Importance of Cascade Systems (ancient irrigation systems) in Sustainable Development of Rural Communities in the Dry Zone of Sri Lanka (a review of the previous studies)

Saseeka Wijesekera

Introduction

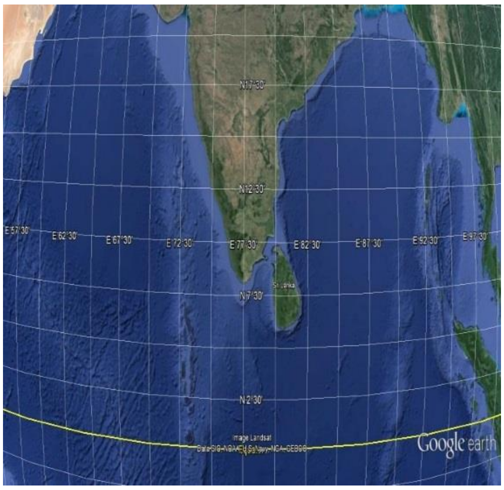

Figure 01**: Geographical location of Sri**

Sri Lanka is an oceanic tropical island in the Indian sub-continent, located at 5_540–9_520N ncnbcb79_390–81_530E. The total land extent of the country is 6,570,134 ha which consists of central highlands with an altitude of more than 2500 m above mean sea level. The central mountain ranges are surrounded by broad lowland plains which include both dry and wet climates. The population of the country is 21 million at present with a population density of 333 persons/km2 and the growth of population has been declined to 1–1.3 percent during the last decade (Geekiyanage & Pushpakumara, 2013).

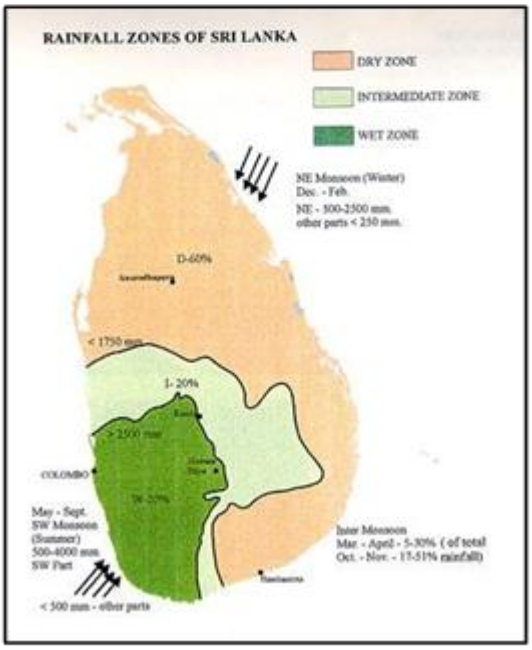

Figure 02: **Climate Zone of Sri Lanka**

Source: http://www.ssssl.org/activities.htm

Sri Lanka's climate can be described as tropical and quite hot. But this tropical island climate has been categorized into three main zones as Dry zone, Wet Zone and Intermediate Zone (Figure 02). The dry zone of Sri Lanka is located within the lowest peneplain of the island and consists of a gently undulating to undulating land surface, or a “planation” surface that is characterized by the occurrence of a large number of small inland valleys. A topography of this type is ideal for the construction of such small reservoirs or tanks, especially when the underlying basement rock is highly impervious and the overlying weathered rock and soil are usually shallow to moderately deep. The mean annual rainfall of the dry zone is less than 1,250 mm and this amounts to approximately 800 mm for most of the dry zone. During the North East Monsoon period (from October to January), 80 percent of the annual rainfall is received as the main rainfall season. South-West Monsoon period (May to September), the dry zone falls within the rain shadow, and this results in a protracted dry period with strong desiccating winds and daily evaporation rates of between 5.5 mm to 7.0 mm. The annual average evaporation in the dry zone is between 1,700 mm and 1,900 mm, which exceeds the average annual rainfall, implying water stress during this part of the year (Panabokke et. al., 2002).

The dry season in the dry zone is plagued by chronic and recurrent droughts and desiccating winds while the seasonal flooding dominates the rainy season. The water problem was further aggravated by the low water retention capacity of the unique soil group (reddish brown earth) which dominates most part of the dry zone. Further, prolonged droughts lower the groundwater table, so that, water is inaccessible for wildlife and large scale agriculture (Geekiyanage & Pushpakumara, 2013). The highly variable nature of rainfall combined with high evaporation rates, for a long period of the year and the scarcity of readily accessible groundwater in this hard rock region meant that no stable human settlement would have been possible without recourse to the storage of surface water in small tanks (Abeyratne, 1956).

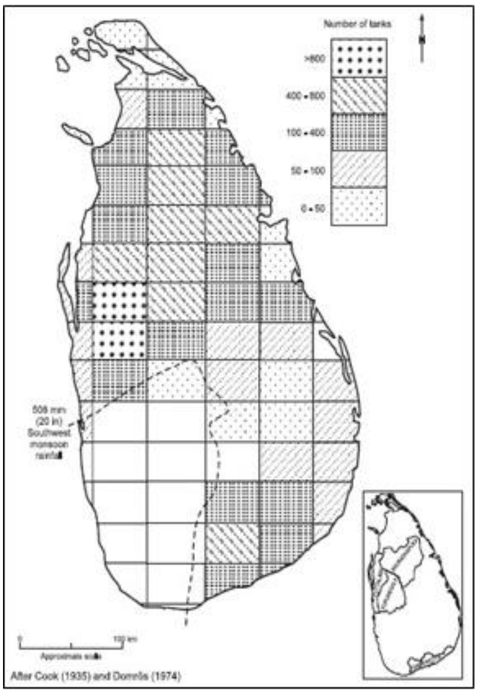

Figure 03: Island wide distribution pattern of small tanks by Panabokke et. al., 2002

According to Leach (1959), the North Central dry zone, became the cradle of Island’s civilization with the national capital city of Anuradhapura, established there from the 3rd Century BC. Civilizations whose agriculture and culture were dependent upon minor as well as large-scale waterworks for irrigation, whereas flood control and water supply are referred to as "hydraulic civilizations". The conditions that prevailed in the Dry Zone fitted into this description quite well. In addition to its large-scale irrigation works, the drier areas are also covered with thousands of man-made lakes and ponds, known locally as 'tanks' (Madduma Bandara, 2009).

Small tank surface storage systems provided the lifeblood for human settlement and existence in these areas (Abeyratne, 1956). It is the back-bone of the Hydraulic Civilization from ancient times. These small tanks find their best expression across the various landscapes of the North-Central, North- Western and Southern Regions (Figure

03). Also, the small tank systems have always occupied a special place in the national consciousness and heritage of Sri Lanka (Madduma Bandara, 2009).

According to hydraulic engineering perspective, it is a little evaporating pan but from a water and soil conservation ecosystem perspective, it is the heart of the dry zone village (Mendis, 2002). Some of the small tanks, functioning well at present and some do not. Brohier (1935), has indicated some of them have been in operation continuously for more than 2000 years. Further he explained the village tanks and their association with ancient irrigation works in Sri Lanka.

Table 01: **Number of operational and abandoned small tanks within each province (by Panabokke et al., 2002)**

Province and area (km²)	Number of small tanks		Total
	Operating	Abandoned	
Northern 3,709	608	816	1,424
North Central 10,365	2,095	1,922	4,017
North Western 7,760	4,200	2,273	6,473
Southern 2,849*	653	757	1,410
Lower Uva 2,901*	16	543	559
Eastern (South of Mahaweli) 3,885*	-	1,017	1,017
Eastern (North of Mahaweli)*	48	425	473
Total	7,620	7,753	15,373

*Includes only the dry zone part of the province.
Note: The data is based on 1995 Department of Agrarian Services (DAS) data bank and 1982 ABMP maps.

Table 01 shows the number of operational and abandoned small tanks within each province.

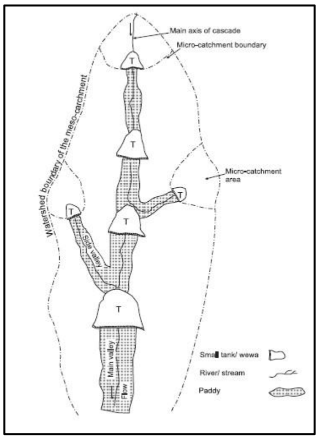

Figure 04: **Schematic representation of a typical small tank cascade system** by Panabokke et. al., 2002

A 'cascade' is a connected series of small tanks to large reservoir organized within a micro-(or meso-) catchment of the dry zone landscape for storing, conveying and utilizing water from an ephemeral rivulet (Madduma Bandara, 1985). Each of these cascades still exist in Sri Lanka, delineates a distinct small watershed or meso-catchment ranging in extent from 13 to 26 km^2 with an average of 20 km^2 (Geekiyanage & Pushpakumara,2013). TCS was the need for a sustainable irrigation and water management technology to meet the challenge of recurrent water shortages and drought conditions in a seasonally dry environment. Therefore, it was the need for more economical and rational use of water that lead to the development of the **recycling or re-use** principle (Figure 04). Water from the upper parts of the cascade was used and re-used several times before it reached the outlet (Madduma Bandara, 2009).

This paper reviews explanations of past studies about the importance of TCSs in sustainable development of rural communities in the dry zone of Sri Lanka through the Environmental Geography Aspect. According to Savindra Singh (1989) "the environmental geography may be defined as a branch of geography which studies the characteristics, compositions and functions of different components of the natural environmental system, mutual interdependence of different components, various processes that link the components, the interactions of different components with each other and among themselves and consequent responses (environmental problems) in spatial and temporal context in terms of 'geoecosystem.' as well as interactions of technologically advanced 'economic man' with different components of natural **'geoecosystem'** and resultant modifications and changes in the natural geoecosystem leading to environmental degradation and pollution, the techniques and strategies of pollution control measures and management of ecological resources". Hence, to identifies the interrelation between the TCS and rural communities while environmental geography provides a sophisticated background.

The ecological importance of a small tank village and TCS

Sustainability of the traditional tank-village system had been maintained in the past, simply not only from structural maintenance (Darmasena, 2004). Four distinctive land use zones can be identified in a TCS such as (i) ***tank bund and tank bed,*** (ii) associated irrigation channels and **paddy fields,** (iii) protected forest in the catchment and rain fed uplands **chena area** and, (iv) **gangoda**, (hamlet or high elevation household area) (Figure 05). Each zone had one or several components of ecological significance (Geekiyanage & Pushpakumara, 2013). Apart from above micro characteristics, micro level land characteristics such as ***goda wala, iswetiya, gasgommana, perahana, kattakaduwa, tisbambe, kiul-ela etc***. have also paid attention to the sustainability.

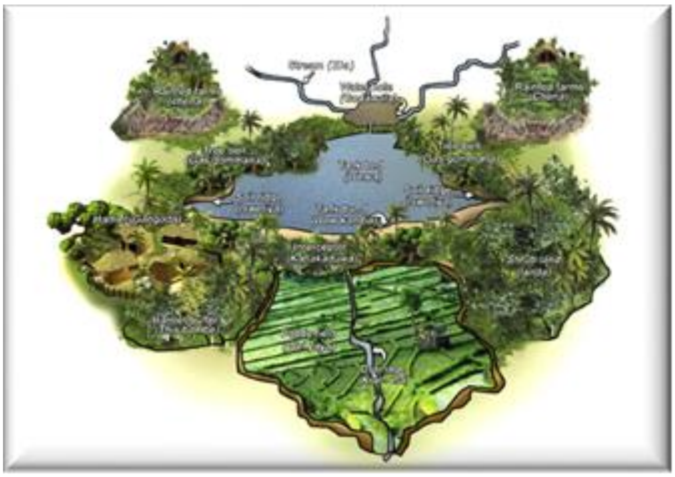

Figure 05: Components of a TCS part of small tank village by Dharmasena, 2010

The geographical setting of above land use pattern and its importance can be seen in the below mentioned way.

- **Gasgommana** - It is the upstream land strip above the tank bed, accommodating water only when spilling. Large trees such as kumbuk, nabada, maila, damba etc. and climbers such as kaila, elipaththa, katukeliya, kalawel, bokalawel etc. are found in this area. This vegetation is natural and seeds are floating on water. The gasgommana acts as a wind barrier reducing evaporation from the tank and lowering the water temperature. It gets closer to the bund from either side where roots of large trees make water cages creating breeding and living places for some fish species. This strip of trees demarcates the territory between human and wild animals.
- ***Perahana*** - It is the meadow developed under gasgommana and filters the sediment flow coming from upstream chena lands.
- ***Iswetiya or Potawetiya*** - An upstream soil ridge constructed at either side of the tank bund to prevent entering eroded soil from upper land slopes.
- ***Godawala*** - A manmade water hole to trap sediment and it provides water to wild animals. This might had been a strategy to evade man-animal conflict.
- ***Kuluwewa*** - A small tank constructed above relatively large reservoirs only to trap sediments and not for irrigational purposes. It provides water for cattle and wild animals.
- ***Tisbambe*** - It is a fertile land strip found around the settlement area (gangoda) and does not belong to anybody. Tree species such as mee, mango, coconut etc. are grown in scattered manner. Mostly this area was used for sanitary purposes as a resting place of buffaloes. Buffaloes were used as a protective mechanism from wild animals and malaria.
- ***Kiul ela*** - This is the old natural stream utilized as the common drainage. Tree species such as karanda, mee, mat grass, ikiri, vetakeya etc. and few rare small fish species are

also found in waterholes along the kiul ela. Most importantly it removes salt and iron polluted water and improves the drainage condition of the paddy tract.

- ***Kattakaduwa*** - This is a reserved land below the tank bund. It consists of three micro-climatic environments: waterhole; wetland; and dry upland, therefore, diverse vegetation is developed. This land phase prevents entering salts and Ferric ions into the paddy field. The water hole referred to as 'yathuruwala' minimizes bund seepage by raising the groundwater table. Villagers plant vetakeya along the toe of the bund to strengthen the bund stability. It appears to be a village garden, where people utilize various parts of the vegetation for purposes such as fuelwood, medicine, timber, fencing materials, household and farm implements, food, fruits, vegetables etc. Specifically, they harvest row materials from this vegetation for cottage industries. (Darmasena, 2004)

Hence, Village Tank is a marvelous man made ecological construction which involves high degree of natural resource management (Witharana, 2004). It clearly shows a small tank village sustainability and its impact on the surrounding environment. Such kind of inter-connected small tank villages can be seen within the TCS. Small tanks are not isolated entities. Natural drainage system in a watershed is blocked by earth bunds in appropriate locations to store water, forming a series of tanks along the drainage. The drainage pattern formed in the undulating topographic formation in the dry zone landscape can be classified as dendritic drainage pattern. This ramifying nature of the drainage system has led to form clusters of small tanks found in the series (Madduma Bandara, 1985). Also TCS is one of the marvelous man- made ecological constructions to preserve both water and soil and specially to facilitate re-utilization of water. Tanks in the cascade can be categorized by considering its location in the cascade such as top, middle and bottom etc., as the performances of these tanks differ from one to another (Witharana, 2004).

Figure 06: Sustainable community development

TCS as a sustainable development component

Sustainability refers to the ability of a society, ecosystem, or any such on-going system to continue functioning into the indefinite future without being forced into decline through the exhaustion or overloading of key resources on which that system depends (Robert Gilman, 1990). According to Bruntland Report (1987), sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Hence it can be identified as a sustainable development arise within society, environment and economy of a country. In the sustainability concept it will be given more priority to the environment protection. This matter can be further illustrated when paying attention to the sustainable community development (Figure 06).

According to the above figure 06, it is a reality when considering the sustainable community development in rural small tank villages. Their sustainability have risen within the cascade system. In the traditional food production system or agrarian system, the *"tank"* or the *"man- made reservoirs"* had played a vital role for food production and for the society and hence, the tanks were considered in a divine manner (Perera et al., 2009). The ultimate goal of the divine manner tally with the spiritual sustainability. Madduma Bandara (1999) convey his idea to examine the spiritual sustainability in a rural small tank village through social, environmental, economic and techno –physio sustainability (Figure 07). In a TCSs environment is protected a unique way. To protect the environment, both knowledge of technical and physical were used optimally. The community had the knowledge to maintain water in TCS. The governance of TCS was mainly based at the village level and therefore, the progress of all the components in tank dependent on the socio-economic harmony of villagers (Avsadahamy, 2003). Also, analysis of TCSs shows that their management was largely done by the social system with established institutions and leadership structures with cultural and spiritual norms that respected life in its all forms. Early practitioners adhered firstly, to have an adequate volume of water in every tank in a cascading valley even in a year of below-average rainfall and secondly, instituting a regulated flow of water from one tank to another downstream thereby, avoiding a sudden influx of large

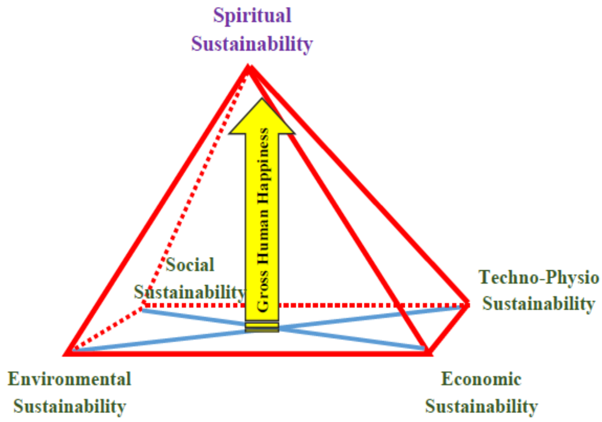

Figure 07: **The pyramid of Sustainable Development** by Madduma Bandara (2009)

volumes of water (Geekiyanage & Pushpakumara, 2013). Hence, it is visible that the ultimate goal of the sustainability was protected within TCS.

In the traditional system agriculture had been manipulated to absorb any weather vagaries by shifting the cultivation time and selecting cultivation practices. Traditional communities made every attempt to conserve soil, water and natural habitat. Food security was one of the in-built aspects of their culture. Use of groundwater for agriculture was never practiced by them and it assured the water security. There was a broad diversity in flora and fauna. Sharing resources equally and the equity of ownership were the most striking features of their culture which led to build up a peaceful and sustainable rural society. Environmental pollution had never been an issue for them to bother. With the disappearance of these features the whole system was subjected to deteriorate socially, physically and economically making the community vulnerable to disasters (Dharmasena, 2004).

TCS do not functioning well as they were in the past. But still some of them distribute their service to enrich the livelihood of village community. There are many reasons effected to the TCS failures. Colonization, agriculture, social changes, etc. are some of the majors of TCS decline. Multiple invasions from South India into Sri Lanka in 437–367 BC have been destructive for the survivability of the TCSs. Thereafter, during the colonial era, TCSs were neglected and abandoned. Because the TCS was the backbone of traditional economy, the destruction of this system had far- reaching effects. Although, the TCSs did not completely collapse in the ancient times, they were temporarily declined due to malaria epidemics and the political instability (Geekiyanage & Pushpakumara, 2013). At present, in the areas of cascade systems, there is a higher prevalence of poverty and as a consequence, some out-migrations from the affected rural areas to cities. These tendencies may be checked to some extent through enhancing the potential for improving productivity. The higher prevalence of malnutrition among the rural communities can also be mitigated through improved tank fishing and animal husbandry. However, health issues related to drinking water, eating tank-fish are contaminated by agro-chemicals (e.g. Cadmium) received by tanks, including kidney failure and malaria would have to be monitored and remedied (Madduma Bandara, 2009). Also, because modern-day engineers believed that centralized large-scale irrigation schemes are more efficient than the decentralized TCSs, were replaced by large scale reservoirs and high capacity feeder channels. These large scale feeder channels now have the capacity to control water flow to remaining TCSs which are directly linked with large reservoirs generating hydropower (Geekiyanage & Pushpakumara, 2013).

Rehabilitate the TCS is not an easy task. It should come through the top level. Political, engineering and community based opinions and technology should be addressed clearly and make plans for rehabilitation of TCS. If the village tank is protected, the village community will survive. It should reach the sustainability where we need. It must be addressed to protect village tank resources management.

According to Witharana (2004), infrastructure development enhance the village tank resource management (Figure 08). There are 06 main drivers which could be effected to infrastructure development.

i Technology

Technology is a drive for managing village tank resources. Technology tells both traditional technologies available with the rural community and the other one is the appropriate technology that should be introduced by the State. This technology must be used to correct decision making.

ii Beneficiary Participation

Efficient beneficiary participation is a must and should be clearly identified and assured from very first stage of decision-making.

iii Finance and Skills

Adequate amount of finance and skills has to be maintained to conduct PSS and for good operation and maintenance programme.

iv Policy or Customs

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

v Institutional Structure

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

vi Demand or Potential

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

(Witharana 2004)

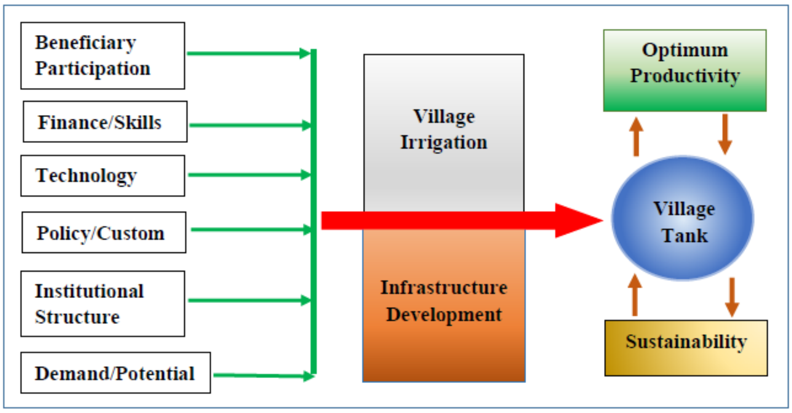

Figure 08: Village Irrigation Infrastructure Development as a Part of Rural Resource Management by Witharana 2004

Further, the ecological issues related to the clearance of village forests and unsustainable land use, may be addressed through better planning based on the cascade principle. The break-down of old social order (cohesion, kinship, leadership, norms and values) may not be easily restored. However, the situation may be improved with innovative approaches that suits modern living conditions. In the place of traditional institutional arrangements are new robust but flexible structures may have to be nurtured. Also, improvement of cascade systems may prove beneficial in view of its time-tested buffering capacity for drought or flood hazards (Madduma Bandara, 2009).

Panabokke et al. (2002) recommended that hydrology of an entire cascade needs to be assessed and understood with a view to make the best use of available water resources within the cascade. It is essential to recognize the knowledge on hydrology of an entire cascade before any intervention to any of the individual tanks in the cascade is considered. However, many large diameter agricultural wells (agro-wells) are being excavated as a solution for the increasing demand for water. This drastically reduces the groundwater table and degrades associated ecosystems because the density of small tanks and feeder channels is reduced due to multipurpose irrigational projects and human settlements (Geekiyanage & Pushpakumara, 2013).

The TCS has been successful over two millennia in sustaining a variety of ecosystems in the dry zone of Sri Lanka. Many lessons can be adopted from TCSs to ensure that the present tank system is sustainable. However, ad hoc raising of dams and spillways and just desilting of tanks in the recent past has seriously affected the hydrological balance in TCSs. A noticeable increase of population has also make difficult circumstance to unbalanced subsistence farming methods and aggravated multiple market forces and exchange of outside inputs (Panabokke et al., 2002).

Conclusion

Considering all these, it could be mentioned that TCSs are playing a marvelous role of community sustainable development in the dry zone of Sri Lanka. Presently the world is experiencing climate changes and Sri Lanka also does. As an agricultural based country, we have to preserve water in the dry zone of the country. TCSs will be a better solution for this scenario. Correct decision making strategies should be taken up to preserve at least the existing functions of TCSs because it will provide a sophisticated environmental background for social harmony.

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