Of these, about 12,000 small tanks have been destroyed or abandoned. The remaining small tanks feed 185,000 hectares, which is about 35% of the cultivable land area. These tanks' size contributes 20% directly to national rice production (Awusadahami, 2010). It can be possible that in ancient times there was a maximum of activity here.

One of the main distinguishing features of the small tanks in the country is that it has been established with great care for the natural environment as it is part of nature itself (*ibid*). One of the main reasons why this system has existed for more than two thousand years in the course of climate change, and political and social change from prehistoric times to the present, is that it has been a part of nature itself.

When we look at the traditional ecosystem associated with the old Cascade tanks in Sri Lanka and other structures related to the tank, it is clear that most of them are fully established in the vicinity of these small tanks in the past and, to some extent, can be seen in the setting of individual tanks today. The landscape is being updated and continues to change. However, with the rapid destruction of the ecosystem associated with these tanks in the current settlement process, it is questionable as to what extent these small networked tank systems will achieve the right results that the ancients had hoped for. An excellent example of this is the adverse effects of the absence of many small tanks today, such as the *Isweti*, *PotaWeti* and *Kattakaduwa*, which in ancient times were located near the surface of a small tank.

Due to the *Iswati* (soil ridges) associated with the tanks found in the Cascade tank system and the small bushy environment in the *Tawalla* (upper inundation area; floods during rain and drained off during drought) area, the accumulation of sand, silt and other contaminants in the tank is minimized; its name is *perahana* (filter). Due to the leachate at the bottom of the tank wall, the surface water is free from heavy metals. It can be obtained for cultivation by leaking the rust-like impurities at the tank's bottom. However, due to the establishment of settlements in the tank's upper *Thavalla* area, the water containing the above effluents enter the tank directly. Because of the removal of *Kattakaduwa* (interceptor) and the preparation of paddy lands up to that point, it is possible to identify many instances of crop failure due to the infiltration of rust and various heavy metals into the paddy fields, which had been deposited at the bottom of the tank (Dharmasena, 1994; 2010).

Small tank systems indeed protect groundwater levels. Even today, the ecosystems associated with such tanks are fertile and vital due to the groundwater protection provided by the environment for vegetation and long-term crop cultivation. It is clear that wherever these tank systems' activity has been broken down, the landscape takes on a dry, rough shape due to the shallow groundwater level in that area. Accordingly, the circulation of water associated with these tank systems is one reason why the Dry zone aquatic civilization's vitality remains more robust than it is today.

The guardians of these tanks formed in the country's Dry zone ecosystem were the villagers (Ausadahami, 2015). From the Anuradhapura period onwards, these tanks connected with the country's ancient society was a formal mechanism designed to maintain their benefit. *Vapi Hamika*, *Vavi Hamika* (*IC*. vol. I: Nos. 1122, 1130, 1132, 1151, 1153, 1200, 1217-8, 1225, 1250) mentioned in Late Brahmi inscriptions was the legal officer who carried out that function. He was probably an aristocrat who was appointed to the post from the village. Some inscriptions reveal that some *Parumakas* and *Gamikas* acted as *Vapi Hamikas* (*ibid*).

Small tank systems and single tanks were the lifeblood of the ancient rural society. It was also active during the Kandyan Kingdom and the subsequent British rule in the Dry zone. Among the various measures taken on Governor Robert Brownrig's instructions to suppress the popular uprising known as the 1818 rebellion, which began in the Uva-Wellassa region (which includes part of the Dry zone), there are reports of the need to destroy irrigation canals, tanks and canals (Marshall, 1846: 187-88; Wimalananda, 1970). Colonel Campbell reports on the actions taken to control the power of the people of Wellassa; which were the cutting down of coconut trees, demolishing of large canals and bunds and abandonement of paddy fields (Campbell, 1843). He noted that the bunds were essential for water retention and that they could take years to repair. These reports show that the destruction of irrigation canals, including small tanks in the lowland Dry zone, had dampened their activity. It is understandable how strongly they have associated with people's lives. Evidence of a large number of small tanks that were destroyed can now be seem in the area. It is clear that the current dry nature of the Wellassa area, which represents the area of Bibila in Monaragala District, results from the destruction of these irrigation canals.

Most of the major irrigation systems in the Dry zone of Sri Lanka may have declined after the abandonment of the Kingdom of Anuradhapura in 1017 AD and the fall of the Kingdom of Polonnaruwa in 1236 AD. However, there are no reports of small tanks and associated systems being destroyed or abandoned. Large irrigation canals have gradually degraded due to the breakdown of existing mechanisms, but small tanks have survived due to the rural people's ability to maintain them. Thus, it is clear that small tanks and their associated systems have continued to exist from the beginning. They are sustainable due to their small size, simple technology, and ability to be maintained in small groups. Sri Lanka's Dry zone networked tank systems are deeply linked to these regions' socio-economic and environmental processes. Accordingly, these small tanks have been the main contributor to the continuation of the contemporary sustainable development built up with the ancient socio-economic process. The result of agriculture and the development of all society sectors build a tolerant mindset and integrity in the people's resulting self-sufficient economic process. Evidence from contemporary inscriptions confirm that the people who lived in the periphery areas, who contributed to maintaining a large capital such as Anuradhapura, primarily formed the economic process based on these small tanks.

King Parakramabahu I (1153-1186 AD) had renovated 2376 small tanks of Polonnaruwa according to the chronicles. It is clear that in the present, the majority of the people in the Dry zone live in these small tank-based rural areas. Due to their contribution to the country's development, the tanks have rehabilitated, and the people's living standards have maintained.

Although the kingdom of Anuradhapura collapsed during various periods of political turmoil, with the capital being destroyed on several occasions, no evidence points to the collapse of rural societies. The main reason for this seems to be the small tank systems developed in rural areas. It enabled rural people to continue their livelihood activities with access to water.

Conclusion

The main objective was to investigate the social and environmental factors that are fundamental to the sustainability of many small rural tanks and associated network tank systems found in the Dry zone of Sri Lanka. Based on field studies and data from various sources, this study confirms that small tanks in the country are a sustainable solution to water scarcity. It is clear that these small tanks' construction further secured their stability due to the utilization of natural landforms found mainly in the dry plains. The technical ability of the ancient people in selecting such sites is also significant. With these small tanks' gradual development, their functionality has become more active as they have become networked tank systems.

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