A PROPOSAL FOR DECLARATION AS A GIAHS

THE CASCADED TANK-VILLAGE SYSTEM (CTVS) IN THE DRY ZONE OF SRI LANKA

MINISTRY OF AGRICULTURE

AND

FOOD AND AGRICULTURE ORGANIZATION

OF THE UNITED NATIONS, SRI LANKA

Food and Agriculture Organization of the United Nations

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ACRONYMS

BD	Biodiversity
AD	Anno Domini
BC	Before Christ
BP	Before Present
CCF	Climate Change Fund
CGIAR	The Consultative Group for International Agricultural Research
CoSOP	Country Strategy Operations Plan
CTVS	Cascaded Tank-Village System
DA	Department of Agriculture
DAD	Department of Agrarian Development
DL	Low Country Dry Zone
DS	Divisional Secretariat
DZ	Dry Zone
FAO	Food and Agriculture Organization
FD	Forest Department
FIM	First Inter-Monsoon
FO	Farmer Organization
GIAHS	Globally Important Agricultural Heritage System
GND	Grama Niladhari Division
IFAD	Internal Fund for Agricultural Development
IWMI	International Water Management Institute
LHG	Low Humic Gley
NGO	Non-Governmental Organization
RBE	Reddish Brown Earth
SIM	Second Inter-Monsoon
SL	Sri Lanka
SNR	Strict Nature Reserve
SWM	South West Monsoon
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

SUMMARY INFORMATION

Name of the Agricultural Heritage System: The Cascaded Tank-Village System (CTVS) in the dry zone of Sri Lanka

Local Name: Ellanga Wev Gammana

Requesting Agency: Ministry of Agriculture

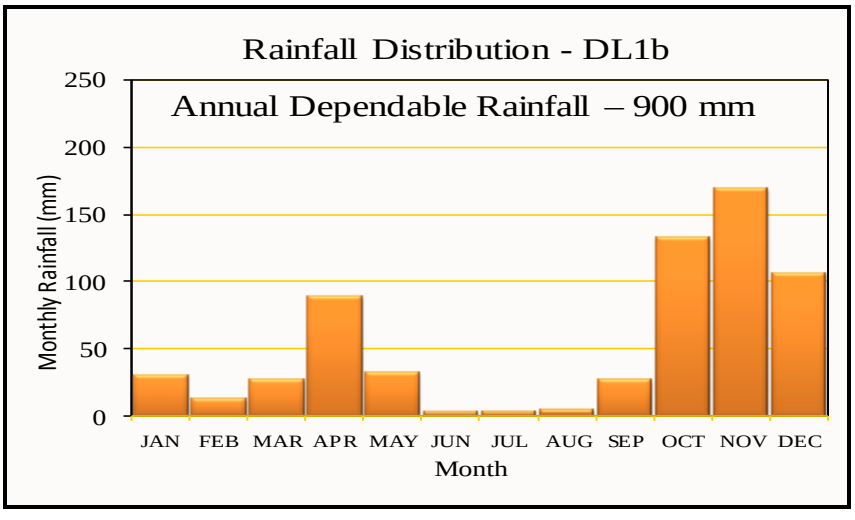
Country/location/Site: The Palugaswewa Divisional Secretariat area with 12 Cascaded Tank-Village Systems (CTVSs) is located in the Anuradhapura District of Sri Lanka. The site is located on N 08^0 25' 12'' and E 80^0 21' 36''.

The site is within the Malwathuoya and Yanoya river basins, which are the home for original settlers, who developed ancient irrigation systems in Sri Lanka. The site falls within the "Cultural Triangle" of Sri Lanka, where ancient cultural monuments are conserved under the UNESCO support.

Accessibility of the site to capital city or major cities: The site is located approximately 175 km away from Colombo, the capital and 40 km from Anuradhapura, a sacred city in Sri Lanka. Further, the distances to local cities with tourist attraction, Habarana and Dambulla are 10 km and 30 km respectively from the Palugasweva GIAHS.

Approximate Surface Area: The site approximately covers an area of 18 700 ha.

Agro-Ecological Zone: The site falls within the agro-ecological zone DL1b, which is characterized by undulating terrain and bimodal rainfall pattern with 75 percent expectancy annual rainfall of about 900 mm.



Topographic Features: The site is located in an area of nearly 165-175 m above mean sea level. The undulating terrain has developed well defined drainage ways in dendritic form, which is a unique feature to form cascaded tank systems. Valley bottoms are more or less flat and formed floor for irrigated terraced paddy farming. Often the crest positions of the terrain are occupied by forest vegetation on rock out crops and mid-aspect of the land catena is generally utilized for *chena* (shifting cultivation) and homestead farming.

Climate Type: The climate of the area as well as the entire dry zone is mainly decided by the Northeast and Southwest monsoons. The annual mean rainfall in the area is about 1,400 mm. There is a distinct dry period, which extends from May to September. Depending on the monsoons there are four climatic phases or seasons namely: First Inter-Monsoon - FIM (March to April), South-West Monsoon - SWM (May to September), Second Inter-Monsoon - SIM (October to November) and North-East Monsoon - NEM (November to February). The rainfalls received during each season vary making a bimodal distribution pattern and give rise to two distinct growing seasons namely *yala* (minor) season and *maha* (major) season. *Yala* season includes FIM and SWM periods. As SWM rains are not very effective in the dry zone the *yala* season rains confine to one month showing a subsequent longer dry period. The *maha* season is the main growing season with sufficient rainfall extending from October to January.

Potential evapo-transpiration varies from 42 to 122 mm/month during the year. Maximum monthly mean temperature varies from 29^0C to 35^0C, while minimum value is in the range of 20 ^{0}C – 26 ^{0}C. Relative Humidity in the morning ranges from 77 to 91 percent, while in the evening it varies from 46 to 75 percent. The periods March – April and August – October are having the warmest climate. Average wind velocity is in the range of 3 – 10 km/hr.

Approximate Population: There are about 5 400 families with approximate population of 17 000 people.

Main Source of Livelihoods: Agriculture is the main livelihood of the people in the proposed site. Almost all people engage in tank irrigated lowland paddy cultivation, while some are engaged in rain-fed upland cultivation with crops such as legumes, coarse grains, vegetables etc. and few in livestock farming. Very few people work in private and public organizations.

Ethnicity/Indigenous population: Sinhala majority with traditional *wanni* dialect and Tamil and Muslim minority

Summary Information of the Agricultural Heritage System:

The Palugaswewa DS Division consists of 12 CTVSs, where 78 tanks are found, of which 53 irrigation tanks are operational and others are abandoned at present. The upper part is covered with dense forest and shrub jungle, where the wildlife is secured. The lower elevation areas are mostly agricultural and settlement sites with a network of tanks and streams.

The families living in the area are self-sufficient in rice. All food items are produced by the farmers themselves. Well-drained paddy fields are used for cultivation of onion, chili, corn and pulses during minor season. Legumes, coarse grains, fruits and vegetables are cultivated in uplands and home gardens. These crops bring significant income to the farmers. The tank itself

is a basket of food including fish and aquatic food sources.

Village commons, forest and the tank ecosystems enhance the bio-diversity. Upstream tree belt (*gasgommana*) and downstream *kattakaduwa* of the main tanks, while conserving water, provide wild fruit and food, local medicine and habitat to many predators.

Some of the practices evolved for centuries and the knowledge passed through generations are still with the community and practicing in agriculture and natural disasters.

The agriculture being practiced in the CTVSs is well knitted and inseparable with their century old culture. Specific folklore, folk song, beliefs, rituals, traditional festivals, practices and traditional crafts are still in existence with this community.

The tank cascade itself is an evidence of the long practiced land and water conservation and management practices. The current state of the CTVSs is no longer in pristine form, but the systems are very much serviceable and restorable. Since the site is located in the midst of the cultural triangle of Sri Lanka, it will definitely become an attractive destination for tourists. The CTVSs once restored would exhibit the agricultural heritage with its unique features to demonstrate the sustainable agro-society, once flourished over the dry zone of Sri Lanka.

CHAPTER 1: INTRODUCTION TO THE PROPOSED GIAHS

Sri Lanka has a rich agricultural history dating back more than 2 500 years. For centuries, paddy cultivation in the island nation was not just an economic activity but also a way of life that shaped the society, culture, religion and economy. Sri Lanka had been extremely rich in natural, historic, religious and cultural heritage sites as well as people with extraordinary rich lifestyle and economic activities with respect to nature, traditional knowledge, values and morality. The country is considerably succeeded in restoring many of the historic and archeological sites to its glory but the restoration of traditional lifestyles and economic activities have been forgotten by modern technological and cultural adaptations of contemporary development efforts. This unbalanced intervention complicated the lifestyle of people as well as resulted in challenging management issues.

Sri Lanka also has an incredibly rich agricultural heritage including over 2 500 varieties of rice as well as huge numbers of indigenous species of fruits and vegetables. It also has traditional labour exchange practices, integrated pest and disease management systems and farming techniques that were once highly productive, all of which are in danger of disappearing as the knowledge dies off.

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Ancient irrigation systems of Sri Lanka and its techniques of culturing the natural surge of water for human needs that harmonizes the multiplicity requirements of entire ecosystem provides an excellent lesson for sustainable development activists. Sizes of those irrigation systems range from village level small lakes of five hectares to over 5 000 hectares of catchment. One thirds of the paddy lands in Sri Lanka are irrigated by small irrigation systems aforesaid. Unfortunate situation today is that mot those systems have deteriorated, neglected and abandoned.

Moderate lifestyle in Sri Lanka had been fundamentally based on diverse varieties of food recipes and eating habits. Hundred percent organic homegrown vegetables have been transients to commercially grown vegetables. All forms of fibrous grains and indigenous varieties of seeds became extinct. People's habits and norms to protect and share seeds are being changed to buy seeds from commercially grown ventures. Food recipes that Lankans had evolved have been distorted and substituted by unhealthy fast foods.

Traditional medicine and nursing therapy systems are to heal both body and mind. Traditional doctors always attempts to find the causes of the disease to heal the cause. Also their treatments were healing as well as preventive; it had never being a business. Most of the medicinal herbs had been found in the village itself it was not an issue for them to do it as volunteers helps in nursing. It was an ethical responsibility of the doctor to heal the patient to gain happiness.

1.1 The Dry Zone

The CTVS is widely found in the dry zone of Sri Lanka. The Dry Zone (DZ) is the area, which receives a mean annual rainfall of less than 1 750 mm with a distinct dry season from May to September. The mean minimum temperature in the DZ ranges between 20 – 26 ^{0}C, while maximum temperature varies between 29- 38 ^{0}C. The DZ is confined to the low-country, which is the area below 300 m elevation. The rainfall pattern is a significant limiting factor in crop production.

The terrain in the DZ of Sri Lanka changes from flat to undulating to rolling when moving from ocean towards the interior. There are broad valleys in the undulating terrain and well-defined drainage ways in the terrain due to the high rainfall received in the *maha* (wet) season. The terrain condition and the rainfall are the two significant factors, which enabled construction of tanks in the DZ that augment water supply for crop production. The construction of tanks has changed the landscape of the DZ to form a land use mosaic of water bodies (tanks), paddy tracts, forests, uplands and hamlets (figure 1 and 2).

Figure 1: A village tank in the proposed CTVS – Mahaweva

Figure 2: A Village tank in the proposed CTVS–Yakandagaswewa

There are several great soil groups found in the DZ. The dominant soil types in Anuradhapura District are Reddish Brown Earth (RBE) and Low Humic Gley (LHG) soils (figure 3). The LHG is found in the valleys of the terrain where paddy lands are formed under the CTVS. The proposed CTVS site also consists of Reddish Brown Earth soil on upper aspects of the land catena associated with Low Humic Gley soils found in the valley bottom.

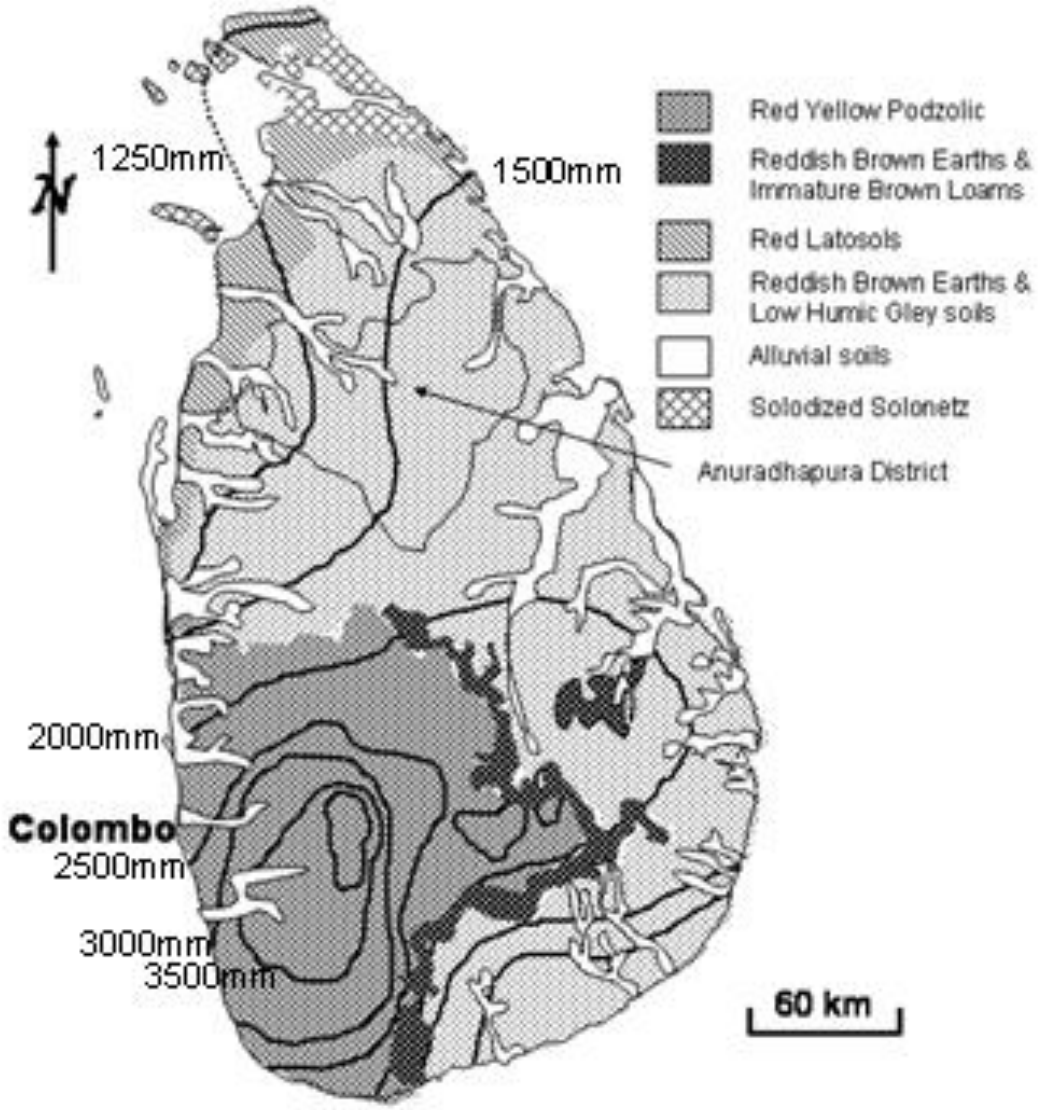


Figure 3: Soil type distribution with annual rainfall isohytes in Sri Lanka
(Source: Dharmasena, 2010a)

1.2 Ancient Hydraulic Civilization of Sri Lanka

Over the course of history, a large number of communities developed their own culture and lifestyle that are intricately tied to nature and the local landscapes. The ancient civilization of Sri Lanka is not an exception, but its social, political and economic interactions with neighbouring countries have interfered during the entire process of the evolution. The known history of Sri Lankan civilization records two main discontinuities due to external invasions taken place in 3 000 BC and 1 200 AD (Dharmasena, 2010 a).

The dry zone civilization might have first emerged around natural lakes (‘vil’) and streams (‘oya’) in varying sizes. Subsequently, human beings developed rainwater-harvesting methods to make living possible in other areas of the dry zone. Intrinsic networks of minor tanks and streams evolved with the formation of organized communities. More logical water-use systems were used when farming societies developed. Culture, customs, agriculture,

traditions, and all sorts of life styles have evolved on this landscape with influence of migration and invasion from northern side of the island. These external factors might have accelerated or sometimes disrupted this evolutionary process of civilization. Two main types of supportive factors of the evolutionary process of this ancient civilization can be identified: need based and problem based respectively. Basic needs were water, food, fibre, shelter, and protection. Problem-based driving forces of the evolution of our human community were strategies to address natural disasters such as droughts, epidemics, floods, cyclones, and external invasions. Strategies adopted to face these challenges were infiltrated to the social systems in form of their lifestyle and as accepted acts in their traditions. The pre-historic evolution that took place in Sri Lanka and India shows great similarities due to continuous interaction between the two countries.

During the last one million years, when human population is known to have existed in various parts of India, Sri Lanka was connected to the sub-continent on numerous occasions. The rise and fall of sea level (due to temperature fluctuations in the global climate) determined the periodicities of these connections, the last separation having occurred at 7000 year BP (Deraniyagala 1992). Hence it is impossible to view Sri Lankan prehistory in isolation from India. By about 125 000 year BP it is certain that there were prehistoric settlements in Sri Lanka. It is estimated that during certain subsequent pluvial episodes the population density in the dry zone of northern, eastern, and southern Sri Lanka could have ranged between 1.5 and 0.8 individuals/km^2, whereas the wet zone in the west would have had densities of 0.1 or less.

From about 34 000 year BP onwards the prehistoric record is much more complete. It appears to have been a remarkably static situation over so long a period, relatively undisturbed by the arrival of new populations with diverse physical traits. Their life style could not have been too different from that described for the *Veddas* of Sri Lanka, the *Kadar, Malapantaram*, and *Chenchus* of India, the Andaman Islanders, and the *Semang* of Malaysia. They would have been moving from place to place on an annual cycle of foraging for food (Deraniyagala, 2002).

The transition from the Mesolithic Culture to the proto-historic Early Iron Age has been inadequately documented in Sri Lanka as the relevant transitional deposits have been disturbed by the extraction of fertilizer (guano) from prehistoric cave habitations. However, at a site there are indications of pottery excavated for the cultivation of a cereal. The discovery of a few pieces of copper-working slag from the Mesolithic context could signify the first identification of a Chalcolithic horizon in Sri Lanka.

The Early Iron Age settlement at Anuradhapura does not have a Megalithic cemetery, to which it can even remotely be linked. The Megalithic mortuary complex could possibly have been associated with just a special group of people, such as pastoralists, on the periphery of those who occupied Anuradhapura. Migration from the North to the island could have occurred primarily before 500 BC. What attracted these people who intruded on the scene at this early date? It is probable that the agricultural potential of Sri Lanka, notably its abundant

supplies of water, with iron technology capable of subjugating the dense equatorial rainforest and heavy soils, was a major factor. Thereafter, Sri Lanka attraction for settlers from further afield than South India appears to have gained rapidly. This swell coincided with the so-called Second Urbanization of the Indo-Gangetic Plain. The settlement at Anuradhapura spread over more than 10 ha by 800 BC. By then prehistoric stone tool technology had been completely superseded by that of iron at this site. Other advanced traits were the manufacture of copper-alloy artifacts, high-quality pottery (notably Black and Red Ware), the breeding of cattle and horses, and the cultivation of rice. By 700–500 BC Anuradhapura exceeded over 50 ha (Deraniyagala 1992).

Evolution of a great civilization in the north central part of Sri Lanka was principally driven by the process of collecting water from the rainfall for domestic purposes and agriculture. It is somewhat a sacrifice made to form societies around small sources of water in a water scarce area and not moving to water rich areas found in the central highlands of the island. This is debatable and difficult to understand unless one deeply probes the interactive process of historic evolution. One might conclude that although the apparent problem in this area was water, the historic fate of the country nonetheless had enabled the erection of the civilization through skilful management of the available water due regard for with the particular landscape features of the region.

With the progressive acceleration of cognitive abilities and technology in the later pre-historic period (30 000 - 1 000 BC), the stage was set for a radical transformation in the interactive balance between man and environment. People steadily proceeded to dominate nature and bend it the collective will. The advent of iron technology in Sri Lanka around 1 000 BC is witness to this ascendance of man. Excavations in the citadel of Anuradhapura have produced important evidence of iron technology, breeding of horses and cattle, and paddy cultivation, from cultural horizons nearly ten metres below the present ground surface. There is incidental evidence (faunal, sedimentological) for water management associated with paddy cultivation. Agriculture would undoubtedly have been dominated by paddy, which can only be intensified in the Sri Lanka dry zone, where Anuradhapura is situated, by the adoption of water management measures to control supplies from seasonal rainfall, streams, and perennial rivers (Deraniyagala, 2002).

The history and cultural heritage of Sri Lanka extends over a period of more than 5 000 years. The great King Ravana ruled the land of Lanka, which covered also part of India, around 3 000 BC as mentioned in the popular Indian epic ‘Ramayana’ (The Epic of Lord Rama) thought to have been written in 500 BC. The capital of the Asura King Ravana is said in the epic Ramayana to be situated in Anuradhapura. The invasion of by Vijaya through the Princess Kuweni (Princess of land) occurred in 600 BC. The Princess Kuweni ruled the area ‘Chalaka’ (Western region), which was one of the ten divisions at that time. Cities of these local kings were said to be on mountains and four of them were around the Anuradhapura city, which was built 250 years later.

The legendary story of civilization in Sri Lanka begins when the island was inhabited by people of the original tribes Yakka, Raksa, and Naga. These early people gradually developed systems of sedentary agriculture based on irrigation, and folklore maintains that the Yakka built some ancient irrigation tanks. By the arrival of Vijaya around 500 BC, small scale irrigation systems were already operational.

The first extensive Sinhalese settlements were along rivers in the dry northern zone of the island. Because of early agricultural activity, primarily the cultivation of wet rice was dependent on unreliable monsoon rains, the Sinhalese constructed canals, channels, water-storage tanks, and reservoirs to provide an elaborate irrigation system to counter the risks posed by periodic droughts. Such early engineering attempts reveal the brilliant understanding these ancient people had of hydraulic principles and trigonometry. The discovery of the principle of the valve tower, or valve pit (*bisokotuwa*), for regulating the escape of water is credited to Sinhalese ingenuity more than 2 000 years ago (figure 4). By the first century AD, several large-scale irrigation works had been completed.

The mastery of hydraulic engineering and irrigated agriculture facilitated the concentration of large numbers of people in the northern dry zone, where early settlements appeared to be under the control of semi-independent rulers. In time, the mechanisms for political control became more refined, and the city-state of Anuradhapura emerged and attempted to gain sovereignty over the entire island. The state-sponsored flowering of Buddhist art and architecture and the construction of complex and extensive hydraulic works exemplify as Sri Lanka's classical age, which roughly parallels the period between the rise and fall of Anuradhapura (from 437 BC to 1 040 AD).

Figure 4: Ancient Bisokotuwa in Korasagalle tank

After King Pandukabhaya (437 - 367 BC) founder of the Anuradhapura city, 122 kings reigned for 1 477 years up to 1 040 AD, until the kingdom was moved to Polonnnaruwa (80 km to the west). The establishment of forests and construction of ponds, reservoirs and irrigation systems were considered great meritorious acts in accordance with popular Buddhism, the faith of the leaders and of the large majority of the people. Sri Lanka history is full of achievements of kings who contributed to the development of water resources. Since the first century AD, kings such as Vasabha (67–111 AD), Mahasena (276–303 AD), Dhatusena (455–473 AD), Agbo II (575–608 AD), and Parakrambahu (1 153–1 186 AD) built numerous reservoirs and irrigation systems that fed vast expanses of paddy field in the dry zone. Construction and upkeep of these irrigation systems became massive undertakings. An indigenous expertise developed over the centuries, which appears to have been called upon by other countries of South Asia.

Figure 5: Ocean of the King Parakramabahu, Polonnaruwa, Sri Lanka

This ancient hydraulic civilization of the dry zone disappeared after the twelfth century AD. Climatic change, malaria, depletion of soil fertility, foreign invasions, and famine are some of the reasons cited. The breakdown of the efficient irrigation management system may have resulted from annihilation of the 'kulinas' (the dry zone nobility who possessed irrigation expertise) by invading South Indian forces (Paranavithana, 1960).

1.3 Traditional Agriculture in the Dry Zone

Traditional agriculture is based on principles that are more realistic. People observed natural phenomena operating around them and have studied how it could be manipulated for their needs. They could see the forest, its anatomy, association of different species for coexistence, regeneration after fire, spatial variations etc. The farming system, which includes *chena*, paddy and home garden cultivation has been evolved with interaction of the man with the

environment and developed in harmony with natural ecosystems (Dharmasena, 1993). Their experience and observations on rainfall pattern, wind, temperature, humidity and soil behaviors have used to adjust their cultivation activities. When they found that some of the tragedies they faced in farming as reasons beyond their control, they appealed the support from the religion and spiritual and cosmic influences. Most important fact they realized on top of others that without giving due respect to the resources using for farming they could not expect the sustainability of their food sources.

A three-fold farming system was evolved in the tank-villages of the dry zone: rain-fed upland cultivation, lowland paddy cultivation ('*wela*'), and dwelling gardens ('*gangoda*'). As in many countries of the world, shifting cultivation is the oldest way of farming in Sri Lanka. Many similarities are found in these countries such as clearing of forest or savannas, burning, sowing a mixture of seeds with onset of rains, cultivation under rain fed condition for few seasons, and moving to other lands once the cultivated land becomes less fertile. However, Chena cultivation in Sri Lanka evolved on undulating terrains with variable soil and rainfall conditions, hence specific practices as given below were developed (Dharmasena, 2010a).

a. Land for *chena* cultivation was selected from middle part of the land catena with gentle slopes, where soil is relatively deep;
b. Risks of farming due to factors such as rainfall, drought, pest and diseases, and damages from wild animals were reduced by adjusting the cultivation to the best times through long experience;
c. Favorable environment for crops was maintained by adoption of various soil and moisture conservation practices and through shade management;
d. Land productivity was maintained by posing least disturbance to soil and using high amounts of burnt biomass;
e. Diverse crop combinations were adopted to cope with variation of climate, soil, and other biotic as well as abiotic stresses;
f. Simple farm implements were used with lesser energy consumption;
g. Land races were improved as family secrets to utilize as most suitable crop varieties for the area.

1.4 Irrigation Systems

Irrigation systems of ancient Sri Lanka consist of a large number of village reservoirs to gigantic reservoirs and an intrinsic network of water canals connecting these tanks while supplying water to farming land. There are about 30 000 village reservoirs in Sri Lanka, of which the majority was built from 3rdcentury BC to 12thcentury. This compared to the Sri Lankan dry zone land area of about 40 000 km^2 (where almost all the tanks are located), is almost equivalent to one reservoir for each square kilometer. These small reservoirs are not meant always for irrigation, and part of them is to secure water for the others and prevent sedimentation of lower tanks. At present, about 14 200 small tanks have been identified as irrigation tanks to supply water to their paddy fields.

The first large reservoir to be built in recorded history is *Abayawewa* in 3rd Century BC. From that day onwards Sri Lankan tank builders developed a remarkable expertise on controlling large bodies of water which allowed them to built massive reservoirs which no other civilization ever could have dreamt of.

The breakthrough which made the Sri Lankan Irrigation Engineers built such massive reservoirs was the invention of the *Biso Kotuwa* or valve pit as early as third century BC, which could easily regulate the out flow of extremely large water bodies. Europeans stared using the valve pits in their reservoirs only in the mid 18th century, 2100 years later according to H. Parker, an Irrigation Engineer who was in charge of restoring many ancient irrigation reservoirs in late 1800's.

In his book 'Ancient Ceylon' he states:
'…….At first, only the simplest works of the smaller class, with very low embankments, would be undertaken; but when a better knowledge of the art of raising such banks of earth to hold back greater depths of water was acquired, schemes of a more comprehensive character would be attempted, until at last no reservoir was looked upon as too great to be constructed, and the lengths of the embankments extended for any distance up to a maximum of nine miles, while their heights in a few instances rose to more than fifty feet……..'
'……. It may appear to be such a simple matter to raise a long bank of earth in order to hold back a certain quantity of rain water for bathing purposes or for watering an adjoining rice field after the rains have ceased, that any people living in hot countries where the rains are only seasonal and are followed by several almost rainless months might be expected to be struck by the idea of making these little reservoirs for themselves, without its transmission from another country ; but as a matter of fact the notion of reservoir-making appears to have been originated in only one country, and never to have been invented independently elsewhere, at any rate in the Old World. ……'

Another development of the ancient irrigation systems is the remarkable instrumentation precision. When king Dathusena (459 - 477 AD) built Yodha Ela, also known as Jayaganga, the ancient irrigation engineers first found out that the Kalawewa was built on a slightly elevated ground compared to Tissawewa in Anuradhapura. Then he built the 54 mile (87 Km) Yoda Ela with a gradient of 6-12 inches per mile (approximately 10 to 20 cm per km) to carry excess water in the Kalawewa to Tissawewa. How these engineers could achieve such precision still baffles experts today.

Various aspects have to be investigated before the proper tank can be constructed:

The catchment area: The area that permits the rainfall to flow into one particular place, which could be transformed into a tank. The rainfall in a particular catchment area must be adequate to fill a tank. A Tank is normally made by building a dam across a flowing stream. Adequacy of any catchment area is determined by a study of the rainfall figures.

Seepage: The tank is by definition a place where water is stored for a long time. Such a situation can cause problems to the tank bund. The main problem is that of seepage. The massive bunds are made of earth and therefore when water is stored for a long time there is possibility of it seeping through the bund and ultimately destroying the bund. The Sinhalese engineers found a method to prevent this. They dug a trench at suitable places horizontal to the bund and filled it with clay, mostly from ant-hills (puddle clay) or *Kiri Mati* and got elephants to trample the clay into a thick mass, effectively preventing any seepage.

The Shape: The shape of the bund had to be determined. The top of the bund was a flat area, which allowed the people to use it as a convenient roadway. The inside of the bund as well as the outside of the bund had to maintain the gradient of under 45 degrees as a preventive measure. The outside area of the tank bund and some other areas where necessary were covered with grass to prevent damage by heavy rain. In some large tanks wave formations occur and at times waves keep beating the inside of the tank bund. To prevent this, bunds were strengthened with stone masonry referred to as *Ralapanawa*.

The spillway (Vana): A tank must have provision to manage excess water as that would cause pressure on the tank bund and destroy it. Therefore, a spillway was built, so that the excess water could continuously flow out of the tank without causing any danger to the tank bund.

The sluice gate: This is, perhaps, the most important aspect of a large tank. Village tanks and somewhat bigger tanks could be used without danger to the bund by making use of other devices that were available e.g. *Ketasorowwa* and *Rajamohol Sorowwa*. However, when the volume of water within the tank increases, it builds up severe pressure that a normal sluice gate cannot handle safely. Then other measures become necessary to safeguard the tank bund. The earlier sluice gate has to be strengthened with a novel device. Large tanks in Sri Lanka would not have been possible but for the invention of a new device called the *Bisokotuwa*, which is an original concept of Sri Lankan engineering.

1.5 Traditional System of Water Management

In the ancient cultural context water management was not taken as an isolated issue. Hear, the main purpose of water management is to optimize the conditions of the proper function of the ecosystem. Water was mainly stored, in the soil and conveyed through the soil and the soil facilitated mainly the water purification process. Water was taken from the soil (from water table) then the used water is again put to the soil, which purify the water and feed the water table for reuse. To facilitate this conservation, physical structures like small tanks were built according to the geophysical nature of the region. In this manner water receive from the two monsoons was reused several times before it ultimately drained to the sea. Even the inter monsoon rains (*Akvehi*) would have facilitated this reuse process. Evaporation from tanks is not a real loss. Also these structures facilitated flood mitigation process in the lower parts of the ecosystem in heavy rainy periods. In this context ecosystem is defined even including the man and the objects and the accessories required by him for his life.

These small tanks from a series of successive water bodies along small water courses and are called a "cascading system". The advantage of such a system is that excess water from a reservoir along with the water used in its command area is captured by the next downstream reservoir, and is thus put to use again in the command area of the second reservoir. This water is thus continuously recycled. This system helps to surmount irregularly distributed rainfall, non-availability of large catchment areas and the difficulty of constructing large reservoirs.

In management of tank water, the ancient people adopted various strategies to utilize limited water most efficiently.

i. When farmers expect low rainfall during the season they adopt a practice called '***Kekulama***'. In this method farmers advance the cultivation time practicing dry sowing to capture early seasonal rains, whenever they guess that tanks would not get enough water to cultivate the command area. They have the experience that if September (2nd inter-monsoonal) rains are high, the total seasonal rainfall is not adequate to fill the tank.
ii. When farmers find limited storage in the tank they adopt '***Bethma***' practice, where people temporarily redistribute plots of land among shareholders (paddy landowners) in part of the command area (territory) of a tank (reservoir) during drought periods. Here every farmer receives certain portion of the harvest depending up on the land ownership.
iii. When farmers expect excessive rains during the season, they get prepared for an emergency situation due to possible breaching of tank. They strnghten the tank bund through a '***Pangu***' method, where people share the rehabilitation work to avoid breach, leak, and excess seepage. Repair and desiltation of tanks and cleaning of canals during dry periods are shared tasks assigned to each farmer proportionately to land ownership. In fact it was a part of the Rajakari service that was owed to the king. Everybody had to provide this service; 40 days of it a year. It was not for the purpose of serving his personal whims or caprices. It was work that had to be done in the interests of the whole community
iv. When a family consists of few sub-families, they decide to rotate the land seasonally among sub-families because each sub-family owns a small land parcel. This aims at minimizing waste of resources. The method is called '***Thattu maru'***, where one family member cultivates entire family land for a season and handover to another for the next season.
v. Farmers maintain precision on water management by using a water disyribution structure called '***Karahana***'. This is a water distribution device fixed across the canal made up of log with two weir-shape cuts. The size and bottom level of these cuts are made according to flow requirements of the two canals below, and the *karahana* is fixed by the village head ('Gamarala') and no one is allowed to change.
vi. Farmers make every attempt to conserve tank water maintaining the tank ecosystem to reduce tank water losses, mitigate salinity effects, prevent tank sedimentation and so on (section 1.7).

Traditionally a holistic approach was used for water distribution in the irrigable area according to community or group interest, rather than individual self interest as seen in modern schemes.

The colonial lawyer F.A. Hayley in his book on Kandyan Law wrote:

"The irrigating system, passes from one allotment to another, arranged, when possible, in a series of terraces, in each of which the supply and depth is regulated by low ridges and blids, temporarily breached or dammed as occasion may require. The regulation of this supply, the formation of the enclosing ridges, the joint use of buffaloes for ploughing, and the need of fencing against wild animals, necessitate community of action on the part of tenants of adjoining lands…."

"To produce a successful crop, organization is required, some *panguwa*s needing, from the nature of the soil or elevation, treatment different from the others. For this purpose, the tenants appoint their own official, the *wel vidane* or irrigation headman …."

"It will be convenient here to refer to the social and administrative organization: for while the lord of the village or the chief or headman, to whose control it was assigned, was primarily responsible for good order, there existed side by side with community of property, a community of responsibility, and a recognition of self-government by the village council (*gam sbhawa*) in the regulation of local affairs" (Hayley, 1993).

Thus, the indigenous method is a bottom-up system of water management, while the modern method is a top down system. In the indigenous system water was supplied to the field in a holistic manner – drainage from upper fields are used in lower fields. In modern system each farmer has a supply and outlet (drainage) separately, thus the unity and social cohesion have gradually disappeared.

Traditionally, much of the maintenance work on the tanks was carried out during the *Rajakariya* – the forty-day period when every Sinhalese villager was required to work free for the King. The Rajakariya should not, however, be seen as constituting a state-run maintenance programme. The villagers were not indentured labourers (a point which was lost on the British who abolished *Rajakariya* service as a distasteful relic of feudalism) nor were they employed by the state. On the contrary, the work was organized at the local level. Moreover, the villagers had a considerable say in the work they undertook.

1.6 Geographical Distribution of Village Tanks

As stated before, this system is predominantly found in the dry zone of Sri Lanka. The density of village tank distribution in Sri Lanka is shown in figure 6. The highest density is found in part of Kurunegala District followed by central part of Anuradhapura District. In general, the average tank density is one tank per 2.6 km^2 for the Northern, North Central and

Southern provinces. For the Northwestern province, the density is around one tank per 1.2 km^2.

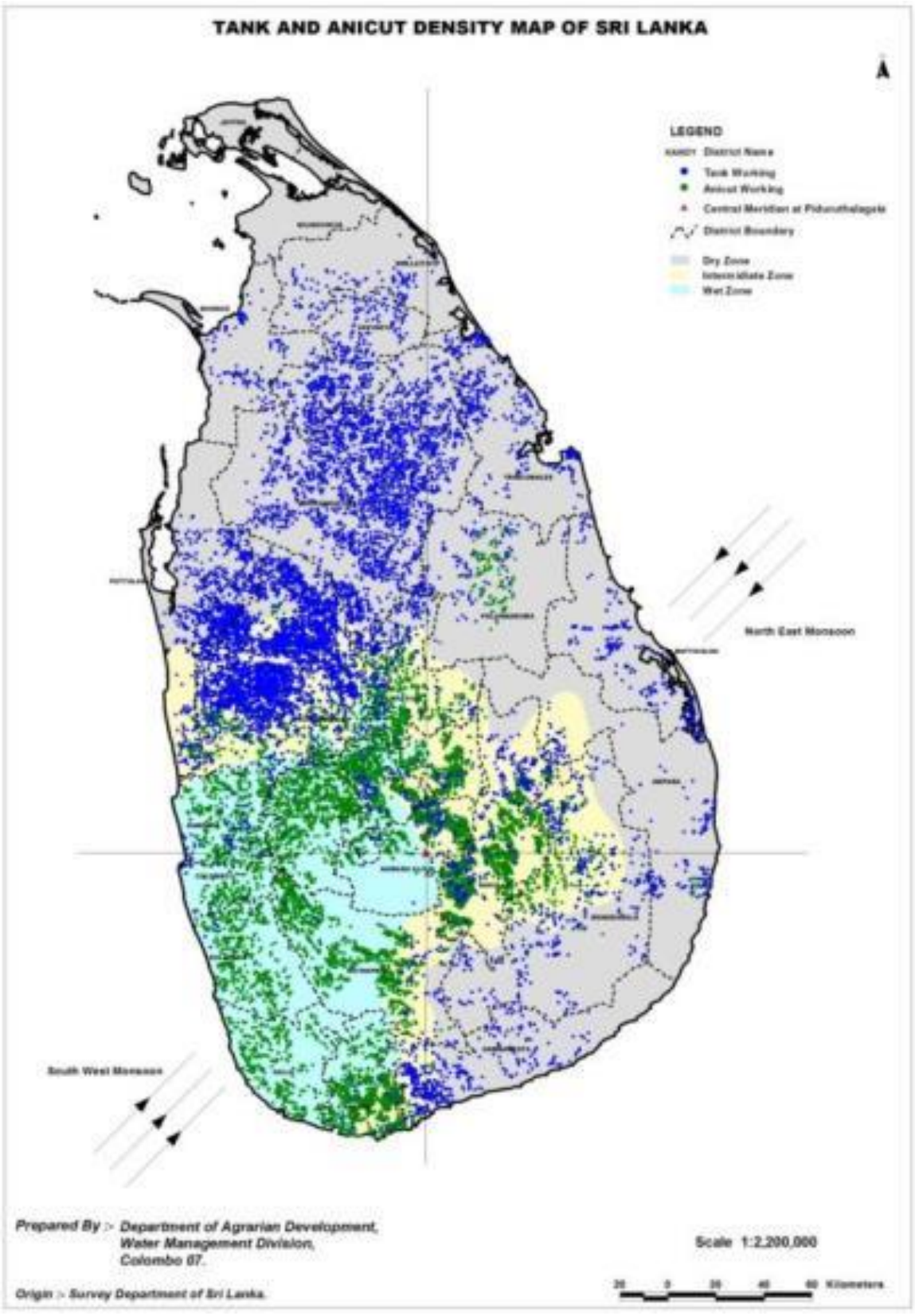


Figure 6: Map showing density distribution of village tanks (tanks in blue and anicuts in green)
(Source: Department of Agrarian Development)

1.7 The Cascaded Tank-Village System (CTVS)

The Cascaded tank-village system is described as 'a connected series of tanks organized within a micro-catchment of the dry zone landscape, storing, conveying and utilizing water from an ephemeral rivulet' (Madduma Bandara, 1985). It is an ancient, widely used and unique traditional agriculture system mainly found in the dry zone of Sri Lanka. The system has evolved over a period of nearly two millennia. It provides water for irrigation, domestic purposes, animals and ecosystems. The CTVS is a dominant feature in the dry zone of Sri Lanka. In a broader sense, the system can be considered as a sustainable ecosystem. According to local terminology, this system is known as *"ellangawa"*. A tank on the other hand is a minor water reservoir formed by constructing an earthen dam across a natural waterway or a depression (figure 7).

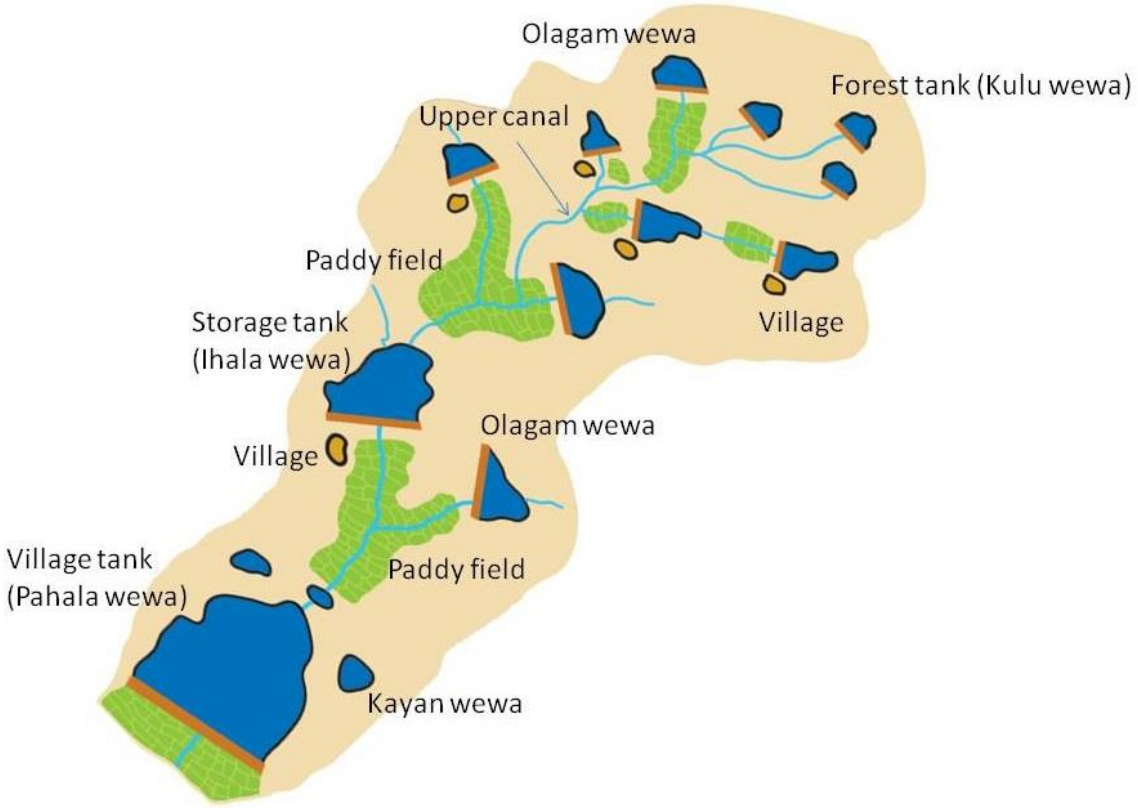


Figure 7: Schematic representation of a tank cascade system
(Source: IUCN)

These ancient irrigation structures were evolved with the advancement of traditional knowledge over two millennia and still act as essential elements of water management for agriculture in the dry zone of Sri Lanka. The main principle behind the cascaded tank systems is recycling and re-use of water through a network of small to large scale tanks.

A cascade in the dry zone is made up of about four to ten individual small tanks with each tank having its own micro-catchment, but all of the tanks are situated within a single meso-catchment basin. These meso-catchment basins could vary in extent from six to ten sq. miles,

with a modal value of eight sq. miles in the North Central Province (Panabokke et al, 2002). Spatial existence of tank cascade systems is shown in figure 8. The advantage of such a system is that excess water flowing from a reservoir along with the water used in its command area is captured by the next downstream reservoir and is thus, put to use again in the command area of the second reservoir. This water is continuously filtered and recycled in subsequent tanks.

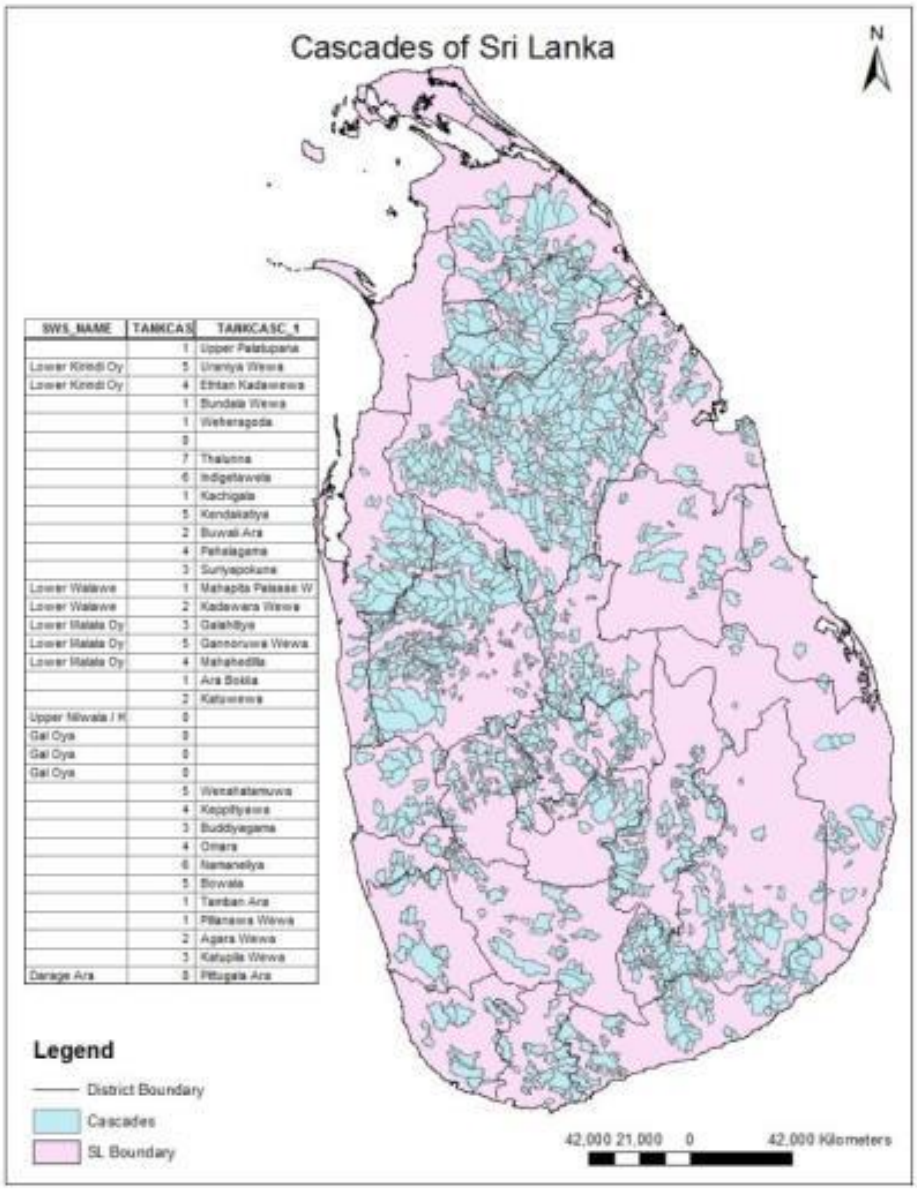


Figure 8: Map showing tank cascade systems in Sri lanka
(Source: Department of Agrarian Development)

Reviewing available maps and information, existence of cascaded tank systems is characterized by Dharmasena, 2017 as follows:

- The CTVS are mainly found in Northern, North Central, North Western, Uva, and Southern Provinces of Sri Lanka;

- Main administrative districts, where the CTVSs found are: Mullaitivu; Vavuniya; Anuradhapura; Trincomalee; Puttalam; Kurunegala; Hambantota; and Monaragala;
- The CTVSs are only found at the elevation range of 100-500 m amsl (annual mean sea level) and on moderate undulating landscapes of Sri Lanka;
- The soil combination of Reddish Brown Earths (RBE) and Low Humic Gleys is the home for CTVSs, but some are found on Red & Yellow Podzolic (RYP) and Immature Brown Loam (IBL) soils also.
- The areas, where the mean annual rainfall ranges from 800 mm to 2 000 mm provide the best opportunity for the formation of CTVSs;

Further, it could be observed that during last two decades forest cover has declined in these cascade zones due to pressure on the use of lands. Compared to urban and war affected areas, poverty level in the cascade zones shows low to moderate. Unfortunately Chronic Kidney Disease with unknown etiology (CKDu) is spreading at an alarming rate in these CTVS areas.

The CTVS in Sri Lanka have been subjected to a number of studies during the last two centuries because of its remarkable socio-technical significance associated with the natural environment. For instance, the distribution and irrigation potential of tanks have been discussed by Nicholas (1954, 1960) and Dharmasena (1985, 1989). In addition, the archaeological and historical significance (Nicholas and Paranavithana, 1951; de Silva, 1977; Gunawardana, 1971), the morphological and geological controls (Cooray, 1984; Tennekoon, 2000), the endowment within the socio-technical systems (Jayasena and Selker, 2004; Gangadara and Jayasena, 2005; Jayasena and Gangadara, 2006) of tanks have been extensively discussed.

Several attempts have been made to describe the evolution of the CTVSs in Sri Lanka; however, more recent investigations have shed some light on the outcome of the planning and designing of the tanks. The modeling of CTVS (Jayatilake et al., 2003) and return flow through paddy fields (Matsuno et al., 2003; Li and Gowing, 2005) express that the seepage and percolation losses from a tank in a cascade system are considerably higher than the design seepage and percolation rates for small tanks. Mahatantila et al. (2007) showed the presence of an active ‘constructed wetland’, locally known as ‘Thaulla’, which plays a major role in decontaminating the water flow into the tanks. It appears that some aspects of the CTVS design were developed to improve return flow and to control non-point pollution of the water supply.

1.8 Key Components of the System

The system consists of a series of tanks (minor water reservoirs) set one after the other on a natural drainage line in a watershed. These tanks are built by constructing an earthen dam across the water stream in the valley. Rainwater is collected in the tanks. Excess water, from tank at the higher elevation, spills over to the one below. Paddy fields are located in the valley of the drainage line below the tank. A *sluice* releases water for irrigating the paddy.

The drainage also passes to the tank below. The watershed of the tank comprises of several land uses such as forest, village hamlets, paddy fields and uplands of crop fields (former *chena* lands) and the tanks. The sustainability of this irrigation system has been secured through associated land use segments. These land uses are: natural tree strip (g*as gommana*), upstream medow (*perahana*), soil ridge (*potawetiya*), seepage interceptor (*kattakaduwa*), natural drainage (*kiul ela*) and hamlet buffer (*thisbambe*) (figure 9). The purposes of these components are briefly described below (Dharmasena, 2010 b).

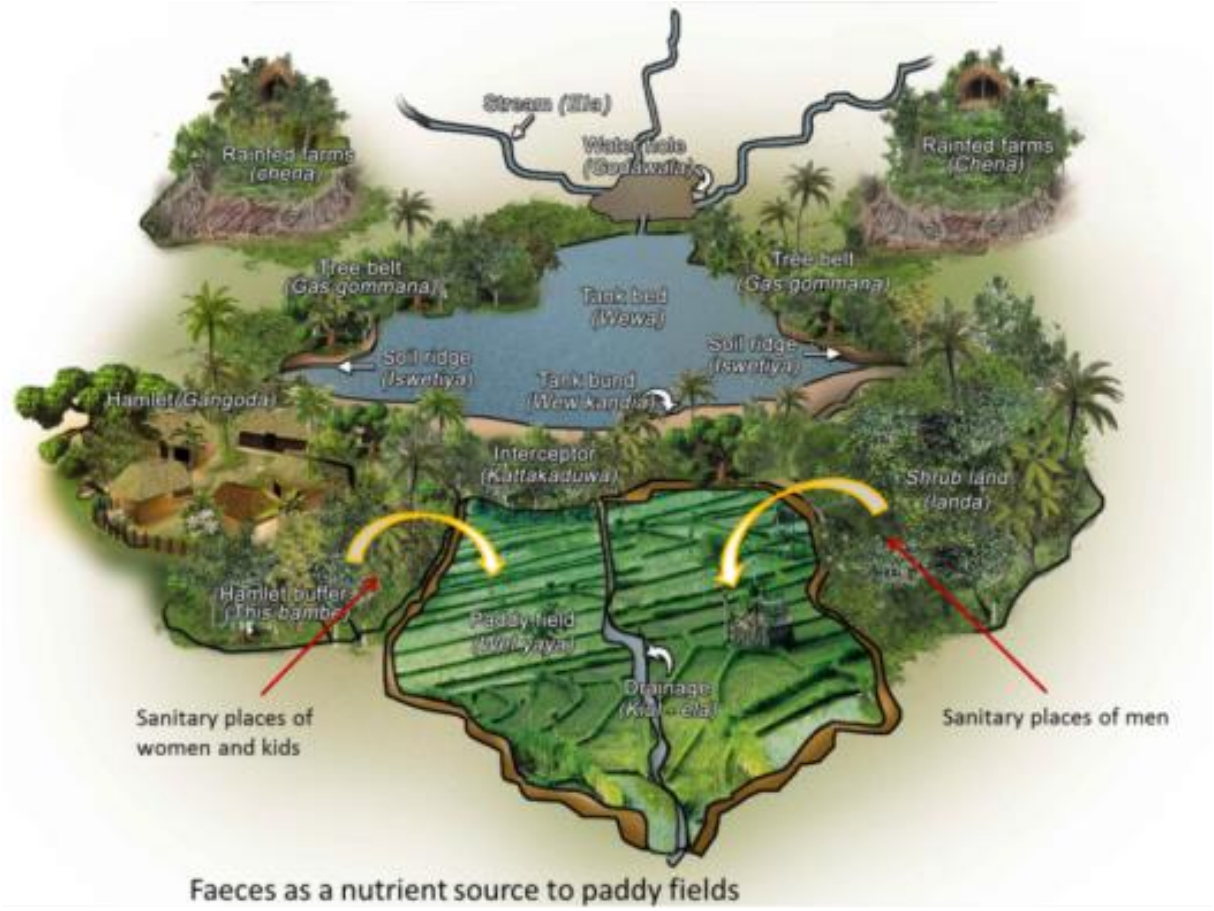


Figure 9: Various components of a village tank (Dharmasena, 2010b)

Upstream tree belt (Gasgommana) - This is the naturally grown vegetation in the upstream land strip above the tank bed, flooded only when spilling occurs from the reservoir (figure 10). Large trees and climbers are found in this area. The *gasgommana* acts as a wind barrier reducing adverse effects of strong winds, minimizing evaporation from the tank, and lowering water temperature. It extends up to the bund (embankments), where roots of large trees create watery conditions suitable for breeding and living places for some fish species. This strip of trees demarcates the territory separating somewhat the human and wild animal domains.

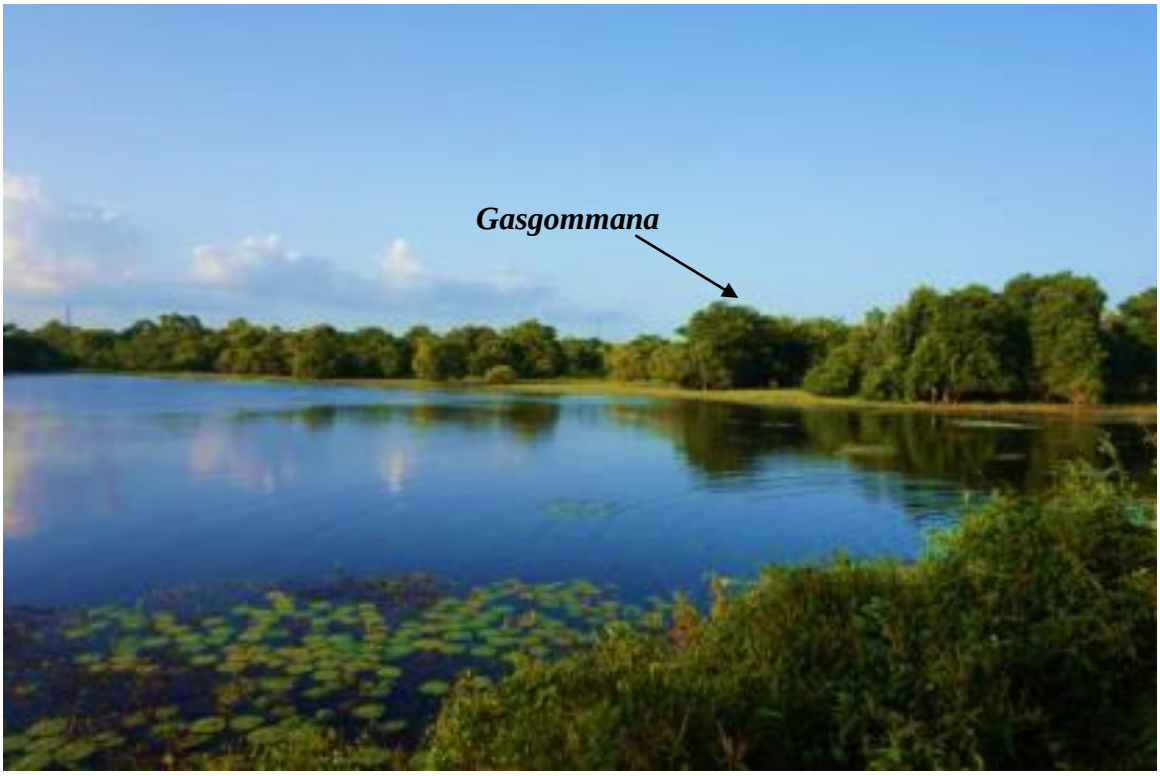


Figure 10: Gas gommana (Tree belt) in tank – Palugaswewa

Upstream meadow (Perahana) - This meadow developed below the *gasgommana* filters out the sediment flowing from upstream chena lands. Ithelps in maintaining the tank capacity reducing the threats of floods and droughts.

Upstream soil ridge (Iswetiya or Potawetiya) - This is an upstream bund constructed to prevent entering eroded soil from upper land slopes.

Upstream water hole (Godawala) - A manmade water hole to trap sediment and. It also provides water for wild animals.

Hamlet buffer (This-bambe) - A fertile land strip found around the settlement area (*gangoda*) that is not privately owned. Tree species such as *Maduka longifolia*,mango, and coconut are grown in scattered manner. This area was mostly used for sanitary purposes and as the resting place of buffaloes. Buffaloes were used as protection mechanism from wild animals and malaria.

Downstream drainage (Kiul-ela) - This is the old natural stream utilized as the common drainage. Tree species, which could absorb salts, and a few rare species of small fish are also found in water holes along the kiul-ela. Most importantly, it filters salts and iron polluted water, and improves the drainage condition of the paddy tract.

Interceptor (Kattakaduwa) - This is a reserved area of land below the tank bund. Its micro-landscape consists of three micro-climatic environments: waterhole, wetland, and dry upland, therefore, diverse vegetation is developed. This land prevents soluble salts and ferrous iron

entering the paddy field. The water hole referred to as 'yathuruwala' minimizes bund seepage by raising the groundwater table. Villagers plant *Pandanus kaida* along the toe of the bund to strengthen the bund stability. It appears to be a village garden, where people utilize various parts of the vegetation for purposes such as fuel wood, medicine, timber, fencing materials, household and farm implements, food, fruits, vegetables. Specifically they harvest raw materials from this vegetation for cottage industries.

1.9 Production System

The production system of the CTVS involves production from the paddy field, home garden, upland crop field/*chena*, tank, forest and the *kattakaduwa*. The paddy fields produce paddy; uplands produce other cereals, vegetable, spices and oil crops; tanks produce fish and some edible plants; forests produce timber and medicinal plants; home garden produces nuts and fruits; *kattakaduwa* produces medicinal plants, material for making mats and some handicrafts (rattan, reed) (figure 11). The tank bed during dry season, the scrublands, and the paddy fields during off-season, serve as grazing lands for the cattle and buffalo.

Figure 11: Kattakaduwa of Udakadawala tank

1.10 Goods and Services Provided By the System

The main livelihood of the people is farming while a few engaged in raising cattle and fishing. Women have the tradition of weaving mats, bags, hats etc. from raw materials collecting from village commons (figure 12). The system provides water and food for human as well as for animals and a series of other ecological functions such as habitats and biodiversity.

The collection and storage of rainfall runoff is the primary function of the CTVS. The water provides a number of ecosystem services such as rice irrigation, domestic water needs and environmental water needs. The tank storage recharges the groundwater table, which helps the villagers to have drinking water from their wells.

The other components of the system also provide habitat for many faunal populations including predators, fish and birds. The tank creates a wetland condition, making it possible to have a very high biodiversity situation in its surrounding and in the paddy fields. The forest, *chena*, scrublands, tank bed and other components (*kattakaduwa*, *gasgommana*) also contribute to a very high biodiversity owing to their varying ecological conditions. The tank bund, tank bed (when water level falls), scrublands and paddy fields after harvest serve as the grazing land for cattle and buffalo. The forests are the sources of timber needs of the villagers. The tank and the vegetation around it create a comfortable microenvironment and aesthetic view.

Figure 12: Handicrafts production in Palugaswewa Junction (2003)

CHAPTER 2: THE PROPOSED GIAHS SITE

2.1 Introduction

The Ministry of Agriculture proposes the Palugaswewa Divisional Secretariat Division in the Anuradhapura District as the GIAHS site, where 12 cascaded tank-village systems (CTVS) are found (figure 13). The site is within the Malwathu oya and Yan oya river basins, which are the home for original settlers who developed cascaded tank-village systems. At present, there are over 3 000 village tanks found in the Anuradhapura district out of total 14 200 village tanks in Sri Lanka. Further, the site falls within the "Cultural Triangle" of Sri Lanka, where ancient cultural monuments are conserved under the UNESCO support. The site is located closer to the popular tourist destination, namely Habarana and easily approached from any part of the country. There are 78 tanks of varying sizes found within the GIAHS (figure 14).

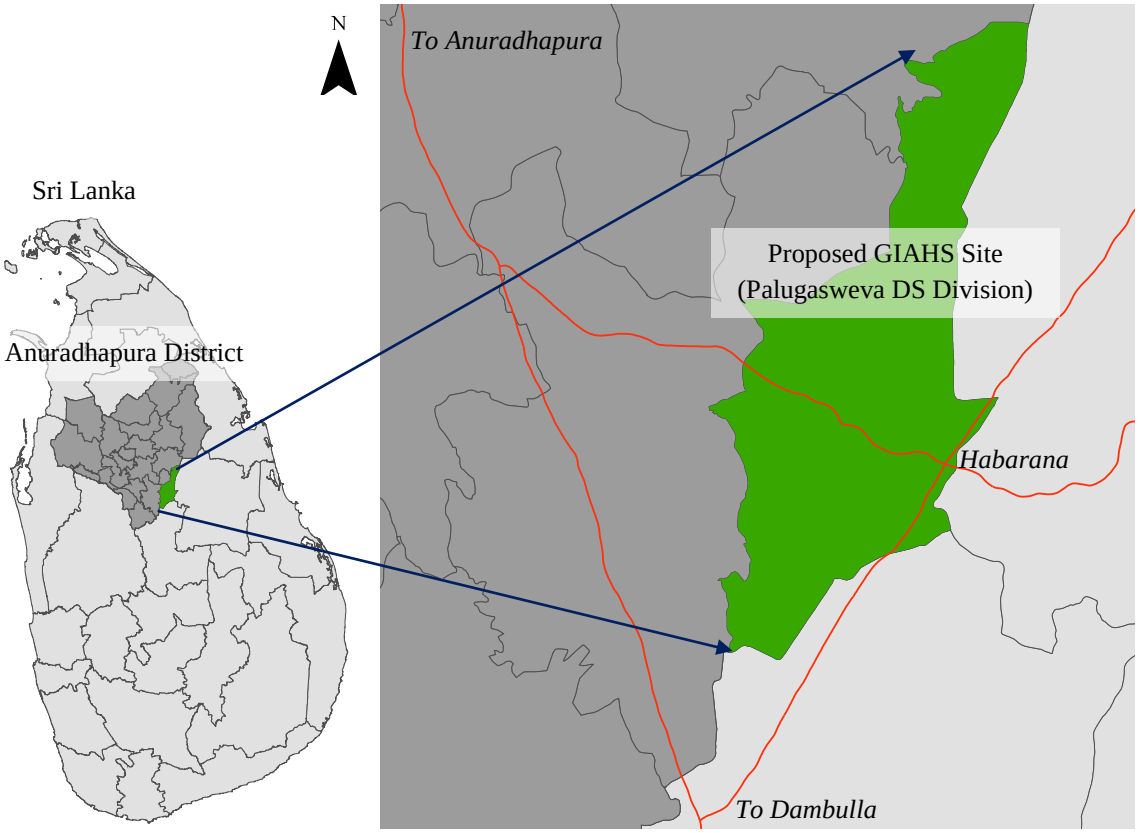


Figure 13: Location map of the proposed GIAHS site

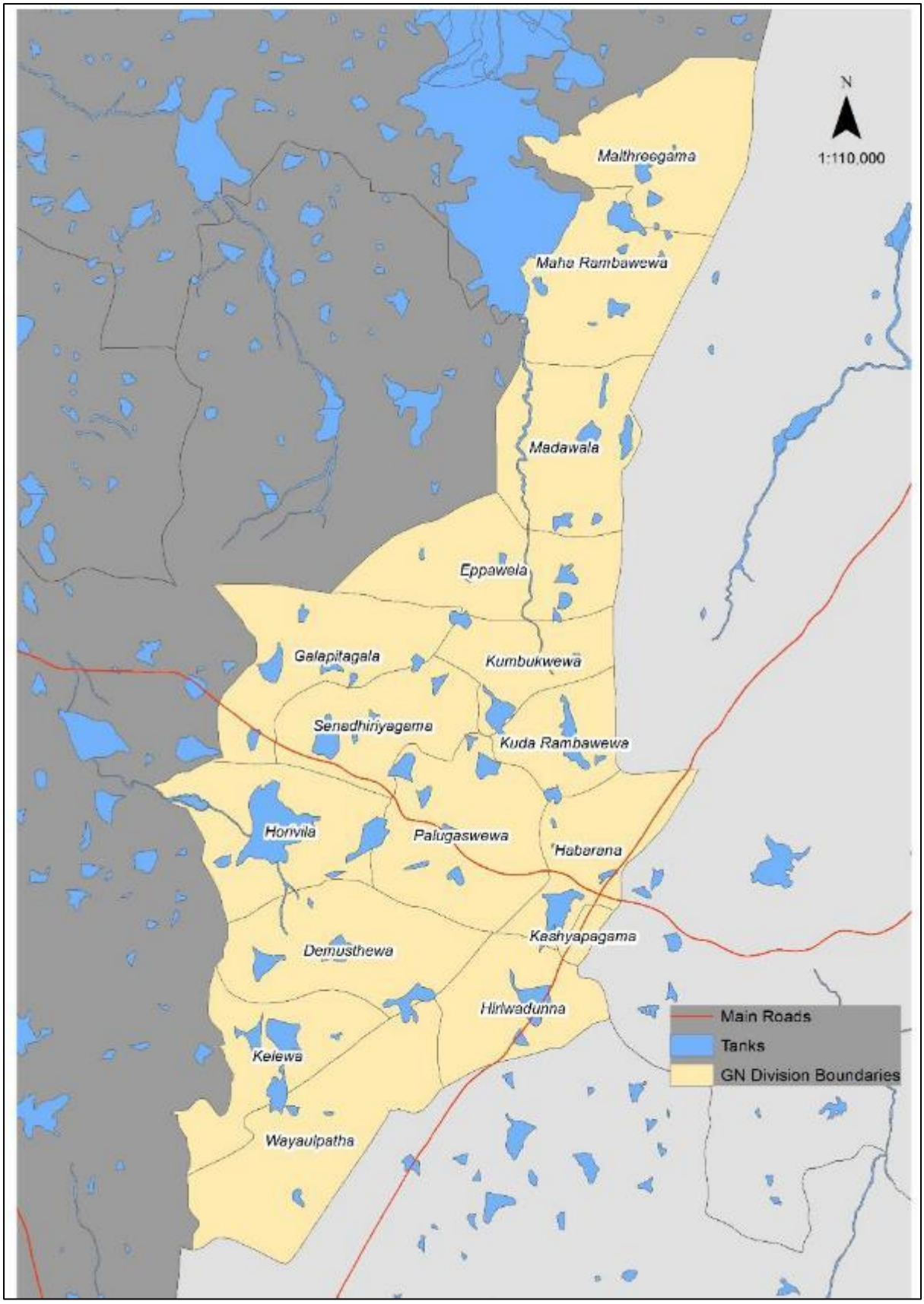


Figure 14 Detailed location map of the proposed site

The total land extent of the GIAHS area (Palugaswewa DS Division) is 187 km^2 (18 700 ha), in which 78 village tanks are found in 12 cascaded tank-village systems. The total population is about 17 000 in 5 400 families living in 37 villages. Administratively the GIAHS area is divided into 16 Grama Niladhari[1] (GN) divisions and basic information to describe the GN divisions is given in Table 1. In some cases, two families (close relatives) are living in one house.

A village has one main tank for various purposes including irrigation and one or few other tanks such as *olagam wewa* (tank without village), *kulu wewa* (forest tank), *kayan wewa* (sediment filtering tank) etc. (Table 2). Most of the *kuluwew* and *kayanwew* are now at abandoned state.

Table 1: Relevant information in 16 GN divisions of the GIAHS site

GN Code	GN name	Extent (km^2)	# of villages	# of houses	Demography			
					Population	Male	Female	# of families
589	Habarana	9.52	3	817	3,277	1,680	1,597	964
590	Kashyapagama	0.99	2	379	1,438	733	705	411
591	Hiriwadunna	9.02	2	279	1,117	551	566	348
592	Waya-ulpotha	17.49	5	281	963	503	460	315
593	Kelewa	10.30	1	271	1,130	568	562	382
594	Demunnewa	13.22	2	127	519	263	256	185
595	Kuda Rambewa	8.60	2	216	818	397	421	286
596	Kumbukwewa	3.51	2	180	764	386	378	275
597	Eppawala	6.94	3	255	926	462	464	326
598	Madawala	11.09	3	266	1,086	511	575	327
599	Maha Rambewa	11.82	3	186	752	375	377	229
600	Maithreegama	19.24	3	130	489	242	247	148
601	Palugaswewa	18.63	1	278	1,005	507	498	345
602	Senadiriagama	15.18	2	287	904	457	447	297
603	Horiwla	11.53	2	284	1,256	631	625	400
604	Galapitagala	20.32	1	145	495	239	256	181
Total		**187.40**	**37**	**4,381**	**16,939**	**8,505**	**8,434**	**5,419**

Source: Resource profile - 2015, DS Office, Palugaswewa

[1] Grama Niladhari Division is the smallest administrative unit in Sri Lanka

Table 2: Details of tanks in the GIAHS site

#	Tank name	Command area (ac.)	Nature of tank	# of farmers	Capacity (Ac.ft.)
1	Thelhamadiyava	186	Village tank	84	246
2	Ihala Rambewa	52	Olagama tank	58	77
3	Maha Kumbukwewa	177	Village tank	85	499
4	Halmillawewa	55	Village tank	122	307
5	Puvakpitiya	54	Village tank	86	819
6	Madavala Podi Wewa	110	Village tank	150	338
7	Patti Wewa	15	Olagama tank	8	64
8	Madugaha Wewa	15	Olagama tank	20	102
9	Kayan Wewa	5	Olagama tank	2	40
10	Abagas Wewa	25	Village tank	20	102
11	Galkadavala Wewa	135	Village tank	115	502
12	Ihala Wewa	8	Olagama tank	10	72
13	Kapugama Wewa	15	Olagama tank	10	64
14	Gambirigas Wewa	45	Olagama tank	47	92
15	Debunnava Wewa	115	Village tank	90	430
16	Rota Wewa	35	Olagama tank	65	123
17	Vidanage Wewa	40	Olagama tank	27	179
18	Nikagaha Wewa	22	Olagama tank	38	108
19	Kalava Wewa	100	Village tank	118	128
20	Siyambalalamuna Wewa	8	Village tank	4	70
21	Bulugaha Wewa	15	Olagama tank	20	46
22	Maha Meegas Wewa	48	Village tank	80	233
23	Ramba Wewa	71	Village tank	71	184
24	Bogahakotuva Wewa	34	Village tank	28	126
25	Siyambalagas Wewa	35	Village tank	30	151
26	Veheragala Maha Wewa	45	Village tank	130	150
27	Madavala Ihala Wewa	37	Olagama tank	150	102
28	Asirigama Wewa	32	Village tank	70	205
29	Habadivul Wewa	48	Village tank	33	158
30	Mha Ramba Wewa	24	Village tank	31	214
31	Phalagama Wewa	33	Olagama tank	30	164
32	Vayaulpatha Wewa	55	Village tank	36	182
33	Tidalava Wewa	86	Village tank	56	166
34	Hirivadunna Wewa	135	Village tank	148	475
35	Habarana Maha Wewa	148	Village tank	76	1012
36	Veera Wewa	50	Village tank	50	77
37	Palugas Wewa	65	Village tank	95	232
38	Yakandagas Wewa	46	Olagama tank	39	130
39	Alapath Wewa	26	Village tank	39	106
40	Ulpatha Wewa	20	Village tank	34	128
41	Karadaka Wewa	100	Olagama tank	30	154
42	Senadiriyagama Wewa	108	Village tank	98	447

#	Tank name	Command area (ac.)	Nature of tank	# of farmers	Capacity (Ac.ft.)
43	Thalakola Wewa	30	Olagama tank	11	213
44	Udakadavala Wewa	110	Village tank	45	552
45	Panvaliyaya Wewa	12	Olagama tank	8	77
46	Nikaathu Wewa	60	Olagama tank	27	148
47	Pandithaya Wewa	15	Olagama tank	25	50
48	Galapitagala Wewa	157	Village tank	205	563
49	Kapugama Wewa	5	Olagama tank	8	70
50	Karavilahena Wewa	8	Olagama tank	21	54
51	Moragas Wewa	8	Olagama tank	25	60
52	Kuda Meegas Wewa	20	Village tank	20	137
53	Kuda Ramba Wewa	62	Village tank	71	205
54	Karuwalagas Wewa	60	Abandoned tank	-	-
55	Marikarayagama Wewa	17	Abandoned tank	-	-
56	Koongolla Wewa		Abandoned tank	-	-
57	Mirishena Wewa	2	Abandoned tank	-	-
58	Thumbikulama Wewa	150	Abandoned tank	-	-
59	Ethawetunu Wewa	18	Abandoned tank	-	-
60	Ekiri Wewa	38	Abandoned tank	-	-
61	Weerawala Wewa	75	Abandoned tank	-	-
62	Meegahapattiya Wewa	20	Abandoned tank	-	-
63	Ulpatha Wewa	5	Abandoned tank	-	-
64	Kokatiyagolla Wewa	7	Abandoned tank	-	-
65	Ichchantottam(Iluwanto.)	15	Abandoned tank	-	-
66	Elapath Wewa		Abandoned tank	-	-
67	Kirimetiyawa Wewa	8	Abandoned tank	-	-
68	Kudagama Wewa	31	Abandoned tank	-	-
69	Bulana Wewa		Abandoned tank	-	-
70	Ihala Thammennawa	26	Abandoned tank	-	-
71	Dambagollagama Wewa	19	Abandoned tank	-	-
72	Kethigonewa Wewa	12	Abandoned tank	-	-
73	Mekichchawa Wewa	25	Abandoned tank	-	-
74	Weli Wewa	5	Abandoned tank	-	-
75	Palugollewa Wewa	35	Abandoned tank	-	-
76	Millaulpatha Wewa	12	Abandoned tank	-	-
77	Goma Wewa	10	Abandoned tank	-	-
78	Karadeka Wewa	13	Abandoned tank	-	-

Source: Resource profile - 2015, DS Office, Palugaswewa

2.2 Land Form and Climate

The landforms of this area are described as a ‘mantled plain undulating’, ‘mantled plain gently undulating’ and ‘mantled plain level’, i.e. level valley floors associated with low order valleys, rock knob plains and erosion remnants. The term “mantled plain” is used to designate

the planation surfaces having a mantle of residual material derived from the weathering of underlying basement rocks. The whole area is underlain by rock formations of the Khondalite complex. All landforms in this land system are developed from in-situ weathering of basement rocks, surface erosion and the process of slope recession. The flat or level narrow valleys have developed from the deposition of slope colluviums and alluvium brought down by streams (Somasiri, 2010). The drainage pattern is parallel to sub parallel forming a dendritic feature, which indicates strong bedrock control on the drainage. The dominant land elements are moderately broad convex crests of uplands, upland slopes in the mantled plains, and level valley floors, bare rock exposures within the rock knob plain and long narrow quartzite ridges crest and dissected ridge slopes. **These specific features of land system has led to develop the unique cascaded tank-village systems in this part of the dry zone.**

Palugaswewa DS division is in the DL 1b agro-ecological region and the closest meteorological station is at Mahailluppallama, 23 km away from the GIAHS site. Monthly rainfall data averaged over the period from 2003 to 2012 is shown in figure 15. It indicates that the annual mean rainfall in the area is about 1,400 mm. All traditional agricultural practices such as selection of varieties, land preparation, time of cultivation to minimize pest damage, water management etc. have been adjusted to this rainfall pattern, therefore crop failure occurred is very much a rare event. Table 3. Shows monthly climate data observed for the period September 2013 – August 2014 at Mahailluppallama. Potential evapo-transpiration varies from 42 to 122 mm/month during the year. Maximum monthly mean temperature varies from 29 ^{0}C to 35 ^{0}C, while minimum value is in the range of 20 ^{0}C – 26 ^{0}C. Relative Humidity in the morning ranges from 77 to 91 percent, while in the evening it varies from 46 to 75 percent. The periods March – April and August – October are having the warmest climate. Average wind velocity is in the range of 3 – 10 km/hr.

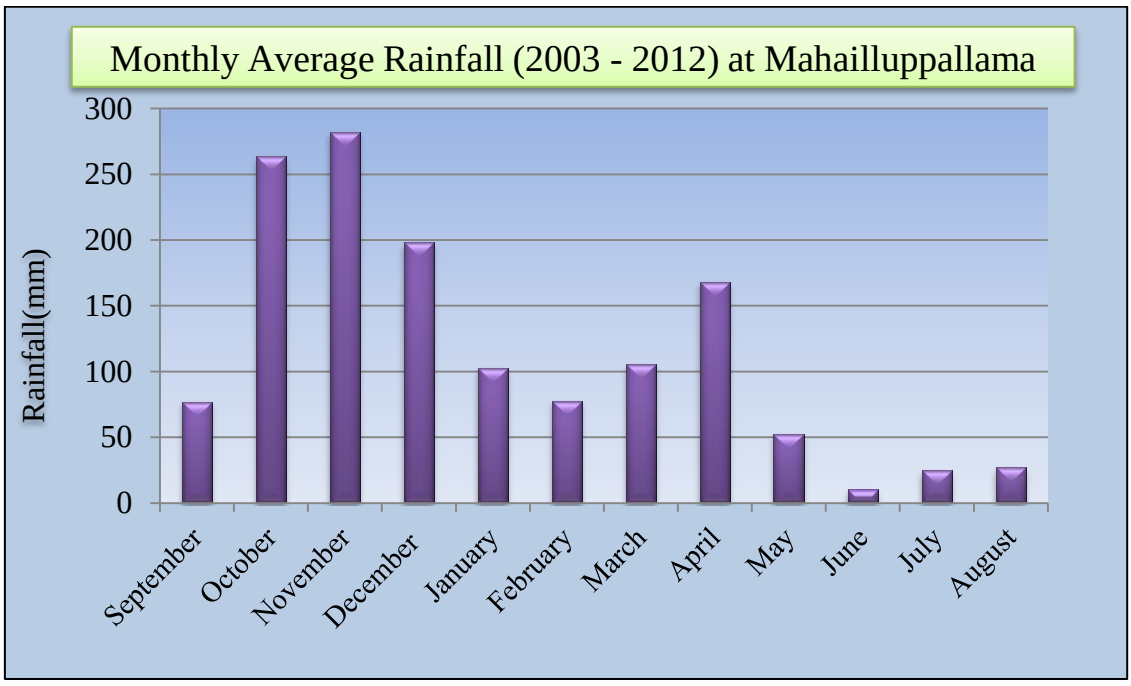


Figure 15: Monthly rainfall distribution at Mahailluppallama
Data source: Annual Performance Report (2014), Department of Agriculture

Table 3: Average monthly climate data (2013/14) at Mahailluppallama

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Rainfall (mm)	21.7	228.8	189.7	70.0	134.1	10.4	0.0	322.9	195.2	2.0	0.0	25.8
PET (mm)	91.2	99.2	57.6	42.2	54.6	69.4	111.6	91.2	86.8	105.6	121.5	106.5
Temp. max. ^{0}C	31.9	32.9	31.2	29.0	29.2	31.6	34.6	34.8	32.7	32.5	32.7	32.7
Temp. min. ^{0}C	24.0	23.6	22.4	21.4	21.3	20.2	22.2	23.5	24.8	25.6	25.3	24.4
RH % (M)	80	77	89	90	91	87	79	83	81	79	78	79
RH % (E)	62	58	72	75	72	51	46	54	67	63	59	59
Sunshine(hrs.)	7.1	8.4	5.9	4.1	5.5	8.4	9.1	9.1	8.5	8.3	8.1	7.5
Wind velocity (km/hr	8.0	6.2	3.5	4.6	5.4	4.9	6.1	3.1	5.6	9.3	9.8	8.1

Source: Annual Performance Report (2014), Department of Agriculture, Peradeniya
PET – Potential Evapo-Transpiration,
RH – Relative Humidity, M - Morning at 8.30 hrs., E – Evening at 15.30 hrs.

2.3 Soil Type

Two soil types are dominant in this area. The Reddish Brown Earth (RBE) soil (well or imperfectly drained) occupies on upper aspects of the land catena and Low Humic Gley (LHG) soil is found in the valley bottom (figure 16). The RBE well drained soil observed in this area is classified as *Aluthwewa* series and described as follows.

The *Aluthwewa* series is a well drained RBE soil with a deep soil profile. The distribution is confined to the crest, upper slopes and mid slopes of the undulating terrain and developed on coarse grained gneisses and migmatites of the Khondalite series. The color of soil varies from dark brown to brown in the surface. The sub surface soil color ranges from reddish brown to dark reddish brown. Texture of the soil, ranges from sandy loam to sandy clay loam with the increase of soil depth. Quartz and ironstone gravel can be observed at depth greater than 100 cm. However, depth to the gravel layer and thickness of the gravel vary according to the physiographic position within undulating topography.

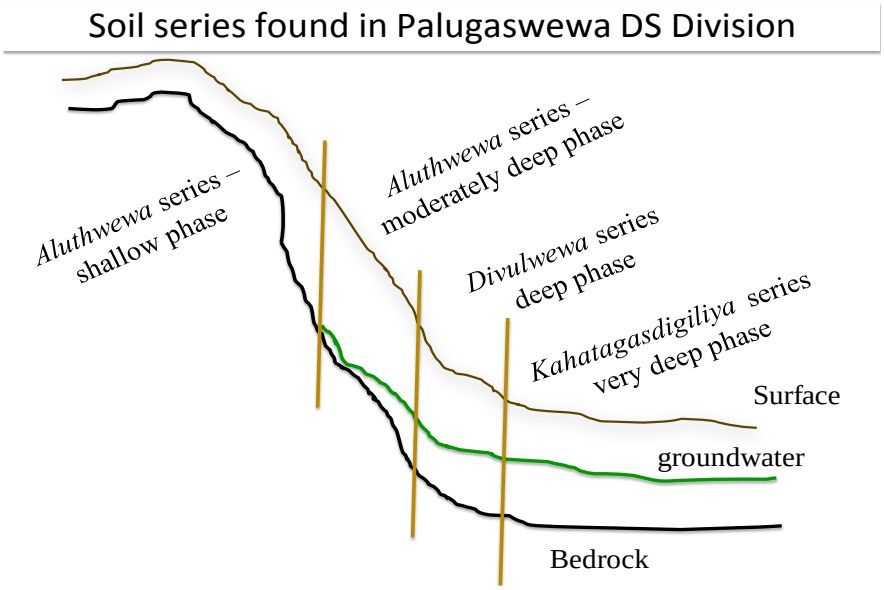


Figure 16: Position of soil series on the landscape - Palugaswewa

The other soil associated with *Aluthwewa* series is RBE imperfectly drained soil classified as *Divulwewa* series, which is briefly described below.

The *Divulwewa* series is a deep imperfectly drained soil. Texture varies from sandy loam to sandy clay loam with the increase of soil depth. The color of soil varies from dark brown to brown in the surface. The sub surface soil color varies from very dark brown to dark brown. Distinct mottles are visible in the lower part of the sub surface as the soils are confined to lower aspects of the undulating topography. Presence of black color iron-manganese nodules indicates the fluctuation of groundwater level within lower part of soil profile. Surface soil is slightly sticky and plastic when wet, friable when moist and slightly hard when dry.

The LHG soil found in the valley bottoms of the CTVS is classified as the *Kahatagasdigiliya* series and briefly described below.

The *Kahatagasdigiliya* series is a deep, poorly drained LHG soil occurring within valley bottoms of the undulating to rolling terrain found in the proposed GIAHS site. Texture is sandy loam and therefore low in moisture holding capacity in the absence of organic matter. The soil is susceptible to drought condition, thus, the dominant rice cultivation depends on irrigation water. Traditionally farmers cultivate these lands under tank irrigation, where the groundwater table is maintained at a shallow depth. The soil is naturally low in organic matter content and poor in available nutrients. **Traditional agriculture with their good practices (fallowing, green manuring, shallow tillage, bio-fertilizer etc.) for nutrient and moisture management people obtain a successful harvest from paddy. Due to the fact that the soil is high in sodium content traditional farmers have adopted good drainage practices (*kiwul ela*) in paddy fields.**

2.4 Nucleus of the GIAHS (Horiwila/Palugasweva Cascade)

The Palugaswewa DS Division consists of 12 cascades, of which the Horiwila CTVS is of particular importance as it is the central hub of the proposed GIAHS site as far as economics, administration and services are concerned. The Divisional Secretariat, trade centre, main school, hospitals (both western and local) and Agrarian Services Centre are located in this site. Therefore, any development activity can be planned initiated from this site and gradually extended to other periphery sites. However, culture, archeological monuments, traditional knowledge, local medicinal centres, martial art education etc. are dispersed within the whole GIAHS site. These hotspots need special attention. The report makes special consideration on this cascade system.

Not all these tanks were built for the purpose of irrigation. Some tanks are storage tanks (*gabada wew*), and tanks in the forest area (*kulu wew*) are meant to trap sediment and serve as a water source for wildlife. Some tanks (*kayan wew*) or water holes (*goda wala*) are found in the immediate upstream of irrigation tanks (*olagam wew* and *gam wew*) to prevent sediment intrusion. All tanks are hydrologically connected, naturally to share water for different purposes (figure 17). There are three tank series found within the Horiwila CTVS.

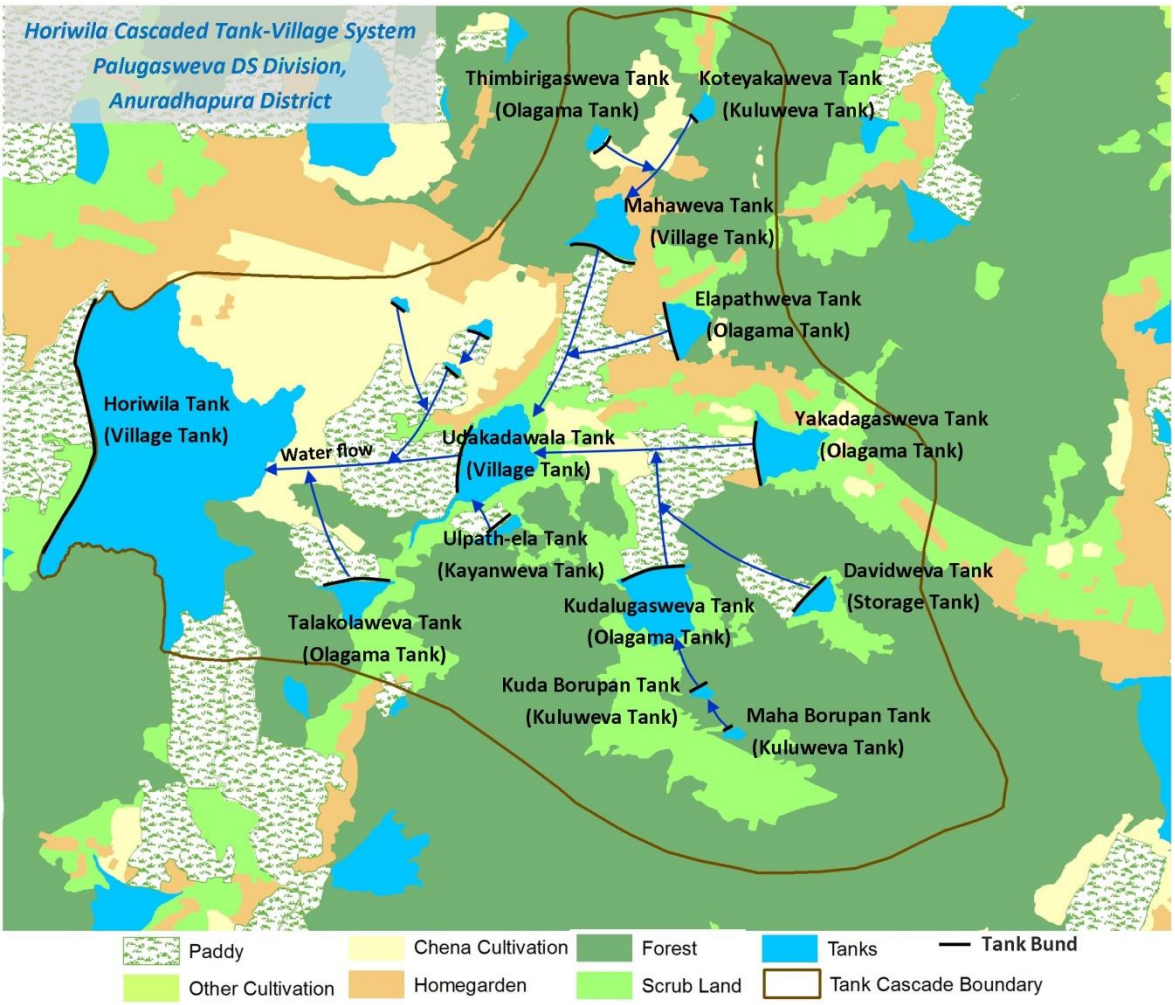


Figure 17: Hydrological connectivity of tanks in the cascade

i. Maha Borupanwewa – Kuda Borupanwewa – Kudalugaswewa tank series:
Maha Borupanwewa and Kuda Borupanwewa are forest tanks (*kuluwewa*), which act as water sources to Kudalugaswewa (an *olagama* – irrigation tank without village). These *kuluwewas* prevent eroded materials entering into the *olagama* tank, serve as water sources for wildlife, maintain the groundwater table for natural vegetation and provide feeding for cattle and buffalo.

ii. David wewa – Diyamalan wewa tank series:
David wewa is a recently developed irrigation tank and this must had been a *gabada wewa* (storage tank) in the past. No archeological remnants are found around to indicate any human settlement. Water is flowing into tank even during dry periods indicating the possibility of being a stock tank for the tank cascade system. Diyamalan wewa is a small depression to trap sediment to protect paddy fields of Yakandagaswewa.

iii. Koteyaka wewa, Thimbirigas wewa, Palugaswewa Mahawewa and Udakadawala tank series*:*
Water collected in Koteyakawewa (*kuluwewa*) moves to Thimbirigas wewa (*olagama*) without debris and eroded materials transported from *chena* lands. Thimbirigas wewa is

an irrigation tank, but paddy fields are at abandoned state at present. Water storage in this tank (if rehabilitated) can be shared with Palugaswewa *maha wewa* in any urgent situation.

In addition to above three series, Yakandagaswewa and Elapath wewa tanks are found standalone in the upper area of the cascade system. The catchment of the tank must had been a thick forest (*maha mukalana*) and do not show any evidence for *kuluwew* above them. A *kuluwewa* is needed if *chena* cultivation is taking place. However, recent removal of forest for *chena* cultivation can be observed in the catchment.

The cascade consists of three villages namely, Palugaswewa, Udakadawala and Horiwila, which cover an area of nearly 2 800 ha. The three villages consist of a population of around 2 300 (745 families) living around (figure 18). The details of the tank capacities, extent of paddy lands under the tanks and farming community are given in table 4. There are two tanks renovated recently from their abandoned state. Provision is kept for development of traditional components such as *kattakaduwa*, *gasgommana* and *kiulela* (drainage way) in these tanks. The other tanks had been in existence in working condition for a long time. The Government has improved those in recent time. Some tanks are very small, those have been constructed most probably to trap sediment. The dominant land uses of the site include, tanks (including bund, *kattakaduwa* and *gasgommana),* streams, lowland paddy fields, home gardens, *chena*, forests and scrublands (annex 1).

Most of the forestlands belong to the Government. One important aspect of this cascade system is that there is considerable proportion of the catchments of the tanks are still under forest cover. Further, the catchment area of each tank is less disturbed by constructions and other activities.

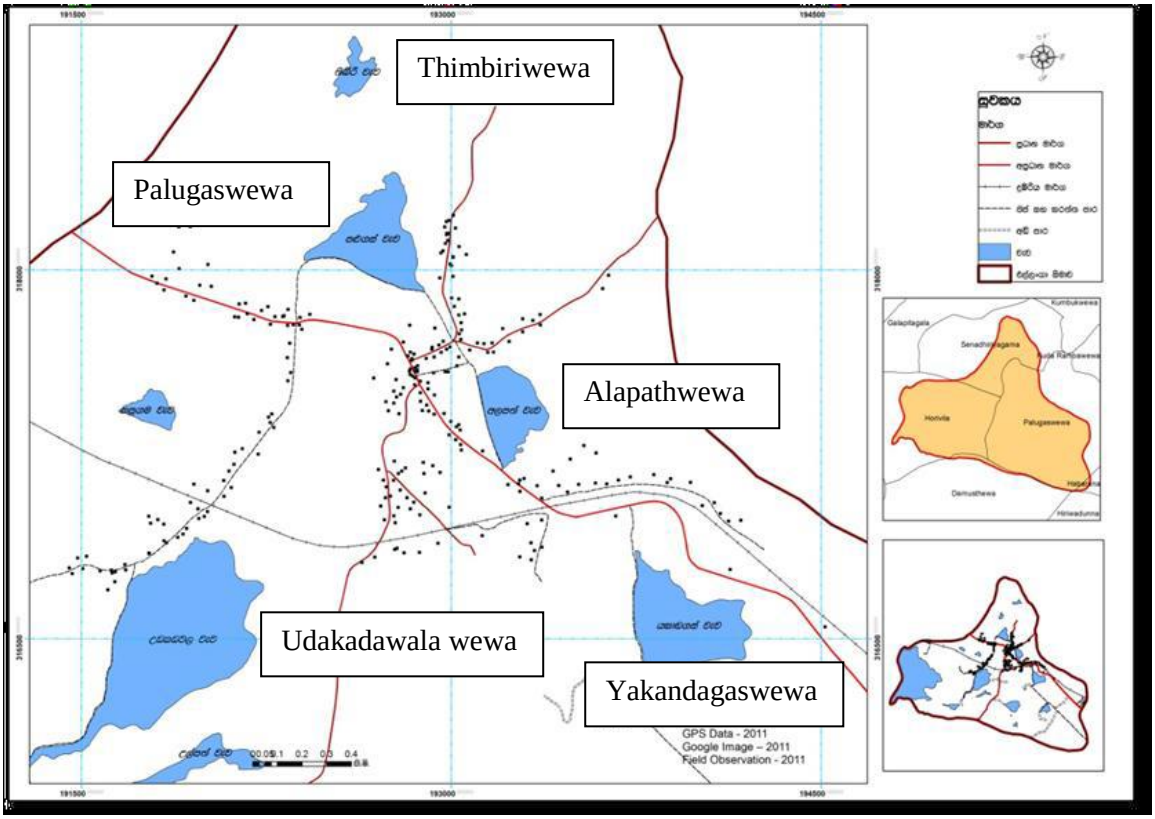


Figure 18: Distribution of houses in a part of the Horiwila CTVS
Source: Piyadasa et al, 2012

Table 4: Tanks and their status in the Horiwila CTVS

#	Name of the tank	Location coordinates		Tank capacity (ha.m)	Paddy land extent (ha)	No. of farmers	Remarks
1	Kudalugas wewa	N 8^0 2' 49.7''	E 80^0 42' 35.2''	43.2	21	22	Working tank with a good storage. Ecosystem components are restorable. It is a tank without village (*olagama*) belongs to Udakadawala
2	Kudaborupan wewa	N 8^0 2' 11.2''	E 80^0 42' 37.7''	-	-	-	This is a forest tank (*kuluwewa*) meant to trap sediment and serve as a water source for wildlife.
3	Mahaborupan wewa	N 8^0 2' 3.5''	E 80^0 42' 52.0''	-	-	-	This is also a forest tank (*kuluwewa*) meant to trap sediment and serve as a water source for

#	Name of the tank	Location coordinates		Tank capacity (ha.m)	Paddy land extent (ha)	No. of farmers	Remarks
							wildlife. Feeding area for cattle and buffalo.
4	David wewa	N 8^0 2’ 47.5’’	E 80^0 43’ 18.1’’	11.8	9	11	A relatively large abandoned storage tank, but can be restored. Water is flowing into tank even during dry periods. The ecosystem components are neglected and need restoration. The old name of the tank could not be traced.
5	Ulpath-ela wewa or Diyamalan wewa	N 8^0 3’ 1.2’’	E 80^0 42’ 48.6’’	-	-	-	This is a sediment trapping structure (*Godawala*) serving Udakadawala tank.
6	Yakandagas wewa	N 8^0 3’ 14.1’’	E 80^0 43’ 1.8’’	42.6	36	60	*Olagama*tank operational at present. Tank and its ecosystem need to be restored. No evidence for old settlement closer to the tank.
7	Alapath wewa	N 8^0 3’ 44.4’’	E 80^0 42’ 41.5’’	18.5	8	35	Working tank. Ecosystem components are in existence, but need improvement. No evidence could be traced for an old settlement closer to the tank.
8	Koteyaka wewa	N 8^0 4’ 43.6’’	E 80^0 42’ 49.3’’	-	-	-	A *kuluwewa* to protect Palugaswewa tank from sedimentation. The entire area is covered with a dense vegetation. Ecosystem

#	Name of the tank	Location coordinates		Tank capacity (ha.m)	Paddy land extent (ha)	No. of farmers	Remarks
							components could not be observed.
9	Thimbirigas wewa	N 8^0 4' 29.4''	E $80^0$42' 25.5''	-	-	-	The tank is an *olagama* tank and has an abandoned paddy field. Tank water is available during rainy seasons. There is a good potential to rehabilitate the tank and restore the ecosystem.
10	Palugaswewa mahawewa	N 8^0 4' 1.9''	E 80^0 42' 31.2''	48.1	31	35	Relatively medium size old working tank with a settlement. Tank bed is heavily sedimented and needs to be desilted. Ecosystem components are in good condition but need improvement.
11	Udakadawala wewa	N 8^0 3' 20.8''	E 80^0 41' 53.7''	77.1	51	81	The last tank of the tank cascade system. Working tank, heavily infested with aquatic weeds. A settlement is found around the tank. Tank ecosystem is in existence but needs to be improved.

Sources: Field observations in 2016 and Piyadasa et al, 2012

2.5 Tourism

The GIAHS site is located close to a few tourist attraction sites of Sigiriya, Habarana and Ritigala. Habarana is a popular tourist destination for safari lovers as it is the starting point for safari's in the nearby Habarana jungle and the Minneriya sanctuary, which is heavily populated by elephants. Elephant back riding is also an attraction in this small city. **Habarana is situated nearby to the Eighth Wonder of The World; Sigiriya (figure 19) and is situated on the main road from Colombo to Trincomalee and Polonnaruwa.**

Tourism is an attractive income avenue to the people living around Habarana. Hiriwadunna village is well known to tourist for its aesthetic value, and the ancient remnants found in the area win the heart of tourists. Travelling on Bullock carts is a naval experience for the tourists (figure 20). Boating in the Hiriwadunna tanks is also enjoyable service rendered by the villagers, and the tourists are given the chance of tasting local food preparations (figure 21). The use of a Catamaran (Dugout canoes) is an exhilarating experience for the tourists. Small-scale lodging facilities are also available for tourists in the Kashyapagama village.

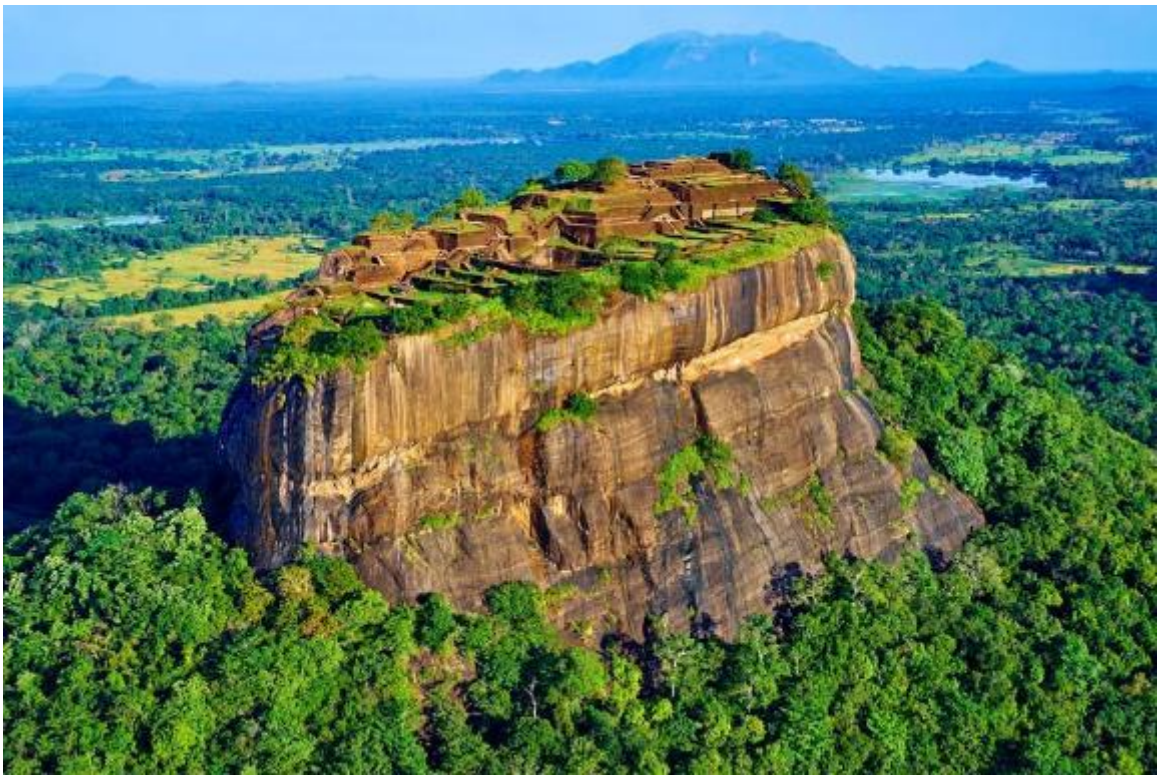


Figure 19: Sigiriya (The Lion Rock)

Figure 20: Travelling on bullock cart at Hiriwadunna

Figure 21: Tasting traditional foods at Hiriwadunna

2.6 Archeological Importance

The whole GIAHS site is full of remnants showing the ancient heritage inviting scholars to discover the Sri Lankan glorious history. Table 5 provides the information showing the archeological importance of GN divisions in the GIAHS site.

Table 5: Archeological remnants in GN divisions of the GIAHS site

GN code	GN name	Archeological importance
589	Habarana	Ancient Tempita vihara (temple on pillars) belongs to Kandy era with wall paintings
591	Hiriwadunna	Historical rock named '*kiri bath dena gala*' is situated in this GN Division. People offer *kiri bath* (milk rice) to the god and pray for protection
592	Wayaulpotha	Pre-historinc stone grave yards are found in the Kalawella Ulpotha area in this GN Division. Some stone pillars are found indicating an ancient building built on pillars. An ancient water spring is found in Ulpothagama village, active even at present. Remnants of collapsed dagabo with stone pillars are found in Bulana village. Remnants of temple with Buddha statue are found close to Wayaulpotha tank.
594	Demunnewa	It is believed that an underground grain storage is in the tank bed of Kumbikulama constructed during kings era to utilize during food shortage periods. People observe ants bringing paddy husk to the surface from this location.

GN code	GN name	Archeological importance
596	Kumbukwewa	An ancient *kovil* of *Paththini* god. A pair of large tusk of an elephant died while worshiping god, is displaying during ritual time in August.
598	Madawala	Ancient Tempita vihara (temple on pillars) belongs to Kandy era with wall paintings. Six stone cages with gutters (*kataram*) situated in the upstream of *Ihalawewa* are believed to be used by ancient monks for meditation.
602	Senadhiriyagama	An ancient stone sheet positioned in the temple. Three water springs found in the upstream of Ulpothagama tank, yielding water even during dry periods suitable for drinking.
603	Horiwila	An ancient stone bed believed to be used by a king. It is located without any cover in the forest. People do annually '*kiri ithurum mangalle*' after harvesting paddy in a location called 'Rame' near the Horiwila tank.

Source: Resource profile - 2015, DS Office, Palugaswewa

The tank cascade systems in this DS Division was selected from a number of candidate sites as reviewed by a technical working group, which was formed by the Ministry of Agriculture. The technical working group used the five GIAHS criteria and at the same time added other criteria such as the level of social capital in the site. Palugaswewa is one of the several sites, where the system is still partially maintained and where there is great potential to restore a few more of the traditional practices that can be adapted to modern times.

2.7 Five Criteria for the Selction of the GIAHS Site

2.7.1 Food and Livelihood Security

The farming systems have evolved based on the natural seasons. The *maha* season (October to February with Northeast Monsoon rains) is the main season where lowland paddy is cultivated in the paddy fields under the tank (figure 22). If the water is left in the tank after the harvest of *maha* crop and *yala* rains are received as usual to collect sufficient water in the tank, paddy is also grown during *yala* season. Average paddy yield under the proposed CTVS is around 3.2 tons per ha. The communities are self-sufficient in rice though most of the produce are no longer the traditional varieties but improved and hybrids. In recent times, well-drained paddy fields are used for cultivation of onion, chili, corn and pulses due to the shortage of water in the *yala* season. These crops bring additional income to the farmers.

Figure 22: Paddy cultivation irrigated by the tank - Udakadawala

Chena cultivation (shifting cultivation) was practiced in the *maha* season in forest area of the tank catchment (which was allocated for that purpose) until the nineteen eighties in the last century. However, at present, the fallowing period required for regeneration of forest is not possible due to a shortage of land. Therefore, most *chena* lands have been converted to land of continuous cultivation. Found mostly in the uplands, chena lands are used for growing other coarse grains, pulses, yams, spices and vegetables. Some of the traditional practices such as plant protection, moisture conservation, mixed cropping etc. are still taking place in these lands. Wild animals were chased away by watching the crop day and night using a multi-storey watch hut (figure 23 & 24). In the *yala* season, as rainfall is limited to a shorter duration of 1-2 months, sesame is grown in uplands. Recent analyses have shown that income from chena per season per hectare varied between Rs. 25 000 and 100 000. Sesame, kurakkan, cowpea and maize were recorded as major cultivated crops (Sandika and Withana, 2010). The income variation is due to the variation of the crops, soil fertility, farmer ability, price of the product and other socio-economic factors.

Figure 23: A traditional multi- storey watch out for protecting crops from wild life – Udakadawala

Figure 24: A traditional multi- storey watch out for protecting crops from wild life – Palugasweva

Perennial fruit and timber trees mostly occupy the home gardens. Beli, wood apple, orange, banana, jak, and mango are the common fruit trees while teak is the dominant timber tree species. The coconut tree is also very common in all home gardens. The home gardens supply most of the wood, firewood and other forest products for the district (in fact a substantive portion of forest products in Sri Lanka come mostly from the home gardens).Fruits produced are used for family consumption and excess if any, are sold. A recent survey in the area of the proposed site has shown that annual income from a home garden was around Rs. 67 000 per ha per year.

The tank is used to produce fish. Fish is enriched with health proteins and the villagers use fish as a main protein source. Sri Lanka has 82 species of indigenous freshwater fish belonging to 11 families. Forty-four species or 55 percent are endemic to the island. Some of these species have yet to be described and recorded scientifically. Unfortunately, several species are already extinct mainly due to habitat degradation. With the ongoing research, soon there will be a better and fuller understanding of our fresh water fish. Traditional fish catching methods are still being practiced (figure 25 & 26).

Lotus (*Nelumbo nucifera)* seed and tubers, Olu (*Lymphaea pubescens*) seeds and some green vegetable leaves, which are naturally grown in the tank, are harvested for home consumption and for sale (figure 27).

Figure 25: Karaka – a fish catching device - Palugaswewa area (2003)

Figure 26: Kemana – a fish catching device - Palugaswewa

Figure 27: A tank with lotus and water lilies – Udakadawala

The villagers, who depend on the CTVS predominantly consume rice. Lunch and dinner essentially consist of rice with curry. For breakfast, they use rice or food produced from rice flour, kurrakkan, meneri, thanahaal, green gram, cowpea or yams. All these food items are produced by the farmers themselves in their paddy land, rain fed upland and home garden. All vegetables as well as spices and medicinal plants important for primary health care are also produced in the home garden, upland or harvested from the locality. The milk, fish and fish products, and meat products are not produced in all households and they have to purchase from the local market (table 6).

Table 6: Egg and milk production in the CTVS

Type of livestock	Type of produce	Production per month
Poultry	Eggs	111,600
Cattle	Cattle milk (lits)	31,620

Source: Resource profile - 2015, DS Office, Palugaswewa

The forest is an integral part of villagers' livelihood strategies. A number of non-timber forest products are in common use. The most important of these are medicinal products, fuel wood, bee honey, some food products, fibers, and wild game (mainly wild boar). However, forests in the cascade are not a significant source of income.

The production system of the Palugaswewa cascade yet maintains the traditional components namely paddy field, home garden, highland crop field/*chena*, tank, forest and the *kattakaduwa*. However, their use has been relatively changed. Irrigated paddy cultivation is

the main farming practice. Chena cultivation has been changed to a settled cultivation by some farmers. In some places slash and burn cultivation is practiced with very short fallow period. Corn and sesame are the popular crops under rainfall in the Maha season (rainy season) in these lands at present. In the Yala season (dry season) paddy or other field crops are cultivated in the paddy field under irrigation by the tanks. In some highlands, crops are irrigated from shallow wells. These are some recent developments. Coconut, wood apple, orange, banana, jack, and mango mainly occupy the home gardens in the Palugaswewa cascade. Teak is grown in home gardens as a timber tree species.

The main livelihood of the people is farming which include cultivation of lowland paddy & other field crops, animal husbandry (dairy) and home gardening (table 7). Average monthly family income is from Rs 32 400 to about Rs. 40 000. Men are engaged in part time work outside the village. A very few number engaged in self-employment activities other than farming. Majority of women are engaged in farming and domestic activities.

Table 7: Percentage of population engaged in various livelihoods

Sector	Percentage
Agriculture (including Animal Husbandary and inland fishery)	89.5%
Rural industry	6.8%
Services	3.7%
Other	0

Source: Resource Profile 2015, Divisional Secretariat, Palugaswewa

2.7.2 Biodiversity and Ecosystems Functions

Sri Lanka's biodiversity is significantly important both at the regional and global scale. Sri Lanka has the highest species density for flowering plants, amphibians, reptiles, and mammals in the Asian region (NARESA, 1991). The CTVSs greatly contribute to this high biodiversity in the country due to the fact that the system combines a large number of ecosystems such as wetlands, seasonally wet and dry lands, paddy fields, uplands, forests, scrublands, tank beds, home gardens, rocky lands and water streams.

A recent study in the Palugaswewa cascade has shown that in the *kattakaduwa*, the tank bund, and the tree belt alone there are 226 plant species. They belong to 51 families (Piyadasa et al, 2012). These plants species include fruit, timber, medicinal, ornamental and forage trees. Many species are found in more than one ecological segment showing their adaptability to different ecological conditions. Figure 28 shows the distribution of flora species in different ecological segments in a tank-village system. There are 180 species altogether found in tank village eco-system, of which 77 species are found in *Kattakaduwa*, 21 species are only found in both home garden and *Kattakaduwa,* and nine species have directly come from the forest. It is not surprising to observe that 44 percent of *Kattakaduwa* plant species are common to all ecological segments. It is also important to note that *Kattakaduwa is* the only

area for 13 plant species. It was also found that 90 percent of plant species found in *Kattakaduwa* are of natural origin (Dharmasena, 1995). Hence, undoubtedly the CTVS fully endowed with globally significant biodiversity and genetic resources for food and agriculture. This is further validated by the below described globally significant plant species, home gardens, livestock, forages and pastures, diversity of forests etc.

Globally Significant Plant Species

Some plant species found in this system are land races adaptable to dry zone and can be considered as globally significant genetic resources. Among them traditional fruit trees and vegetables are of particular importance and adaptable to dry and extremely dry climatic conditions. Most of them are rare and disappearing. Some photographs are given in annex 3.

Wild fruit species:

Mora (Dimocarpus longan), Damba (Syzygium assimile), Palu (Manikara hexandra), Koan (Schleichera oleosa), Weera (dryptes sepiaria), Karamba (Carissa spinarum), Indi (Phoenix pusilla)

Wild fruit trees (domesticated):

Divul (Feronia limonia), Mee amba (honey mango), Beli (Aegle marmelos, Siyambala (Tamarindus indica), Veli anoda (Annona squamosa)

Wild vegetable species (domesticated):

Kiri dambala (Dolichos kiblab Linn), Niyan vetakolu (Luffa cylindrica), Thumba karavila (Momordica dioica), Batu-karawila (Momordica charantia), Ela batu (Solanum melongena), Thibbatu thakkali, Goraka thakkali, Wanni miris, Nayi miris (Capsicum chinense)

Figure 28: Plant species distribution in CTVS
Source: Dharmasena (1995)

Many traditional rice varieties have been lost during last few decades. However, with the current trend of global awareness of the benefits of consuming organic food and the dangers

of using chemical fertilizer and pesticides both to human health and the environment, traditional rice is gradually making a come-back. Farmers had many rice varieties, which they developed using natural selection by observing the adaptive ability of tolerance to water scarcity, resistance to pest and disease, impact on soil fertility as well as for various social needs such as health, cultural functions and religious needs. Among them, are many varieties found for specific purposes.

Farmers in the CTVS still cultivate few traditional rice varieties such as *Suwandel*, *Rathdel*, *Kaluheenati*, *Kuruluthuda*, *Kuru wee*, *Suduru samba*, *Kahata wee*, *Pachchaperumal*, *Elankalian*, *Madathawalu*, *Hetadha Wee*, *Hondarawalu*, *Girisa*, and *Heenati*. Importance of these traditional rice varieties are given in annex 4.

Vegetables grown in the *chena* (rain-fed upland) include pumpkin, luffa, snake gourd, long beans,*labu* (bottle gourd), e*labatu* (*Solanum melongena*), *kekiri* (*Cucumis melo*), *thibbatu* (*Solanum torvum*), *batu-karawila* (*Momordica charantia*) (figure 29) etc. In addition, cowpea, *kurakkan* (finger millet), *bada-iringu* (maize), *thana haal* (foxtail millet), *meneri* (proso millet) (figure 30), chillie, mustard, *kollu* (horse gram), sorghum were also cultivated before. Now growing of *thanahaal*, *meneri*, *chillie*, mustard, *kollu*, sorghum is not very common.

Figure 29: Batu-karawila (Momordicacharantia)

Figure 30: Meneri (Panicummiliaceum)

The home gardens consist of fruit, timber, medicinal plants, vegetables and ornamental plant species as seen commonly in the lands under the CTVS. Common fruit trees include: mango, jack, lime, wood apple, banana, papaya, guava, anoda, *Beli*, orange, cashew, and pomegranates. Common timber species in home gardens are: margosa, jak, *Lunumidellea*(bead tree) and *halmilla* (*Berryacordifolia*). *Ahu* (Indian mulberry), *ehela* (pudding pipe), *ingini* (*Strychnospotatorum*), *kaduru* (nux-vomica), *karapincha* (curry tree), lime, tamarind and margosa are the common medicinal species. Vegetable species such as *murunga* (drumstick tree), *ambarella* (*Spondiascytherea*), jak and coconut are very common in the home gardens of the CTVS.

Aquatic biodiversity is found in the tank and the paddy fields. The tank and the paddy fields act as wetlands. Hence, their biodiversity is very high. The produce of vegetation in the tank and the paddy fields serve as: 1) food; 2) ornamental material (flowers for religious offerings and decorations); 3) medicinal plants; and 4) material for handicrafts (weaving of baskets, mats, bags, etc.).

Kattakaduwa (Downstream Interceptor)

The land reservation between tank bund and paddy field is known as kattakaduwa. It consists of a water hole (*yathuruwala*), marshy land, wet land and the dry land showing a wide spectrum of floral vegetation.

A field survey conducted in the Udakadawala tank (Piyadasa et al, 2012) showed that there are 226 plant species within the *kattakaduwa* and downstream side of the tank bund. Of them 171 plant species are found in the *kattakaduwa* area. Spread of *kattakaduwa* in the Udkadawala tank is shown in figure 31.

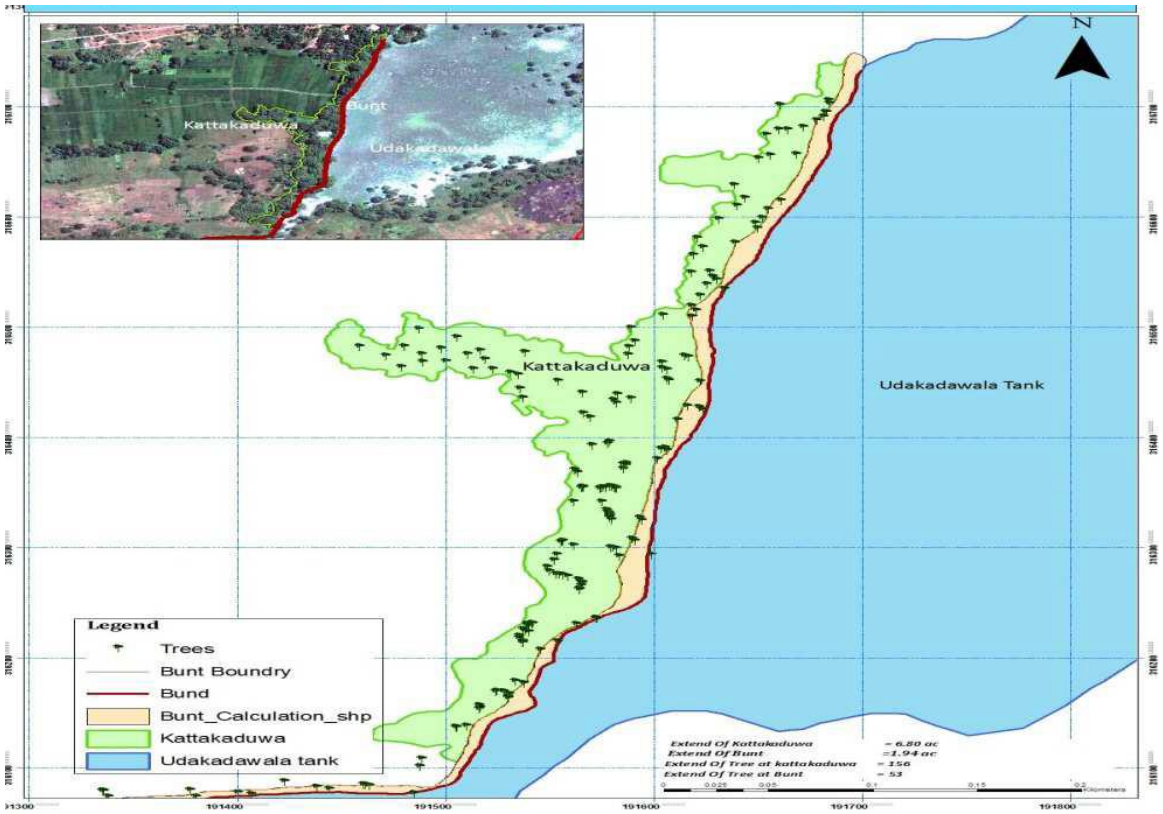


Figure 31: Spread of kattakaduwa in Udakadawala tank

Source: Piyadasa et al, 2012

Of total vegetation in the *kattakaduwa*, 68 percent of the trees are kumbuk (*Terminalia arjuna*), damunu (*Grewiadamine*), helamba(*Mitragynaparvifolia*) and karanda (Indian beach) plants at different ages. Among 55 plant species found in the Udakadawala tank bund, most prominent species are *thotila*, *maila* and ipil-ipil. Villagers use these plant species found in kattakaduwa for different purposes. Table 8 shows the uses of those in rural villages.

Table 8: Uses and functions of plant species in kattakaduwa (Dharmasena, 1995)

Name of the plant	Botanical name	Uses and functions
Margosa (neem)	*Azadirachtaindica*	Oil, pesticides, timber, medicine
Mee	*Madhucalongifoia*	Honey, oil, habitat for bats
Damba	*Syzygiumassimfle*	Mortar and pestle, timber, fruit
Kumbuk	*Terminaflaarjuna*	Lime, timber
Tamerind	*Tamerindusindica*	Fruit, soft drinks, sweets, chutney, medicine
Koon	*Schleicheria*	Fruit, chutney,
Ebony	*Diospyrosebenum*	Wood carvings, furniture
Kotta	*Ciba pentandra*	Pillows, toys
Indi	*Phoenix zeylanica*	Fruit, hats, bags, baskets, broom etc.
Palmyra	*Borassusflabellifer*	Timber, mats, bags, baskets, honey, sweets, toddy.
Bamboo	*Bambusa vulgaris*	Wood carvings, handicrafts, building materials etc.
Kithul	*Caryotaurens*	Honey, jaggery, toddy, timber, household implements
Patabeli	*Hibiscus tfliaceus*	ropes
Vetakeya	*Pandanuskaida*	Bags, baskets, mats
Rattan	*Calamus spp.*	Baskets, furniture
Reed	*Cyperuspangoreil*	Mats, baskets, trays
Wood apple	*Feronialimonia*	Jam, juice, soft drinks, medicine

Gasgommana (Upstream Tree Belt)

Gasgommana is the temporary flooding area between tank water levels of Full Supply Level (FSL) and High Flood Level (HFL). There are 396 trees and bushes belong to 25 plant species found within the *Udakadawalagasgommana*. Many trees have already been removed by villagers and at present trees are found in a scattered manner (figure 32).

Most abundant species in the Udakadawala *gasgommana* area are kumbuk (*Terminafiaarjuna*), nabada (*Vitexleucoxylon*) and karamba (*Carissa spinarum*). Abundance of plant species in the Udakadawala *gasgommana* is given in Table 9.

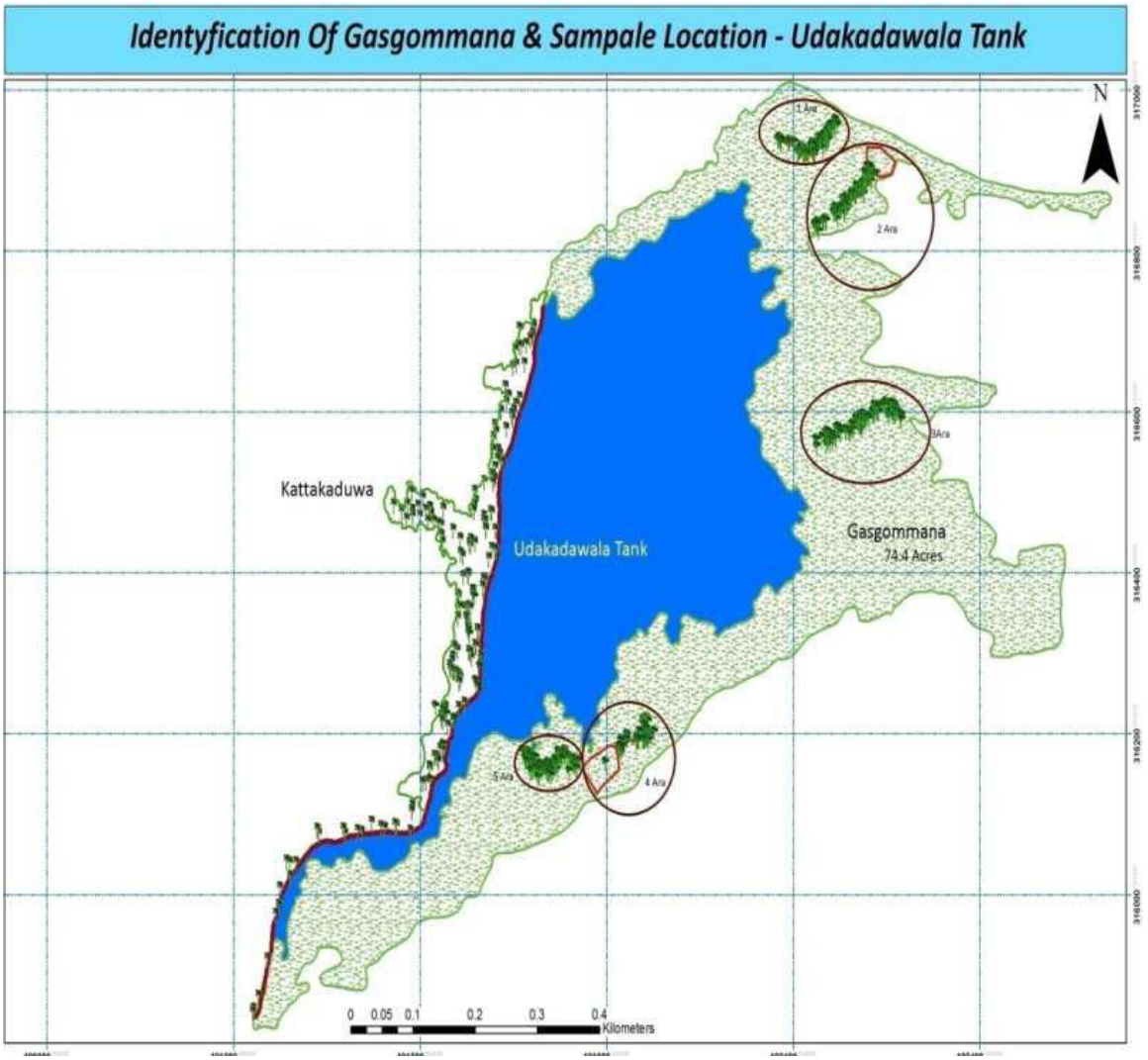


Figure 32: Spread of gasgommana in Udakadawala tank
Source: Piyadasa et al, 2012

Table 9: Relative abundance of tree species in Udakadawalagasgommana

Plant species	Abundance		Medicinal value	Other uses
	#	%		
Kumbuk(*Terminalia arjuna*)	124	33	To balance the three "humors": *kapha*, *pitta*, and *vata*. It has also been used for asthma, bile duct disorders, scorpion stings, poisonings and for heart disease	Traditional lime production, timber
Nabada (*Vitexleucoxylon*)	87	23	To cure diabetics, inflammatory diseases, liver disorders and free radical mediated diseases.	
Karamba (*Carissa spinarum*)	61	16	Known for its therapeutic effects against liver disease, epileptic disease, microbial disease, cytotoxic, viral diseases. It has antioxidant, antimicrobial, antiviral, anticonvulsant,	for use as fruit and medicine, fruit is of potential commercial interest.

Plant species	Abundance		Medicinal value	Other uses
	#	%		
			anticancer, antiarthritic, antihelmintic, cytotoxic value.	
Helamba (*Mitragynaparvifolia*)	29	8	To treat fever, colic, muscular pain, burning sensation, poisoning, gynecological disorders, cough, edema and as an aphrodisiac	
Bokalawel (*Derris scandens*)	21	6	Good antibacterial (*Escherichia coli*, and *Bacillus megaterium*), antialgal (*Chlorella fusca*), and antifungal (*Microbotryumviolaceum*) medicine	In preparation of Bio-pesticides
Rathmal (*Ixoracoccinea*)	20	5	It has antioxidative, antibacterial, gastroprotective, hepatoprotective, antidiarrhoeal, antinociceptive, antimutagenic, antineoplastic and chemopreventive effects	
Kaila (*Breyniavitis-idaea*)	10	3	Roots decoction is used as mouthwash, for the treatment of chronic bronchitis and wounds	For the control of mosquitoes
Kothalahimbutu (*Salacia reticulate*)	9	2	It helps normalize blood sugar and insulin levels, and supports healthy blood lipids. Traditionally used in Ayurvedic medicine to treat diabetes, and a potential antioxidant for human use against toxins that cause damage to the liver	
Palu (*Manikarahexandra*)	5	1	Used for treatment of various diseases such as ulcer, bronchitis, jaundice, ulitis, fever, hyper dyspepsia, arthritis and alimentary disorders.	Used as timber, edible and nutritive fruit, useful wood, latex and bark and it provides substantial livelihood support to local inhabitants.
Nithul (*Streblusasper)*	4	1	Treatment for filariasis, leprosy, toothache, diarrhea, dysentery and cancer.	Fodder source for buffalo calves
Total	370			

Data source: Piyadasa et al, 2012

Home Gardens

In the year 2012, 300 home gardens were surveyed in Palugaswewa and Udakadawla by Piyadasa et al. and results revealed that a complete canopy cover has occurred in 8 and 18 home gardens in Udakadawala and Palugaswewa respectively. Villagers have planted 58 plant species in their home gardens. Most abundant plant species are coconut, mango, jak, guava, banana and orange. Table 10 shows the canopy cover in the home gardens of the GIAHS site.

Table 10: Canopy cover in Udakadawala and Palugaswewa village home gardens (Piyadasa et al, 2012)

Canopy cover	# of home gardens	%
> 75 %	26	8.7
74 – 50 %	101	33.6
49 – 25 %	110	36.6
< 25 %	63	21.0
Total	300	

Livestock, Forage and Pastures

Cattle and Buffalo are the dominant livestock in the system. Goat and Poultry are not very common. Some farmers practice backyard poultry. Cattle and Buffalo were reared by almost all households until 1960s. However, due to the decreasing grazing lands, only few households rear cattle and buffalo at present. Cattle breeds, which are common in the villages are: *Zebu* (local breed), *Jersey, Sindhi, Sahiwal* and crosses of local breeds with Indian and European breeds. Buffalo is comprised of *Niravi* and *Murrah* breeds. Goat includes *Jamnapari, Saanen* and local breeds.

Diversity of Forest

A total of 93 wildlife protected areas have been declared in Sri Lanka. It includes 21 nature parks, three Strict Nature Reserves (SNR), five nature reserves, three jungle corridors and 61 sanctuaries. The total area covered is 14 percent of the country. Some of the cascades fall within the declared protected areas or close proximity to them. *Ritigala* is an SNR with high biodiversity and located very closely about 7km North-West of the selected GIAHS site.

The vegetation of the Ritigala SNR shows a clear pattern of altitudinal zonation. Most of the Wet Zone species are found at higher elevations and some of them are strictly confined to the summit areas of Ritigala. Some species occur within more or less sharp altitudinal zones. Most of the Dry Zone species are restricted to lower elevations. A Short-Stature Forest occurs on the summits and upper slopes of Ritigala.

Rock out crops and associated vegetation are common throughout Ritigala (figure 33). Tree species associated with rock outcrops include: *Commiphora caudate, Ficusar nottiana, Ficusmollis, Givotia moluccana, Lanneaco romandelica, Memecylon petiolatum, Euphorbia antiquorum, Bambusa bambos, Sapium insigne* and *Wrightia angustifolia*. Shrubspecies

include *Carmona retusa, Croton laccifer, Munduleasericea, Ochnalanceolata, Osbeckia aspera* and*Cassipourea ceylanica.*

Scrub forms in places of *chena* (shifting cultivation). Soon after *chena* is abandoned, various herbaceous pioneer species appear and they are followed by successions ofwoody species, culminating in the appearance of secondary forest. Characteristic species include *Azadirachta indica, Bauhinia racemosa, Carissa spinarum, Catunaregam spinosa, Dichrostachys cinerea, Flueggea leucopyrus, Gmelina asiatica, Grewia orientalis, Hugonia mystax, Ichnocarpus frutescens, Lantana camara, Limonia acidissima, Memecylon umbellatum, Phyllanthus polyphyllus, Scutia myrtina, Syzygium cumini, Toddalia asiatica* and *Ziziphuso enoplia.*

Figure 33: Ritigala Strict Nature Reserve (SNR)

Another forest reserve found closer to the proposed GIAHS is 'Hurulu Forest Reserve' found just about 5 km North East of Palugaswewa (N 8^0 12' 36", E 80^0 50' 59"). The reserve was designated as a biosphere reserve in January 1977. Initially, it was declared as a forest reserve in 1942. It comprises 25,500 hectares within the tropical dry evergreen forest in Sri Lanka.

The forest reserve contains Dry Monsoon Forest (Dry Mix Evergreen Forest) with a typically layered structure comprising an upper canopy of moderately large trees, a sub canopy of smaller pole-sized species and a distinct herb layer. The upper canopy is dense about 15-20m height and interrupted by emergents of which Satin and Palu are typical. The sub canopy is characterized by species such as *Korakaha, Kunumella*, *Weliwenna*. The orchid *Dendrobium maccarthiae* in bloom is a colorful sight. Dominant plant species are Setinwood (*Chloroxylon swietenia*) and Palu (*Manilkara hexandra*) together with the ebony tree (*Diospyros ebenum*). Among the most endangered animal species are the turtle (*Testudo elegans*), Ceylon Jungle fowl (*Gallus lafayettii*), the elephant (*Elephas maximus*), the leopard (*Panthera pardus*) and the rusty-spotted cat *(Felisru biginosa*).

Mammals include endemic torque macaque, loris, wild boar, sloth bear, spotted deer, pangolin, bandicoot rat, porcupine, rabbit, jackal, leopard, rusty spotted cat, mongoose, water buffalo and elephant. The avifauna includes a variety of endemic birds. Endemic birds such as Sri Lankan jungle fowl, spur fowl, and blue faced *malkoha*, and rare rufous woodpecker can be observed.

Forest found in the dry zone cascades belong to the following categories: dry monsoon forest, shrub and riverine dry forests. They show very high biodiversity. Dry monsoon and riverine forests are dominated by species such as *Manilkara hexandra* (Palu- use for timber), *Chloroxylon sweitenia* (Satin-Burutha-use for timber), Diospyros ebenum (Ebony for timber), *Drypetes sepiaria* (Weera-use for firewood), *Feronia elephantum* (Wood apple-use for fruit), *Vitisaltissima* (milla-use for timber), *Syzygium spp.,Chukrasia tabularis* (hulan hith- use for timber), *Madhuca longifolia* (mee- use for timber and medicine), *Berryya cordifolia* (halmilla- use for timber), and *Alseodaphneseme carpifolia* (wewarana-use for timber). The shrub and regenerating forests are characterized by *Bauhinia racemosa* (maila-use for medicine and forage), *Pterospermumsu berifolium* (velang-use for soft timber), *Cassia fistula* (ehala- use for medicine), and *Dichrostac hyscineria* (andara). The biodiversity in the forests is at risk due to selective felling of trees for timber. Some of the species are listed as threatened species.*Chloroxylon sweitenia* (Satin) and *Diospyros ebenum* are two nationally important timber species listed as threatened species.

Monoculture forest plantations (predominantly teak) have been established in some areas of the catchments by the Forest Department since 1970s. In recent times, farmers have also grown teak and *Halmilla* (a local species) in their home gardens under the support programs of the Forest Department.

Utilization of the Forest by the Community

The contribution of fruits, nuts, seeds, leafy vegetables to the local diet, products to the native medical practices and condiments to flavor and supplement food, nuts, roots, barks and seeds to extract edible oils, resins, latex, honey, raw materials for industries, construction materials and others to the survival maintenance, are increasingly recognized in the interest of managing the forest resources for the betterment of life.

The forest was used for *chena* cultivation, bee honey extraction, timber needs of the villagers, extraction of wild fruits (Eg: *gal syambala*) until mid-1980s. *Chena* cultivation was practiced by obtaining a permit from the Forest Department (FD). After 1981, FD discontinued issuance of permits to use forests for *chena* cultivation. However, village communities are allowed to use non-timber forests products. Eco-functions are the important services provided by the forests in the tank cascades at present. Forests serve as watersheds of tanks and provide habitats for fauna and flora. In some cases, Buddhist hermitages are located in the village forests. Forests in the cascade are not a significant source of income.

Forests legally owned by the Government are widely used by almost all fringe communities for their multiple products. The usufruct rights of the communities have been maintained

without recognition. Although the level of dependence of the households vary, the service functions of the forests are considered a condition that helps them to maintain the non-forest activities, primarily agriculture. The forest is equally considered as a source of multiple products, which include a large number of non-timber forest products. For those who depend heavily on agriculture for a living, the forest is the next most important source of survival. A study carried out in Ritigala SNR shows that throughput the year the forest is a source of survival needs and these include food, fuel wood, medicinal products, binding and fencing materials etc. The well marked seasonal nature of other forest products, the varieties sold in the market, primarily 'gal-siymabala' (*Dialium ovoideum*), Honey and 'bin kohomba' (*Munroniapumila*) help smooth the seasonal difficulties in getting an income. The gathering groups are formed for better harvesting within a given periods in which these products are available. Community interaction with the forests for cultivation has resulted in their heavy dependence on cultivated crop in the forest reducing the complementary nature of subsistence farming and non-timber forest products. The concerns of the fringe dwellers over the forest has been driven away from the gathering of non-timber forest products.

Participatory Forestry Development

Community Forestry approach has been one of the best models in the world for sustainable management of forest resources and livelihood improvement of the local communities. The Sri Lanka Forest Department has also tested a number of participatory forestry models since 1980s. The community forestry model was intensively tested in Sri Lanka from 2003 with the help of Sri Lanka Australia Natural Resources Management project, which concluded in January 2009. During this period a number of policy documents such as Operational Guidelines for Community Forestry, Agreement Provision between Forest Department and community were approved by the Government, which were in the line with National Forest Policy and the Forestry Sector Master Plan. As a result, more than 55 groups have been registered, have approved management plan and have agreement for 25 years. Linkage development with other service providers through Forest Department for leveraging fund and technical service was very crucial for the success of the project as the local people are less dependent for tangible benefit from the forest. The impact study and the Independent Completion Review Mission fielded in late 2008, concluded that the project has made substantial contribution in the management of forest and other natural resources, contributed in the livelihood of the local communities significantly and developed the capacity of Forest Department for Community Forestry Implementation. As the program was very successful, the Government of Sri Lanka has made this program as a national program and is being expanded throughout the country.

2.7.3 Knowledge Systems and Adapted Technologies

Indigenous knowledge evolved for centuries in traditional agriculture is a mixture of many aspects derived from religious and spiritual origins, cosmic influence (astrology) and natural phenomena. Beauty of the traditional agriculture is that it has followed at many instances the rules, principles and phenomena of nature. This is the vital reason for the sustainability and

the environmental compatibility of these systems, which prevailed for centuries under very harsh climatic conditions tolerating sudden shocks of natural events (Dharmasena, 2007).

Knowledge gained by these communities has transmitted through generations and it is still available with them. Some of them have been documented in ola leaves and still can be traced in the Palugaswewa area (figure 34).

Figure 34: Ola books, which store their traditional knowledge – Palugaswewa

One example for their traditional knowledge is that the rural people understand the salinity status of soil by observing the plants found in an area. Diwul (*Feronia limonia*), keeriya (*Acacia chundra*), indi (*Phoenix zeylanica*), ikiriya (*Hygrophila spinosa*), pothu-pan (*Scleria poaeformis*), vetakeya (*Pandanus kaida*), illuk (*Imperata cylindrical*) are grown in saline soils. They believe that Many plant species are known to be salt absorbing such as Vetakeya (*Pandanus thwaitesii*), Matgrass(*Cyperus pangore*), Ratton (*Calamus spp*), Palmyra *(Borassus flebelfifer*), Karanda (*Pongamia pinnata*), Thimbiri (*Diospyros malabarica*), Damba (*Syzygium assimile*), Areconut (*Areca catechu*), Milla (*Vitex pinnata*), Tamarind (*Tamarindus indica*), Beli (*Aegle marmelos*), Margosa (*Azadericta indica*), Kumbuk (*Terminalia arjuna*), Wood apple (*Feronia fimonia*) and Mee (*Madhauca longifolia*). Hence these plant species can be used for water purification in the bio-remediation process.

Families had become experts and specialists for different purposes. Some examples are *Wedadura* (physician), *Yakadura* (healer), *Kammalkararaya* (blacksmith), *Dadayakkaraya* (hunter) and *Gamarala* (village headman). They gave their education to next generation through instructions, apprenticeships and learning through observation.

Martial arts

One of the reflections of our heritage system is the martial arts, which are still prevalent in its dynamic form (figure 35). ***Vishuddi haramba*** is a form of martial art from the proposed GIAHS site that combines combat techniques, self-defense, sport, exercise, and meditation. A key component of vishuddi haramba is the *angam*, which incorporates hand-to-hand fighting, and *illangam*, involving the use of indigenous weapons such as the ethunu kaduwa, staves, knives and swords. Another component known as *maya angam*, which uses spells and incantations for combat, is also said to have existed. The Angampora's distinct feature lies in the use of pressure point attacks to inflict pain or permanently paralyze the opponent. Fighters usually make use of both striking and grappling techniques, and fight until the opponent is caught in a submission lock that they cannot escape.

Figure 35: Ritigala Vishuddi Haramba (Martial Art)

Usage of weapons is discretionary. Perimeters of fighting are defined in advance, and in some of the cases is a pit. With the advent of colonialism over the entirety of the island in 1815, Angampora fell into disuse and was very nearly lost as a part of the country's heritage. The British administration prohibited its practice due to the dangers posed by a civilian populace versed in a martial art, burning down any *angan madu* (practice huts devoted to the martial art) found: flouting of the law was punished by a gunshot to the knee, effectively crippling practitioners; Angampora nevertheless survived within a few families, allowing it to emerge into mainstream Sri Lankan culture post-independence.

A number of paintings related to angampora are found at Buddhist temples in Sri Lanka. These include Embekka Devalaya, Gadaladeniya Rajamaha Viharaya, Temple of the Tooth, Saman Devalaya (Ratnapura) and Lankathilaka Rajamaha Viharaya.

There was a time, many centuries ago, all the villagers in the ancient villages around the serene 'Ritigala' knew a martial art, which was purely a Sri Lankan way of defending themselves against the enemy. The highly disciplined method of 'physical combat', known as '*Angam Haramba*' was practised by most ancient Sri Lankan men, who were 'on call' for any emergency when the country's security was threatened.

'*Angam haramba*' is unique to Sri Lanka and was also an indigenous martial art that helped the ancient kings, who were also well trained in this art of combat, to defeat the foreign invasions – Indian, Portuguese and Dutch.

"*Angam haramba*" had been in existence since the 16th century and had faced threats from time to time as it was a well-disciplined, comprehensive form of martial art, especially in combat missions. During the British rule, they destroyed *Angam haramba* and our ancestors feared to come out as they would be killed or their families harassed. Ours is one such generation, which kept it a secret. The ola leaves, where the art was documented, according to researchers of the University of Kelaniya, is over 500 years old,

Local Medicine (Horiwila Wedagedara)

The village Horiwila is located with the tank just below the Palugaswewa tank cascade system, where the GIAHS site is proposed. The Horiwila indigenous medical tradition commences from King Dhathusena era (455 AD) and Dr Herathhamy's reputation expanded beyond the shores of Sri Lanka. Lived in a remote village in Anuradhapura District, he had thousands of miraculous treatments for his credit derived from recipes, which are of confidential hereditary by the family tradition.

Figure 36: Horiwila Wedagedara (medical center)

The family is a repository of vast traditional knowledge in Sri Lanka Ayurvedic herbal medicines handed over through centuries within the family and from the clinical and pharmacological experience gained from years of intensive and dedicated practice of Ayurveda.

All his medicinal secrets were relayed to his son Sena Banda, who later became a prominent member of the Ayurvedic Medical Council of Sri Lanka for the past two decades and is doing a yeoman service for the preservation and development of Sri Lankan indigenous medicine, apart from treating thousands of patients – both local and foreign.

Evolution of the CTVS

The historical evidence suggests that the CTVS has been evolved over a period of two millennia. The dry zone of Sri Lanka where this system has been evolved, experiences a protracted dry period which occurs every year from May to late September. Life is not possible during this period without a reliable source of water for domestic use. Panabokke (2010) reported that the early settlers in this part made rudimentary ponds by damming across valleys to store run off water during the rainy season for use in the dry period. They took the advantage of the heavy run off during the rainy period and the undulating landscape for this purpose. Lately they have invented the *ketahorowwa,* the sluice made of terracotta pipes to take the water out of the ponds and the ponds were transformed into irrigation tanks. In the valleys, lowland rice was cultivated as soils were essentially hydromorphic and suitable for retaining water after puddling the soil. The dendritic drainage pattern on the undulating landscape made it possible to develop cascading system of small tanks in the valleys where ephemeral streams drained rainwater to the main river systems. As time passed, probably by trial and error they have learned how to manage the water in the cascade system by proper catchment management and developing various components in the system such as *kattakaduwa* and *gasgommana* etc. In order to assure that the paddy crop is raised without subjecting to water stress, the cultivation of paddy under the tank commenced only after an assured storage is accumulated in the tank. This practice gave them sufficient time to complete chena cultivation before they come to the paddy field.

Basic problems faced by farmers were shortage of water in less rainy seasons, development of salinity in certain part of the field, and damage from wild animals, pest, and diseases. Strategies adapted to address these problems were not specific to a certain problem but collective. The following strategies were adapted to minimize the water shortage problem in the CTVSs (Dharmasena, 2010 a).

a. ‘Bethma’ practice—It is a practice that temporarily redistributes plots of land among shareholders (paddy landowners) in part of the command area (territory) of a tank (reservoir) during drought periods.
b. ‘Pangu’ method—The tank had to be maintained properly to avoid breach, leak, and excess seepage. Repair and desiltation of tanks and cleaning of canals during dry periods are shared tasks assigned to each farmer proportionately to land ownership.
c. ‘Kekulama’—Farmers advance the cultivation time using early seasonal rains whenever they feel that tanks would not get enough water to cultivate the command area. They have the experience that if September (2^{nd} inter-monsoonal) rains are high, the total seasonal rainfall is not adequate to fill the tank.
d. ‘Karahana’—This is a water distribution device fixed across the canal made up of log with two weir-shape cuts. The size and bottom level of these cuts are made according to flow requirements of the two canals below, and the *karahana* is fixed by the village head (*Gamarala*).
e. Village commons—micro-landscapes are utilized to reduce tank water losses, mitigate salinity effects, prevent tank sedimentation and so on.

Maintenance of the System

The tank and the forests were considered as sacred by ancestors of the system as those were the basic sources that helped providing water. These resources were considered belong to gods and deities. This belief was passed from generation to generation. Hence, it was the responsibility of all individuals lived in the community to protect and maintain them. Maintenance of the tanks, irrigation canals, roads and other common property was carried out by community participation under the leadership of village headman until this was transferred to the state institutions at recent times.

Soil Fertility Management in the Paddy Fields

Unlike the chena where upland crops are cultivated in rotation, the soil fertility tends to decline by continuous cultivation of the paddy fields. This problem has been tackled by allowing cattle and buffalo to graze during fallow period (figure 37), by adding green manure, promoting leguminous weeds to grow in the fallow period and by fallowing the field for several years when poor growth is noticed. Grazing cattle add sufficient quantities of urine and dung to restore the soil fertility. (Nayakekorala, 2010)

Figure 37: Cattle and buffalo to graze paddy field during fallow period

Equitable Sharing of Land & Water

Water availability to a plot of land in the paddy field depends on the proximity of the land to the tank. The paddy plots which are closer to the tank can get water easily and those that are far away get less water. In order to minimize inequalities of water distribution to lands under a tank, a system of land allocation is practiced in the villages. In this system, lands were grouped into three based on the proximity to the tank namely: upper section (*upayapotha*), middle section (*heranapotha*) and lower section (*aswdduma*). Each farmer has allocated land in each section so each person enjoyed the same benefit of water allocation. This also reduced any disparity that may arise from differences of fertility of the soil due to fertility gradient along the paddy tract. In order to deliver the correct amount of water in each channel, depending on the extent of land under each channel, a device called "*karahankota*" is used. *Karahankota* is a kind of weir made of wood and placed in the main channel to divide the water flow.

Cropping Systems

The cropping calendar is based on the rainfall pattern. There are two seasons of cultivation based on rainfall pattern, these are: *maha* and *yala* seasons. There are two farming components important in the system namely: upland crop cultivation and lowland paddy cultivation. The lowland paddy is grown with irrigation water. The upland crops grown during *maha* season are rain-fed. Generally, farmers give priority to upland crop cultivation as crops have to be established at the onset of rainfall. Paddy cultivation is based on the availability of the water in the tank. Therefore, lowland paddy cultivation begins later in the season. The general crop calendar adapted in the CTVS is shown in figure 38.

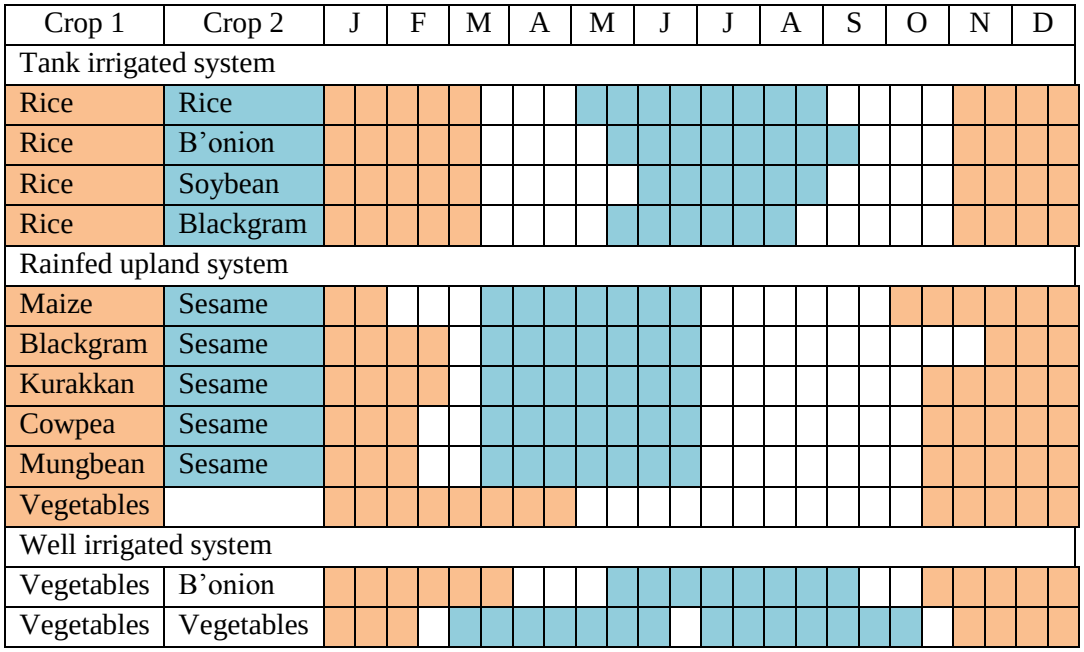


Figure 38: Cropping calendar of the CTVS

Vegetables – Pumpkin, water melon, longbean, tomato, luffa, brinjal,elabatu (Solanum melongena), kekiri (Cucumis melo), thibbatu(Solanum torvum),batu-karawila (Momordica charantia)

Source: Mrs. Janaki Ariyadasa, Agriculture Instructor, ASC, Palugaswewa

Crop Management and Protection

Traditional agriculture is based on certain strategies aiming to adjust for climate variability and conservation of resources. Main strategies are as follows (Dharmasena, 2010).

- Land for chena cultivation was selected from middle part of the land catena with gentle slopes, where soil is relatively deep. Paddy is cultivated in valley bottoms, where groundwater influence is high during longer period of the year.
- Risks of farming due to factors such as rainfall, drought, pest and diseases, and damages from wild animals were reduced by adjusting the cultivation to the best times through long experience.
- Favorable environment for crops was maintained by adoption of various soil and moisture conservation practices and through shade management.
- Land productivity was maintained by posing least disturbance to soil and using high amounts of biomass through fallowing.
- Diverse crop combinations were adopted to cope with variation of climate, soil, and other biotic as well as abiotic stresses.
- Simple farm implements were used with lesser energy consumption. Shallow tillage with '*sinhala nagula*' does not penetrate the hard crust, which prevent percolation of water with nutrients
- Land races were improved as family secrets to utilize as most suitable crop varieties for the area.

Paddy Crop is protected from birds and pest damage leaving a small portion of land (*kurulu paluwa*) to attract birds for pest management and if necessary supplement these actions with use of plants or plant extracts (bio-pesticides).There are three spiritual categories of

traditional practices also to protect crops from pest damage. The first group is based on astrology, the second on the powers of the spirits and Gods, and the third involves the chanting of verses and the use of specific symbols. Often these different practices are combined (Upawansa, 2000).

Management of Animals, Pastures and Forage

At present, the livestock farming in the system is not a major activity as compared to the old days. There are some limitations. Shortage of grazing lands has been the main reason. Some farmers in the system keep a few cows of cattle/buffalo for milk production. These animals are managed in extensive manner, feeding on communal grazing ground during daytime, brought back home in the evening, and kept in paddocks. The usual grazing lands are paddy fields after harvest, catchment areas of the village tanks, tank bed during dry period, tank bund, shrub jungle and other open areas. There are number of forage species, which are naturally grown in grazing lands such as maila and ipil-ipil. *Gliricidia* is a common tree species, which is grown in fences of land and grazed by cattle and buffalo. The grazing lands are generally not managed. They are naturally regenerated. In a village there can be one or two herdsman who keep a larger herd.

Management of Forests and Water Bodies

Forests serve as the main catchment area for the tank. The village community understands well the importance of forestland in the cascade and takes communal responsibility in protecting it. Forests are traditionally classified according to its importance namely: "*landu kela*" (shrub jungle), "*mukalana*" (forest)" and *maha mukalana*" (thick forest). By tradition use of "*mukalana*" was prohibited so that nobody dared to clear this forest for *chena* or any other purposes. The village forests are also protected by the forest ordinance of Sri Lanka. Home gardens are sources of nuts and fruits and wood. Farmers know the combinations of species to plant to minimize competition for light and soil nutrients. Farmers also maintain forests for medicinal plants apart from forest trees. Apart from the culture of medicinal plants, certain members of the family also know how to formulate a range of concoctions and decoctions for application to cure common ailments.

The village tanks with a command area of less than 80 ha are designated as minor tanks and they become under the jurisdiction of the Department of Agrarian Development. Historically, these tanks were managed by the community under community leadership. A person designated as "*Vel vidane*" (to oversee the paddy cultivation and water management) was elected by the farmers from the farming community. He was paid with a certain quantity of paddy depending on the paddy extent one has under the tank. The *Vel vidane* used to visit each farm and ensured that there is a supply of water during the season. However, this system was abolished by the government after the introduction of Paddy Land Act in 1958 and the water management and farming responsibility were entrusted to the cultivation committees appointed under the act. With several rounds of amendment of the act, now, the cultivation committees have been replaced by the farmer organizations. Farmer organizations meet yearly to agree on the nature and timing of cropping based on water availability and for water allocation. Relevant government officials joined the said meetings as resource persons.

The community was previously responsible for the maintenance of the tank bund and irrigation channels under the village leadership of the village headman. This responsibility has now been entrusted to the farmer organization.

At the moment, there is no formal or informally organized system for passing the knowledge associated with the agricultural heritage of managing CTVS and is its land uses. Children observe their parents practice the remaining few practices or recite and chant songs during special events. Families are left on their own initiative to seriously pass on certain practices, particularly those that remains to be relevant to economic livelihoods.

Sharing Paddy Land During Water Short Seasons – Bethma

There are unique systems of sharing resources in the village community. One important aspect is the sharing of the paddy tract during seasons of water shortage. Paddy lands are individually owned. But during the seasons of water shortage, as cultivation of the full extent under the tank in not possible, one portion of the command area (paddy fields) is left out while the other portion is distributed among all the farmers under the tank equally. This system is known as "*bethma*" cultivation. The decision is taken during a meeting attended by farmers and officials collectively. This arrangement is only for that season.

Sharing of Fish Harvest in the Tank

There was a tradition of distributing the fish harvest among the households under the tank. This was done by the village headman during the dry period when tank is dried-up. All the fish are harvested and distributed among the farmers depending on their share of land under the tank.

Village Commons

Various micro-landscapes such as *kattakaduwa*, *gasgommana*, *thisbambe*, *kiul-ela* etc. are maintained by villagers to ensure the system sustainability. These village commons are described in section 1.8. The commons are of multi-purpose and multi-functions, and many services are rendered for the benefit of human and wildlife.

2.7.4 Culture, Value Systems and Social Organizations

Culture

Sri Lanka's rich cultural heritage has been nourished by characteristics, challenges and opportunities provided by the landscape and the resultant values, knowledge systems associated with the agrarian society and refined by the Buddhist teachings. The culture in the CTVS has been developed centered on inter linkages among the village, the temple, tank and the stupa as stated before. The cultural aspects such as livelihood, knowledge, belief, art, law, morals, custom, and other capabilities and habits are developed to lead a simple and happy life while sustaining the natural resource base in the village and in surrounding area.

Social Structure in the CTVS

The present social structure in the CTVS has been transitioned from ancient feudal system under which the agrarian society thrived for centuries. The feudal society was characterized by a cast system based on the occupation that the people were engaged in. The occupations ranged from farming, blacksmiths work, laundering, dancing and drumming, goldsmith work etc. There was a hierarchical system prevalent among these castes. However, this caste system has been gradually diminished starting from the time of colonial administration in the country. The present village society consists of farmers, carpenters, government and private sector officials, soldiers in the armies, traders and laborers. They are formed into upper middle, middle, lower middle and poor classes based on the economic status. The majority is farmers and fall in the poor class.

Value System

The agrarian life in the CTVS essentially depends on sharing of common resources, mutual help and dedicated work. This needed to cultivate values such as integrity, respect, loyalty and responsibility among the villagers. The villagers are honest in their behavior, respect the leadership and elders, loyal to the village community and the family and ready to discharge their responsibility to the common causes at any time. These values prompted villagers to protect their natural resources, volunteer to common causes such as maintenance of tank, wells, channels and other common property and sharing of labor. However, some of these values are not much respected at present due to changing social status in the village life. Further, the villages are 'invaded' by out siders who to some extent do not appreciate very much the traditional norms and values. Although some erosion of these values and norms is happening due to social change and modernization, substantive portions of the community still observe many of these values and practices. Community leaders are conscious of the gradual loss of values and practices. They have begun to identify actions that can arrest rapid loss of local heritage and make adaptation to modern times possible through a participatory process. Among the remaining values are conservation of traditional forests and biodiversity and sharing of natural resources.

Under the section on knowledge systems above, the practices related to sharing of water resources, paddy and fishery products from the tank are discussed. The traditional management systems practiced by the community has been superseded by the modern governance structures and processes. However, CTVS management is considered a joint responsibility of both government and community; regular annual meetings are conduced to decide on priority actions for the maintenance of CTVS and sustainability of its ecosystem services.

Performing Arts

Traditional dancing, folklore, folksong, folk poems, folk music, rituals, traditional festivals, and folk drama, have been evolved in the village tank farming culture during its long existence .Some examples are:

1. *Pal kavi* (The poems recited in the night at watch hut to protect fields from wild animals)
2. *NelunKavi* (Poems recited by women when weeding and filling in vacancies in paddy fields)
3. *Andahera* (Verses recited at ploughing and threshing)
4. Folk dance *such as* Reaping dance, *Kalagedinatuma*and Winnowing dance (*Kulunatuma*)
5. *Sokeri dance* (A dramatic dance performed after harvesting paddy in villages)
6. *Hevisi and berawaadana*

Folk dances in the area depict activities related to agrarian life, such as kalagedi natuma (depicting fetching water in the pots) (figure 39-41), Kulunatuma (depicting winnowing of rice in the threshing floor), and dance depicting harvesting of paddy. Often, these dances are performed in the open air in celebration of community events. These dances are performed to the beat of the drums and tune of the music and are very colorful and attractive. Other traditional dancing are performed by descendants from dancing families of the feudal society of the past. In the Palugaswewa DS division there are several families who are very reputed for their performances. They have won national and international awards for their excellent performances. These families run their own training centers for passing the dancing traditions of them. Some performance arts are twined with the rituals such as *bali* and *thovil* (healing methods by chanting and dancing to the beat of drums). There are many traditional instruments that they play in these performances (figures 42).

Figure 39: Traditional kalagedi natuma – Palugaswewa (2016)

Figure 40: Traditional folk dances – Palugasweva (2016)

Figure 41: Traditional folk dances – Palugasweva (2016)

Figure 42: Traditional instruments for dancing performance

Believes, Faith and Rituals.

The dwellers of CTVS believe in gods, deities and devil spirits. They believe that some powerful kings who lived in the past have become gods after their death and they can help the people when they are in desperate situations. Some such gods they believe are *Minneridеviyo, Aiyanayakedeviyo and Bissobandaradeviyo.* They believe that through various ritual these gods support them to get through bad times. Most prominent rituals include: *Mutti nameeme mangallaya, Kiri ithirim mangallaya, Kohomba kankariya*and *Pideni.*

*Mutti nameeme mangallaya (*Ceremony of pot overturn*)*

Before commencing the cultivation when the tank is full of water, the elders of the village, chiefly *gamaralas,* go to the tank and at the *mutti namana* tree, the chief *gamarala* addresses the god (of the area), announces that the tank was filled and that cultivation will begin and that the *mutti mangallaya* (a ceremony) will be performed after the harvest. He would also request the god and deities to protect their crops and livestock from evil and natural disasters. As a token, they would tie a copper coin wrapped in a piece of cloth on a branch of the tree. Once the harvesting is over, the villagers then perform this festival. This is a ceremony where all village communities participate. Milk rice, oil cake, rice and curry are offered to the gods and deities on a platform erected on the tank bund. Food is also served to all who were assembled. This is followed by dancing ceremony with *tom-tom* beating.

Kiri ithirim mangallaya(Festival of milk boiling)

After reaping of each crop *kiri ithirim mangallaya* is performed to thank the gods and deities for protecting their crops and cattle from evil and natural disasters. This is performed collectively by contribution and participation of all villagers. In the tank bund, they cook rice milk, offer the first portion to the gods and invoke their blessings. Then the remaining rice milk is served to all assembled. In disastrous situations such as drought, floods, epidemics, etc. also this activity is performed.

Kohomba kankariya

KohombaKankariya, one of the most venerated and elaborate traditional dance rituals in Sri Lanka is held to invoke the blessings of the twelve deities (*KohombaYakka, IrugalBandara, KandeBandara, ViramundaYakka, MeleyiYakka, VadiYakka, KadavaraYakka, ValiYakka, Kadu Guru, Maha Guru, Ambrapati and Kalu Kumara*). The *Kohomba Kankariya* is a *Shanthi Karma* (a traditional art of healing) demonstrating the pre-Buddhist worship of *Yakshas* (demons) who are regarded as deities (figure 43). It is an all-night event that commences in the evening and continues until the early hours of the following morning. This is also an event usually performed by the villagers after harvesting of the paddy crop.

Figure 43: A ritual invoking blessing from deities and gods

Figure 44: A ritual (mask dancing) – Palugasweva (2016)

Aluthsahalmangallaya (Festival of fresh rice)

This is a festival to offer milk-rice cooked with the first portion of the paddy harvest to the Buddha collectively at the village temple. After offering of milk-rice to Lord Budhdha, the merit that they earned through this act is offered to the gods and deities invoking blessing from them. In order to protect their cultivations from wild animals and natural disasters

Ritualistic Plant Protection Methods

Various ritual are performed in farming for protection of crops from pests and diseases and wild life. These include carrying out various farming activities such as ploughing, seeding, planting at auspicious times based on astrology, use of method called *Kem* and chanting of religious verses and charming of *mantra.* Astrology plays a dominant role in agriculture as most activities are based on the astrological calendar. 'Kem' practices demand complete faith from those who practice them. These practices vary from elaborate, time consuming rituals to simple, instantaneous methods. These methods are mostly carried out in secret, hence most of they are not in public knowledge.

Traditional Crafts

Common traditional crafts of CTVS include the handicrafts made out of reeds, other cured leaves of palm trees, and rattan, wood carving, rock carving, and pottery. There are a variety of produce such as mats, hats, handbags and purse made out of reeds and cured palm leaves. These are traditionally woven by women in villages. Reeds used are *Gallaha, Havan, Vetakeiya, Borupang, Thunhiriya* which grow in wetlands found around the tanks and the paddy fields. Of these, *Gallaha* is the most expensive (figure 45). Leaves of Palmyra tress and *Vetakeiya* are also used. Wood carvings include statues religious leaders, images various animals, various sceneries and ornaments. Similarly the rock carvings and pottery also include articles of ornamental value.

Figure 45: Weaving mats with special designs using Gallaha reeds, Palugaswewa

Traditional Foods and Food Habits

The traditional food consists mainly of rice which is the staple food of the nation. However, other cereals such as finger millet, *thanahaal, and meneri* and pulses such as mung been and black gram and various types of yams supplement rice in these traditional villages. The seeds of water lilies (oolu seeds) which grow in the tanks also make a special food item in these villages. It is used as a substitute for rice. Rice and curry are the well-known regular meals as in other parts of the country. Curries are full of spices and other tasty ingredients used which are specific to each village and housewife. The recipes may change from village to village. The flour of rice are used to make various preparations such as *roti, pittu, hoppers, kavum, kokis, and aggala* etc. Kavum, kokis and *aggala*are sweets which go as snacks. *Thalapa* is a special preparation made of flour of finger millets. Special curry is made to go with thalapa. The curries mainly consist of vegetable which are grown in the home gardens or in the chena. There are several types of wild yams such as *katuala* and *gonala* naturally grown in the forests and road reservations. People collect them for breakfast.

Figure 46: Traditional foods – Palugasweva (2016)

The fish and dried fish are also cooked with spice. Previously local fish species such as *Loola, Aanda, Kanaya and Hirikanaya* were the common fish species in the village tanks. However, after introduction of foreign fish species such as Thilapia, the local fish species have been disappeared from village tanks.

A complete rice and curry meal includes a meat or fish curry, two or three different vegetable curries, curry of pulse seed or dhal (lentil), and a ‘mallum’ made of chopped green leaves and grated coconut. For special occasions, especially religious occasions, rice is boiled in thick

coconut milk to make a creamy textured rice pudding called 'kiri-bath' which is very delicious preparation .Dairy products such as curd, ghee, whey etc. were very common in these villages until 1960s of the last century but now they are rare due reduction of cattle population as a result of shortage of grazing lands. Milk (neat cattle) is produced in some villages as a house-hold activity for sale to companies which produce milk powder.

There are many herbs used as herbal tea called "*osupan*" with very high health benefits. Some of the herbs in the villages are used to make herbal porridge. Herbal porridge are recommended for a range of ailments and to improve the nutrition of people.

Food habits are different in these villagers compared to urban community. Villagers take three meals- breakfast, luch and dinner- a day as usual. Dinner is the main meal, which consists of rice and curry. Breakfast includes boiled cassava, yams, mung bean, cowpea etc and preparations from rice / wheat/ finger millet flour. Lunch also consists of rice and curry.

Traditional Healing Methods

Traditional healing system focuses on mental and physical health simultaneously. This is by using herbal medicine for the physical component and "*yanthra* and *manthra*" for the mental aspects. This indigenous medical practice descends from old generations. The prescriptions are handed from generation to generations and there are families known as "veda parampara" (generation of medical practice). In the Palugaswewa DS division there are several such families. In local language these practitioners are known as "vedamaththaya' or "vedarala". There are specialists such as General Physician (Sarvanga vedamahattaya), Eye specialist (as vedamattaya) Snake-bite treating specialist (Sarpa visha vedamahattaya) and Orthopedic spealist (Kadum-bindumVedamahattaya). The medical family of orthopedic practice in the division is renowned for their practice nationally and internationally. Known as "Horiwila kadum bidum vedaparamparawa" has established their own hospital in the Horiwila village (figure 47).

Sorcerers and exorcists also are part of the mental healing system. They too descends from old generations. Sorcerers carry out rituals afflicting misfortune on people and they also carry out ritual to eliminate such bad effects. The exorcists treat mental ailments which are considered to be caused by devilish activities. Rituals include, tying of amulets in the body, cutting of lime while chanting manthra, tying of threads subjected to chanting of manthra, making offers of foods and fruits to gods and demons (*pideni*) etc. There are several families who treat for devilish afflictions. Fortune tellers and horoscope readers are also part and parcel of the traditional system in these villages (figure 48).

Figure 47: Horiwila local medicine practitioner

Figure 48: Yanthra Manthra practitioners and horoscope readers – Palugaswewa

Festivals

There are no specific festivals confined to CTVS. These villages also celebrate national "Sinhala and Tamil new year which fall in the mid April each year and the "Vesak" festival on the full- moon day in May. The New Year celebration marks the ending of one year and beginning of the New Year according to Astrological calendar.

Ritualistic Plant Protection Methods

Various ritual are performed in farming for protection of crops from pests and diseases and wild life. These include carrying out various farming activities such as ploughing, seeding, planting at auspicious times based on astrology, use of method called *Kem* and chanting of religious verses and charming of *mantra.* Astrology plays a dominant role in agriculture as most activities are based on the astrological calendar and auspicious times. 'Kem' practices demand complete faith from those who practice them. These practices vary from elaborate, time consuming rituals to simple, instantaneous methods. These methods are mostly carried out in secret, hence most of them are not in public knowledge.

Social organization in the villages

Traditionally Gam Sabhas (Village Councils) administered local affairs, addressed people's grievances & needs and settled minor disputes in villages. In 1818, the Village Councils were abolished by the British rulers. After colonial administration different organizations were introduced for local administration and at present Pradeshiya Sabhas represent the local government system. The administration is represented by locally elected members from villagers. The Palugaswewa DS division falls in the administrative division of Kekirawa pradeshiya sabha. The other social organizations in the DS division includes official organizations such as Farmer organizations (FO), Rural development societies, Samurdhi societies and voluntary organization such as Womens' societies, Death and welfare societies. The FOs are linked to the Agrarian Development Department, which is officially responsible for CTVS. The office bearers are elected from the membership. The holders of the paddy fields under the village tanks become members of the organization. The farmer organizations attend to maintenance of tanks &cannals, irrigation water management, fertilizer distribution, making of crop calendar and collection of fees from the farmers. The activities of the FO are governed by the Agrarian Development act No. 46 of 2011.

2.7.5 Remarkable Landscapes, Land and Water Resource Management Features

The dry zone (DZ) landscape has been completely changed to give rise to a panoramic view with the development of the village tanks in the cascading system. The tanks make water bodies here and there in the undulating landscape, giving an attractive view. These water bodies located one after the other are associated with various vegetation, including lotus, water lilies, many other flowering plants and trees. Due to long existence, these tanks have become almost like natural wetlands creating a unique ecosystem that attract various types of birds. The paddy fields, forest patches and home gardens combined with the tanks make a mosaic of beautiful scenery. This mosaic changes its color and appearance all year round as the cultivation progress and seasons change (figure 49).

Figure 49: Cross sectional view of paddy field and home garden

The proposed CTVS consists of several land uses within a single tank catchment. These land uses make a unique land management system aiming a long-term sustainability of lands. The forest reservation in the catchment makes the main watershed area of the tank. It is used for *chena*/upland crop cultivation. Even if the *chena* cultivation is not practiced in its real sense at present, fallowing is done for short durations in order to maintain the soil productivity. In the tank, a soil ridge called *isvetiya* or *potavetiya* is constructed just below the lands used for *chena*/upland cultivation and above the tank water level to prevent eroded soil coming in to the tank bed.

In the main natural drains, which carry runoff water from the catchment, a pit locally known as *godawala* is dug before reaching the tank bed to collect all soil and debris with water. This pit is periodically cleaned when filled by communal action. In some cascades, tanks have been built in the forest which serves only for environmental services such as groundwater recharge and use of wildlife. They also serve as additional storage tanks in the cascade.

The tank cascade itself is an evidence of the long practiced land and water conservation and management practice. The current state of the cascade and CTVS in Palugaswewa is no longer in pristine form, but overall the system is still very much serviceable in terms of its main objective of water conservation for the agricultural communities in this part of the Cultural Triangle. The fact that the system is located in the midst of the Cultural Triangle of Sri Lanka makes the system a very attractive destination by both Sri Lankans and foreigners alike who want to understand this particular gem of a heritage in the country's dry zone.

In section 1.8, the components of the CTVS are described together with their intricate set of ecological functions. Each tank cascade system in the dry zone must have been in existence for more than at least over a thousand years.

Udakadawalawewa has the largest reservoir capacity because it receives drainage and spill water from five tanks. This cascade system is described as “branched” system. The maintenance of tanks and irrigation canals and water management are carried out by two farmer organizations under the supervision of the Department of Agrarian Development. Palugaswewa Farmer Organization manages four tanks namely Palugaswewa, Alapathwewa, Davidwewa and Kundalugaswewa. The Udakadawala Farmer organization manages the rest of the tanks. As generally practiced in the other CTVSs the cropping calendar and the crops are decided at the “Seasonal Meeting”, which is held with participation of farmers. The seasons and the cropping system of the Palugaswewacascade follows the general pattern that of the CTVS.

CHAPTER 3: GLOBAL SIGNIFICANCE

The proposed GIAHS system referred to as Cascaded Tank-Village System (CTVS) has been evolved in the dry zone of Sri Lanka as a result of intrinsic and steady human-nature interaction. These village tanks in the form of cascade systems, constructed in ancient times, could be considered as well designed irrigation systems with a distinctive assembly of land uses. The land and water management practices that were refined and perfected over several centuries in order to match the capricious nature of rainfall, along with the special attributes of the landscape led to the system of irrigation development referred to as cascading system (Panabokke et al. 2002). The small tank builders must have had a profound understanding of landscapes and hydrology of the region (Panabokke, 1999). Features and characteristics described below in this chapter are the remarkable outcomes of the steady human-nature interaction, yielding beneficial functions, services and protection (from natural disasters) to both environment and human being, which can be considered as an asset to other countries having similar climate and landscape. Following features, characteristics and practices can be adopted elsewhere.

- The system absorbs shocks of natural disasters:
    a. Flood and drought occurrence can be controlled by storing water in the various storage structures found in the upper part of the system such as *olagama*, *kuluwewa*, *godawala* etc. and absorption by the upper forest vegetation,
    b. Drought impact can be further minimized by reducing the water loss from tanks due to existence of the surrounding ecosystem,
    c. High wind damages are minimized through vegetative cordons maintained around hamlet, paddy fields and tank,
    d. Regulating mechanisms of the system for natural disasters are illustrated in the section 1.8.

- The system provides solutions to water shortage in paddy farming:
    a. Seasonal water shortages for paddy farming are addressed by practicing *bethma*, *kekulama* etc.,
    b. Water can be released from upper tanks to main tank below in the cascade when and then needed
    c. Short age paddy varieties, which are tolerant to water stress conditions are used during water deficit seasons (Ex. *Suwnda Samba* – 3 months, *Rathu suduru* – 3 months, *Hatadawee* – 2 months)

- The system contains globally significant genetic resources (wild and domesticated plant species):
    a. There are globally important fruit, vegetable, medicinal and food plant species found as local land races which can be improved and popularized in other countries,

b. Plant diversity in *kattakaduwa, gasgommana* and *thisbambe* of diverse water regimes provides regulating, supporting and provisioning services to the community.

- The system ensures the food security for the community:
    a. Local methods of food preparation and preservation;
    b. Extraction practices of oil from coconut, mee (*mudhuka logifolia)*, sesame, and neem *(Azadirachta indica)*
    c. Grain storage structures (*atuwa, bissa*),
    d. Traditional fish catching methods

- The GIAHS community adopts traditional farming practices, which are environment friendly, and producing healthy foods:
    a. Use of traditional crop varieties having nutritional and medicinal values
    b. Adoption of soil and moisture conservation practices
    c. Application of bio-fertilizer and bio-pesticides (Dharmasena, 2016a)

- Various other matters pertaining to global significance of the proposed GIAHS are described under the sections of Production system, Goods and Services provided by the system, Food and Livelihood Security, Biodiversity and Ecosystems Functions, Knowledge Systems and Adapted Technologies, Culture, Value Systems and Social Organizations; and Remarkable Landscapes, Land and Water Resource Management Features.

CHAPTER 4: OTHER SOCIAL AND CULTURAL CHARACTERISTICS

4.1 Relevant Structures, Architecture

Houses

The culture in the dry zone villages is based on the concept of "*Wewai, Dagabai, Gamai, Pansalai*" which means the culture is based on the relationship of the components, namely: "The Tank, Stupa, Hamlet and the Temple" which are common to any village (figure 50). The Traditional village consisted of houses (figure 51) built with *wattle* and *daub* walls thatched with straw or a grassy weed called '*illuk*' (*Imperata cyylindrica).* These houses are eco-friendly and ideally suited to the local climate. The houses have one or two rooms with a large verandah. The verandah consists of a pila, a raised bed attached to the back wall of the verandah. The verandah is open on three sides where visitors were entertained. Due to the influence of modern development these houses are now modified with new technology. The roofs are thatched with tiles or asbestos and walls are built with bricks.

Figure 50: Tank, stupa, village and the temple as the main elements of the community

Figure 51: A traditional village house - Palugasweva

Village Tanks

Village Tanks comprise of unique engineering structures in the villages. The traditional sluice and the tank bund prove the skills of ancient villagers. The traditional sluice is known as *Kata sorrowwa*. At present most of these sluices are replaced by modern gated sluices.

Ketasorowwa (Traditional sluice in the tank): This has two components. One is the linear horizontal layer of burnt clay (*terracotta*) pipes laid under the tank bund extending from inner side to the outer side. The other component is the set of similar pipes arranged vertically fitted to the opening of the horizontal pipe in the inner side of the tank (figure 52). The pipes are about 2 ft in length and can be removed to the water level of the tank so that water can be released from the tank.

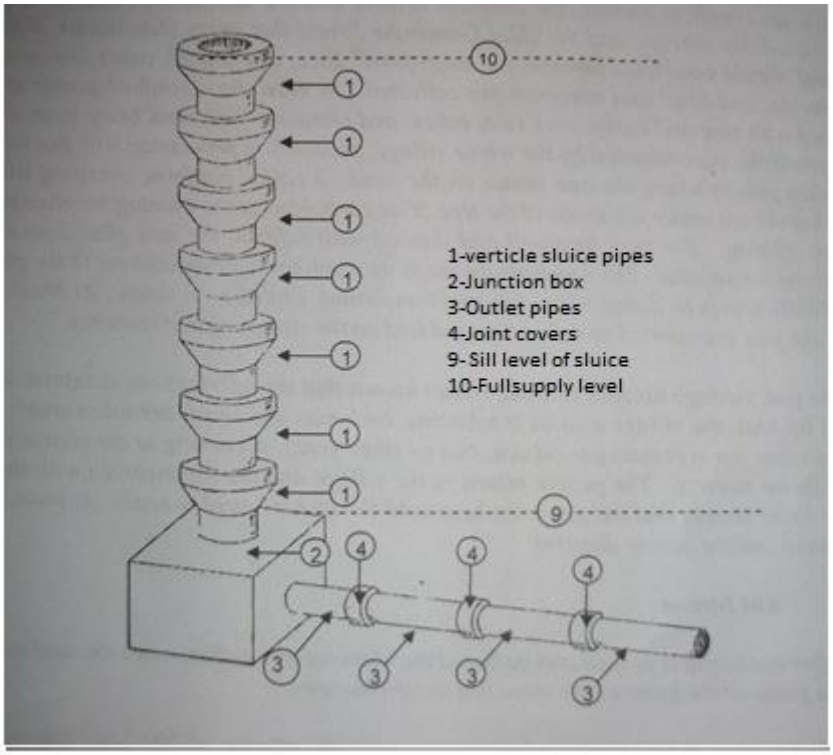


Figure 52: Ketasorrowwa

The tank bund is made of compacted earth which retains water in the tank. The height and the width of the bund has certain proportion which approximate to 5:1 (width to height). This gives a slope to the bund suitable for climbing up and down the bund by human beings and other animals (figure 53).

Spillway is another structure one can see in the tank irrigation system. The spill way allows excess water to flow away from the fields in the rainy season. This structure is located in a corner of the tank bund and built with rocks or selected a place with plane rock.

Figure 53: A Tank bund

Vee Bissa (Rice bin

This is a traditional structure built with wattle and daub wall for storing paddy in the villages. This is erected outside, near the house and thatched with straw (figure 54).

Figure 54: Vee Bissa (rice bin)

Atuwa: This is a large box made of wood to store paddy inside the house or outside. This is not very common as the vee bissa

Temples

Each village has its own temple. The temple consists of shrine room, *avasaya* (house for monks), stupa and Bodhiya (Bo tree with its protecting wall). Some of the temples remain from historical times. Tampitaviharaya in the Maha Rambewe GN division is such a temple.

Figure 55: Tampitaviharaya in the Maha Rambewe GN division

Rock Caves

These caves are made naturally. The ancient people have carved out gutters (*kataran*) to prevent rainwater dripping inside the cave. Rock caves are used by meditating Buddhist monks. There are nearly twenty rock caves found in the Galapitagala GN division. They are located in forests adjoining Ritigala rock mountain which borders the Palugaswewa DS Division. Some of these caves are occupied by meditating monks.

Figure 56: A natural rock cave, Galapitagala

4.2 Traditional Agricultural and Domestic Implements

Tank-village communities in the dry zone of Sri Lanka have developed their own tools and implements for agriculture and domestic purposes. Energy conserving simple devices were made by them using raw materials that can be found from their surroundings. The tools of iron are turned out at the blacksmith yard in the village. There are families who have mastered the smithy work. In the Palugaswewa DS division there are several smith yards maintained by the individuals. The basic principles they used in making these devices depict the traditional wisdom they had in the past. Some of the tools and implements are listed below;

<u>The Implements Used in Land Preparation</u>

- Nagula (buffalo drawn plough)- used for ploughing of paddy lands
- Udalla (mammoty)- used for digging, loosening, turning soil & scraping weeds
- Poruwa (buffalo drawn leveler)- used for rough leveling of the puddled paddy land
- Ath-poruwa (hand leveler)- used for final fine leveling of the puddled paddy land
- Kaththa (knife with long handle)- used for cutting shrub jungle
- Porowa (axe)- used for felling trees, cutting wood

Figure 57: Poruwa (buffalo drawn leveler)

Figure 58: Nagula (buffalo drawn plough)

The Implements Used in Harvesting of Paddy and Other Cereals

- Daa-kaththa (sickle)- used for harvesting rice and other cereals
- Ukunu-gaha –used for removing of straw after rice is threshed
- Bathaporuwa- used for gathering and leveling of rice in the threshing floor
- Kulla (winnowing basket)- used for separation of debris of straw from rice seeds

Figure 59: Daa-kaththa (sickle)

Other Domestic Tools and Implements

- *Pas pattalaya* (for extracting oil from mee seeds)
- *Kurahan gala (*grinding stone device of finger millet*)*
- *Mmirisgala (*grinding stone device of chili*)*
- *Kemana (*cage for trapping fish in the tank*)*
- Bags - *Karaththamalla, kata palalmalla (*bags made of reed for carrying things*)*
- Grain measuring devices - *laha, kuruniya,busala*
- *Killotaya (*bowl for keeping lime as an ingredient of chewing beetle*)*

Figure 60: Pas pattalaya (for extracting oil from mee seeds), Palugaswewa

Figure 61: Kurahan gala (grinding stone device of finger millet), Palugaswewa

Figure 62: Grain measuring devices - Kuruniya and Busala, Palugaswewa

4.3 Gender Roles

As per the traditional culture in the villages in CTVS, the men and women work in harmony under a reasonable division of labor among them. The women manage tasks related to the home garden, household jobs of cooking, washing clothes, cleaning the house, looking after children while helping in nursery preparation, transplanting, weeding and harvesting. Men engage in work such as land preparation, irrigation, crop care, marketing, labor supervision and farmer organization activities. Children also help in the farming activities, housekeeping and home gardening whenever they have free time from their educational activities.

Figure 63: A women enaged in household cooking

CHAPTER 5: HISTORIC RELEVANCE

Village tanks gained reference in inscriptions, especially during reigns of King Walagambahu (104 – 77 BC), King Bhathikabhaya (21 – 7 BC) and king Washabha (67-105 AD), all those located at mid-points of cascades. One of the examples is Horiwila in the palugaswewa cascade in the Maminiya sub-watershed (Thennakoon, 2000).

There are a few reported studies that have been carried out on the historical aspects of the small tanks in the country. Some references indicate that these small tank systems have been in existence since era of B.C. Nicholas (1959) reported that "The village tank was a well-established feature in the dry zone by the beginning of the second century B.C." According to *Siriweera* (2005), the stone inscriptions of first, second and third A.D. centuries refer to about 150 tanks.

Panabokke et.al. (2002), who studied the village tank cascade system reported that they observed that majority of the small tanks were hydrologically well endowed and were also less susceptible to breaching during major rainfall events. According to oral village tradition, they had been in continuous existence and had been used from the period of *King Valagambahu* (approximately 300-400 B.C.). This would have started as small village settlements around small tanks, which gradually increased in size in response to increasing population (Panabokke et. al. (2002). Robert Knox (1681), who lived in the country in captivity during the period 1660-1679, reported that "Every town (village) has one of these ponds (tanks) of which there is a great number, the banks of which are in length above a mile, some less - –ot all of a size". These evidences suggest that the tank systems have been there during the long history of the country.

5.1 The Extent to which the System has been Maintained

The system has proved its excellent technology for collection, storing and use of rainwater that fall within the catchment for domestic, irrigation and environmental needs of the village. Therefore, the basic features of the system are preserved despite heavy pressure on the lands due to population increase and other social and economic changes. The main components such as tank, paddy field, and hamlet are yet intact. However, the tank catchment management has been disturbed due to changes of land uses. There is no more chena cultivation in its traditional form. The *kattakaduwa* is maintained in most tanks. However, due attention is not paid to other components such as *gasgommana, iswetiya,* etc. This has resulted in siltation of tank bed causing a range of other problems. Villagers have understood the importance of maintaining the historically perfected system and are trying hard to rectify what has gone wrong.

The governance of tank cascade systems was mainly based at the village level and therefore all components in tanks have been progressed with the socioeconomic harmony of villagers (Avsadahamy, 2003). Analysis of tank cascade systems 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 (Dharmasena, 2004; Tennakoon, 1986). 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 volumes of water (Tennakoon, 2005). By doing so the risk to tank bunds breaking was minimized.

Only sketchy and rudimentary evidence exists from ancient times indicating the ownership, maintenance obligations, sanctions, penalties and taxation in tank cascade systems (Madduma Bandara, 1995). However records show that the *velvidane* was the officer in charge for the management of tankm cascade systems. In the pre-colonial era, the systems were managed through an ancient custom of compulsory labor. But, this system was abolished by the British in 1832 AD because it was considered a form of slavery (Panabokke et al., 2002). An alternative maintenance scheme for the compulsory labor was not introduced which resulted in gradual abandonment of tank cascade systems (Madduma Bandara, 1985). This contrasts with previous management where farmers did not have tenure to tank cascade system, tanks were community owned and were properly maintained. The farmer's willingness to sustain the system was also declined over several centuries (Madduma Bandara, 1985). In the post-independence era, however, large scale development projects to manage water have been undertaken in the dry zone; the TCS is now managed by both the government and farmer organizations.

5.2 Unique Contribution of the Practice to the History and Socio Political Evolution of the Nation

It is well established that the history of Sri Lanka has evolved with the progress of irrigation development in the country. Development of irrigation work commenced with development of village tank systems. Panabokke (2010) described how evolution of small village tanks cascade systems took place in the North Central Province of Sri Lanka. The technology of village tank systems later expanded to the construction of large-scale tanks. With such development of irrigation works, Sri Lanka earned a prestigious name "Granary of the east" during ancient times. The CTVS were managed by the villagers. It was not a burden to the state. The country was self-sufficient in food and excess labor was used for construction of Stupas and large irrigation work by the kings under "*rajakariya*" (free labor for the king) system. As the nation was self-sufficient in food and kings were strong, they could pay more attention on development of other areas such as art, culture, religion etc.

The village irrigation system in the dry zone helped to keep the people in villages even when administration in the area collapsed due to foreign invasions. During these periods, the major irrigation works collapsed as heavy maintenance was not possible without the support of the central administration. However, the villagers managed to carry on the repairs and maintenance of village tanks by themselves. Further, the system has high resilience to natural hazards such as drought and floods. The villagers even survived the severe destruction caused

to irrigation systems, paddy fields and property by invading foreign forces several occasions in the history.

Irrigation management, the driving force of agriculture, was the key of the social setup at the village level. For this purpose, there was a special package of rules and regulations, called Sathwida Ana-vidhana. It was the policy framework of the water base civilization, though rudimentary today. These policies were properly implemented by the relevant officials in the village, starting from *Wel vidane* (Officer in-charge of paddy fields), *Wev vidane* (Officer in-charge of irrigation), *Gama rala* (nobleman of the village), *Mohottala* (sheriff), *Veda rala* (physician), *Anumethi rala* (approving officer) and *Denumethi rala* (wiseman of the village). They had following ten commandments to be obeyed, which would be the greatest pride of the civil society and ensure the sustainability of the rural society (Dharmasena, 2007).

1. *Diyapaththayam thahanchiya* – Keep control over limited water available during extreme dry seasons
2. *Niyama kanneta govithen bath* – adopt risk evading faming
3. *Gahakola satha seepawa – binkare wathurai ayubowa* – Utilize the environment ensuring its sustainability
4. *Hithe ispasuwata dan pin karannata peti-pas parane hadapan wadapan*- Live with minimum needs and in simplest way.
5. *Akahe wehi katen wev amunu puropan* – Harvestrainwater and store for future use
6. *Ekathu pada novi hari haman wedak nokaran* – Work as a team
7. *Wee kurahan sambhare, atu kotu purawan rale* – Store excess grains for future use (food security)
8. *Thel pani atthan kewum the panggnan* – Be independent from external interventions
9. *Kem pahan denagan, sanuhare rekagan* – Protectthe knowledge for future generation
10. *Kavi sindu ragan, hithata kawaddan* – Continue to practice cultural activities

The ‘Velvidane’ system of pre-colonial times, where a water headmen was made responsible for the management of irrigation, continued even after Independence in 1948. However, responsibility for maintaining minor irrigation systems was taken over by the Ministry of Agriculture and Food. In 1958, when the Department of Agrarian Services was established with the introduction of the Paddy Lands Act, the age-old Velvidane system was replaced by Cultivation Committees. It is pointed out that the objectives of these reforms could not be achieved due to problems such as poor leadership, discipline and maintenance. More reforms in the organizations came in the 1960s with the introduction of cultivation officers involved in the management activities in small tanks. Many social anthropologists and sociologists note that the post 1970 period was characterized by the intrusion of politics in rural villages: “The post-1970 era in rural Sri Lanka witnessed increased party political intervention in local village organizations. A clear indicator of this process was the move from the election of office-bearers of the cultivation committee (CC) to their appointment by political leaders. This move led to further deterioration of village level irrigation leadership, as the members were appointed by politicians on the criteria of political popularity and the ability to deliver votes in an election. Property ownership, family status and social standing, which constituted

the traditional criteria of village leadership, thus became less important, while the ability to be a good "vote bank" became more important in the appointment of CC members. The politicization of rural leadership culminated in the 1979 Agrarian Services Act" (Groenfeldt et al 1987).

CHAPTER 6: CONTEMPORARY RELEVANCE

Sri Lanka remains vulnerable to natural disasters such as floods, droughts, cyclones, landslides, epidemics etc., causing substantial threats to the food security situation of the country. Challenges posed by external factors due to globalization and open-economic policies have directed the country's agriculture to move away from self- reliance. This situation demands a firm and perfect policy for the country's agriculture. Furthermore, present agriculture does not show any indication of sustainability as it has ignored the centuries-old wisdom of traditional agriculture (Dharmasena, 2010 b). Farmers' dependency mentality evolved due to modern agriculture and government policies, which dealt with agriculture from time to time. This should be gradually replaced by developing farmers' self-confidence, self-motivation and empowerment. In this process cognizance must be taken from the country's deep rooted customs and traditions. The best example is the sustainability exhibited by the cascaded tank-village system (CTVS).

The tank-village communities addressed and continue to address all issues as a systematic whole rather than individually. In addition to rain-fed farming (*chena*) area,hamlet and paddy fields, they take care of the commons (their territory) surrounding them. It is vital to understand why these commons have been maintained purposely. These communities had the wisdom to mitigate the effects of droughts, floods, cyclones, and epidemics by managing properly their natural landscape and conserving natural resources (Dharmasena 2004). The micro-land uses mentioned in the section 1.8 (Key Components of the System) serve specific purposes to village community due to rich bio-diversity, and play a distinct role in sustaining the balance of the eco-system.

The land use associated with tank cascades demonstrated a profound knowledge of resource management in a challenging environment essentially transformed from natural ecosystems into agro-ecosystems. Integrated land and water resources management in ancient times is reflected in the zonation of land use within the micro-catchments. The tanks and the paddy fields occupied the valleys, where Low Humic Gley soils with poor drainage had limited use other than for bunded paddy cultivation. Ridge summits, often strewn with rock outcrops and inselbergs, were converted into works of art and places of worship and spiritual retreat. The influence of Buddhism led to the establishment of sanctuaries early in history and the enduring protection of wildlife unusual in many parts of the world (Dharmasena, 2009).

Therefore, the cascaded tank-village system (CTVS) is a valuable, historically tested technology, which is based on scientific principles in harmony with the ecology. In an analysis of the cascade tank-village ecosystem Dharmasena (2013) has identified three main services, which could contribute to food security, human well-being, climate adaptation and bio-diversity conservation. Those are regulating services, supporting services and provisioning services as described below.

Regulating Services:

i. Drought mitigation-
    a. Tanks and anicuts with effective dead storage
    b. Reduction of bund seepage and bed percolation through water regime management
    c. Clean water in the tank through arresting sediment inflow
ii. Flood mitigation-
    a. Absorption of rainwater through tanks, upstream and downstream water holes and anicuts in the paddy field
    b. Drainage of excess water in a controlled manner through spill and *kiul-ela* (downstream drain)
    c. Flow regulatory mechanisms such as releasing excess water through sluices, blocking water in the upstream stock tanks in the cascade etc.
iii. Cyclone-
    a. Tree belts found in *gasgommana, kattakaduwa, tisbambe* and surrounding forest protect the hamlet by regulating the wind flow
iv. Epidemics-
    a. Mosquito based diseases are controlled by the sanitary cordon *tisbambe*, which is the resting place of buffaloes. A research found that mosquito is more attractive to buffalo blood.
    b. Waste from dwelling is recycled in *tisbambe* and nutrients move to the paddy field down below.
    c. The tank water is free of pollutants due to the role of *perahana, godawala, iswetiya and gasgommana*.

Supporting Services:

i. Nutrient sources:
    a. *Tisbambe*, the sanitary cordon provides nutrients to the paddy field
    b. *Gangoda*, the dwelling provides waste materials decomposed in *tisbambe* to the paddy field
    c. Mee (*Madhuka longifolia*) trees grown in the paddy tract and *kattakaduwa* are habitats to the bats, which add dung and fruit residues to the paddy tract

Provisioning Services:

i. Raw materials for cottage industry from *kattakaduwa*
ii. Consumables such as food, fruits and vegetables from *kattakaduwa, gasgommana* and tank water body
iii. Day to day requirements such as timber, fuel wood, farm implements, household materials etc. from village commons
iv. Other provisions such as medicine, bio-pesticides, bio-fertilizer, animal feeds etc. are found in village commons

Therefore, the conservation of the ecological foundations of the system while using the modern technology to improve the efficiency is vital for Sri Lanka. This implies

improvements in the production system, introduction of new products out of available resources in the villages, improving thequality of produce, new markets and development of skills of the community. Conservation of forests and watersheds, de-silting of tank bed, regularization of agrochemical use, increasing the efficiency of water application and use, and proper land use, maintenance of tank system are important aspects with respect to the production system.

The use of traditional crop varieties and organic farming will support agro biodiversity conservation and production of quality food. This will generate new experience on management of this vital system of the economy, which can set as an example for the development of thousands of CTVS in the country. Restoration of Tank Cascade System has a wider implication from the point of view of climate change. The system has proved its resilience to extreme weather events so far and the restoration of the system will be useful as an adaptation strategy as the effects of climate change escalate further. Nevertheless, this will also preserve our unique agricultural heritage.

The current relevance of restoring the ancient cascade irrigation technology is felt due to several reasons. Among the foreseeable adverse impacts of global climate change is the exacerbation of extreme climatic events such as droughts and floods. Therefore, in a situation of increasing drought proneness or flood proneness, improvement of cascade systems may prove beneficial in view of its time-tested buffering capacity. At present in the areas of cascade systems, there is a higher prevalence of poverty and as a consequence some out-migration 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 mal-nutrition 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 contaminated by agrochemicals (e.g. Cadmium) received by tanks, including kidney failure and malaria would have to be monitored and remedied. 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 new robust but flexible structures may have to be nurtured (Madduma Bandara, 2009).

Although we cannot achieve the prosperity we had in the past in the same manner, we might be able to understand many aspects of sustainability and the important lessons and best practices. Perhaps the tank-village communities in the dry zone were compelled to conserve resources and achieve food security merely to struggle against the drought, flood, cyclone and epidemics, which frequently harassed them.

CHAPTER 7: THREATS AND CHALLENGES

There are several possible threats for the conservation and restoration of cascade system in the changing social, political and economic scenario.

The water holding capacity of the CTVS has been affected through time – there is lesser volume available and shorter duration of water available to irrigate farms depending on the CTVS. Farm productivity, resiliency and profitability of farming is locally perceived to have declined, hence, the integrity of CTVS and sustained practice of farming revolving around CTVS is threatened. Further, the climate change may influence the rainfall amount, pattern and intensity affecting the cropping pattern and water availability in the tanks. Torrential rains evident as a result of climate change and poor catchment management yield very high runoff during shorter time periods. The tank bunds and spillways may not able to tolerate such quick run off and may subjected to breach and wash off.

7.1 Challenges in Natural Resources and Water Management

The water holding capacity of CTVS is largely affected by siltation, which in turn has been caused by encroachment of forested catchment areas (whether government or village owned) by upland farming, which does not adequately incorporate soil erosion control strategies. The stability of tank bunds and their water filtering functions are affected by the encroachment of the kattakaduwa for farming purposes.

Traditional community-based land and water management of CTVS has given way to a government-driven approach to management. This has been partly supported through the participation of Farmers Organizations (FOs) who play a major role in the annual village water utilization planning. However, the current management system could not adequately absorb all traditional functions for natural resources management. Among the crucial functions that are no longer consistently practiced is the maintenance of buffer zones important for water quality management (*kattakaduwa, Iswetiya, gas gommana*) and wildlife control. The loss of natural sanctuaries for birds has reduced natural capacities for crop protection. Lands supposed to serve as buffer for wildlife have been encroached thus, abetting human – animal conflict.

Since the tank system is rather old, occasional renovations are inevitable. Physical modifications and engineering works of the CTVS have been done on a tank by tank basis. Planning has not been done on cascade wide basis or on the basis of the hydrology of the meso-catchment upon which the CTVS has been embedded. As such, the effects of physical improvements are occasionally short lived.

7.2 Challenges in Agricultural Productivity, Resiliency and Profitability

The reduced supply of water combined with the high cost of farm inputs and limited access to markets, have made farming less productive and less resilient while profitability is no longer stable. The mainstream agricultural program promotes farm modernization through the use of higher yielding varieties and adequate fertilization and pest control, which imply higher production costs. The promotion of new crops and varieties has caused a decline in agro biodiversity, thereby, making the cropping systems more vulnerable to pest and disease outbreaks.

Usually, farming villages have inadequate access to mainstream markets for their products, They usually end up indebted due to loans for seeds and chemical inputs. In recent years, the government has piloted organic agriculture and promoted traditional varieties. The idea has been successful in some pilot areas. Most areas covered by CTVS await the opportunity for widespread implementation of this approach as an alternative to current agricultural approaches.

The questionable profitability of farming practices and the attraction of less physically demanding off-farm labor among the younger generation has led to serious labor shortage for farming. This means that more cost effective agricultural innovations such as organic agriculture cannot be readily tried out without addressing these issues.

7.3 Access to Agricultural Land

There is an acute agricultural land shortage and farmlands are increasingly fragmented. This is due to population increase and the drive towards putting back areas into forest and/or protected area status. The dwindling land: man ratio and resulting land fragmentation is also one of the challenges to both the integrity of buffer lands that stabilize the CTVS as well as to farm productivity. For instance, encroachment of lands traditionally allocated for animal grazing has reduced the livestock population of villages. Farm mechanization has also reduced the need for livestock. Lesser availability of livestock has reduced availability of livestock manure important for soil fertility and farm productivity.

7.4 Appreciation of the Value of CTVS

The physical manifestation of the CTVS, which is the tank, has been regarded as an important part of history. However, the system of agro-ecological practices that is embedded in the CTVS and has formed part of the day-to-day culture in the dry zones is not yet recognized by the general public, as part of the country's cultural heritage. Thus, there is inadequate effort yet to document the traditional practices. Within the village, the younger people observe a few remaining traditional practice sustained by their parents but do not have the chance to discuss or reflect upon their significance.

CHAPTER 8: PRACTICAL CONSIDERATIONS

8.1 Ongoing Efforts (National and Local) to Promote Dynamic Conservation

There are a number of programs that if fully tapped, can support promotion of cascade conservation program. In recent times, a separate ministry, the Ministry of Environment has been established to monitor and address environmental issues arising from development activities. Recently, the ministry of Environment updated the National Action Plan for combating land degradation in the country. The plan has considered the conservation of village tanks. In order to conserve the Sri Lanka CTVS heritage, relevant concerned are included in the mandate of the Ministry of Agriculture. This ministry will support the conservation of tank cascade irrigation system through the Agrarian Development Department which has the authority on management of tank cascade irrigation systems and promotes development of village tanks.

A cascaded tank-village system was recently restored by IUCN with financial assistance of HSBC during 2013-2015 in Rambewa DS Division of Anuradhapura District. The work included; Rehabilitation of tanks and restoration of their ecosystems; Enhancement of the productivity in the paddy fields; Improvement of the tank catchment areas for desirable quantity as well as quality; Strengthening the local institutional mechanism; Development of sound knowledge base for tank cascade management; and Learning strategies, knowledge and experience for use in future cascaded tank system development (Dharmasena, 2016 b). This tank cascade restoration project has been recognized at the Best Corporate Citizen Awards hosted by the Ceylon Chamber of Commerce under the 'Best Project Sustainability Awards 2016' segment in November 2016. In June 2016, the same project was named Winner at the Asia Responsible Entrepreneurship Awards by Enterprise Asia under the Social Empowerment category (Ceylon Today – 11.12.2016).

There are other sectoral programs that would support the cascade conservation program. For example, the government policy on dairy development is aimed at increasing country's milk production which is only 17 percent of the national requirement up to 50 percent off by the year 2015. This is an opportunity that can be tapped in the tank dependent villages. The national biodiversity program facilitated by the Biodiversity Secretariat encourages the conservation of agro- biodiversity through active use. The traditional varieties that have been grown in the cropping systems and home gardens can help achieve this. The Ministry of Agriculture through Plant Genetic Resource Center maintains a wide collection of accessions of traditional varieties and the more desirable varieties can be reintroduced to the system if needed. The Forest Department's present policy is to increase the forest cover up to 35 percent that would involve community participation such as through community forestry and Agro-forestry. Climate Change Secretariat of Sri Lanka promotes the CTVS as this system has been recognized to show high resilience to extreme weather conditions.

A project is being implemented by the Ministry of Mahaweli Development and Environment for formulating cascade development plans under North Central Province canal during 2016 –

2018, where cascade development plans are prepared for the areas benefitted by the canal in Anuradhapura and Vavuniya Districts. The Project will deliver following outputs.

i. Water distribution and management plan in the cascade system
ii. Rehabilitation and improvement plan of infrastructure as well as operation and maintenance (O&M)
iii. Agriculture and livestock development plan including processing and marketing improvement
iv. Institutional development/ capacity development plans for farmer organizations and the extension agencies of the Government

The project team has made several discussions with professionals, who suggested incorporating traditional knowledge into planning in order to ensure the sustainability of the systems. Under this a total of 157 cascade systems, where about 1,400 tanks are found will be benefitted.

An attempt is being made collectively by Department of Agriculture (DOA), Sri Lanka and the Ministry of Agriculture, Forestry and Fisheries (MAFF) Japan through two projects namely Biodiversity for Adaptation to Climate Change (BACC) Project and Biodiversity for Food and Nutrition (BFN) Project for conservation and utilization of local varieties and traditional knowledge associated with genetic resources and agriculture.

An European Union funded FAO project on 'Support to District Development' is implemented during 2013 – 2017, in 7 districts of Sri Lanka, where one of the key components is rehabilitation of small tanks to enhance the system productivity. Under this component, one activity is to restore the tank ecosystem in order to enhance the water conservation and increase the bio-diversity. This brings the traditional heritage perspective back to the tanks, most of which belong to cascaded tank systems.

8.2 Potentials and Opportunities for Sustainability and Management

The CTVS provides multiple windows of opportunities for improving food security, agriculture and livelihoods in the villages where the CTVS reside, thereby helping reducing poverty and enhancing socio-economic development. As a basic first step, food security and agriculture can be further enhanced through improved natural resources management and tank improvement to arrest the decline of water supply that supports the production of paddy rice. Through improved agronomic practices such as soil moisture management, some farmers may be able to plant an additional cash crop (pulse) in the paddy fields to augment plant protein and cash supplemental cash income.

Arresting the decline of yields through better water management can be complemented by improved access to markets. Farming communities may also wish to assess if it is worthwhile to compete with other more established suppliers for mainstream agricultural markets. Alternatively, the farm community may instead aim for engaging emerging niche markets

who put premium to organically grown products as well as wellness products. Organizations that assist CTVS communities may help the latter transition to less chemically dependent products and link the same to these niche markets. Linking may involve identifying and understanding the needs of emerging markets and helping communities produce, package and market their products for these markets in ways that enhance competitiveness (organically grown, certification and labeling).

In addition to improving agriculture, eco- agri-ecotourism that is designed and managed with communities represents a new source of livelihood. This would be likely possible if the agricultural heritage practices are recognized and sustained while the existing biodiversity (ecosystems and species) associated with the CTVS are protected and promoted. Improving water management and agriculture through ecologically sound strategies, improved markets and enabling locally managed eco-agritourism provide incentives for improved management and sustainability of the system.

8.3 Expected Impacts of GIAHS on Society and Ecology

There are four key impacts expected as a result of declaration of the CTVS as a GIAHS. They are:

1. Sustainable conservation of the cascaded tank-village system;
2. Increase in income of the community in the declared site;
3. The potential replication of the good practices to be developed in areas declared as GIAHS in other cascades in the dry zone as well as formulation of policies that would enable such spread; and
4. Improved global awareness of the natural and man-made attraction in Sri Lanka.

8.4 Motivation (Interest) of the Community, Local Authorities and Other Relevant Stakeholders

The local authorities and farming communities are very interested in the prospect of dynamic conservation as a means to help conserve heritage that is fast dwindling and at the same time, a means for livelihood enhancement.

The various Ministries are interested with the potential value as model for good practices in the areas declared as GIAHS along their respective lines of interest. For instance, the Department of Agriculture (DA) is interested to develop and pilot approaches for agri-tourism, which would be based on agricultural heritage as a new form of agriculture-based income generation. Also of interest is to develop approaches for natural farming that utilize suitable indigenous species of cereals and vegetables that cater to emerging niche markets for safe food and wellness products. Both the DA and local authorities also want to provide alternative farming practices that rely on less chemical inputs partly because of emerging concerns on the increased frequency of renal (kidney) ailments among the populace.

The Department of Agrarian Development is particularly interested to be part of an effort for a holistic cascade wide approach to improve the hydrology of the CTVS while at the same time strengthening CTVS governance through improved capacities of FOs. International partner agencies such as the International Water Management Institute (IWMI) are likewise interested to provide R&D for developing the said approach.

A Presidential Task Force is now in operation referred to as '*wasa visa nethi ratak'* (A country free of poisonous substances). This Three-Year National Program named "A Wholesome Agriculture - A Healthy Populace - A Toxin free nation" has been initiated with the intention of preventing the use of highly toxic agrochemicals in farming sector. **Traditional paddy Cultivation program and organic fertilizer program are two components of this** '*wasa visa nethi ratak'* propaganda. This program is beiing implemented in several districts such as Anuradhapura, Polonnaruwa, Monaragala, Badulla Galle, Matara, Hambantota, and Kandy in small scale as pilot project and found successful achievements. However, it is observed that marketing problems for traditional rice is a negative impact for further improvement of Traditional Paddy.

CHAPTER 9: DYNAMIC CONSERVATION PLAN FOR THE PROPOSED GIAHS

9.1 Ongoing Efforts at National and Local Levels and a Preliminary Gap Analysis

The following is a preliminary list of ongoing efforts (table 11), subject to further study, that have potential relevance to dynamic conservation and from which future actions might build upon. The third column indicates the possible gap in the current effort, which can be a possible area of concern for future plans.

Table 11: List of ongoing efforts

Constraint	Relevant On-going Work and Opportunities	Potential Gap
Catchment degradation and lessened capacity of tanks	Some of the tanks in the Palugaswewa DS Division (the proposed GIAHS site) have been identified for rehabilitation by the Department of Agrarian Development	Tank bed surveys have already been completed in selected tanks. Many tanks marked as 'abandoned' in Table 2, will not be undertaken for any development as people are not interested due lack of understanding the function of them. Removal of sediments, drainage improvement and tank ecosystem development are not included in such programmes.
	Rain-water harvesting and soil conservation demonstrations by the Department of Agriculture in the highlands (uplands)	Total Catchment Management (TCM) approach through a multi-disciplinary team needs to be promoted as a Government policy to ensure the system sustainability. Participatory forestry development programmes successfully implemented elsewhere in Sri Lanka has not been attempted in this CTVS area.
Limited availability of agricultural lands resulting in agricultural land fragmentation, and encroachment of land use zones reserved for ecological functions that protect the tank's integrity, etc.	Promotion of Ecotourism by the Forest Department under Community Forestry program	Capacity of communities to plan and co-manage ecotourism may be limited at the moment
	Promotion of Agroforestry within Forest lands under the Community Forestry Program of the Forest Department	Lack of opportunity and capacity for the community to fully avail the potential incentives and support for Agroforestry under the Community Forestry Program .
Declining productivity	Promotion of Traditional Rice cultivation by the Agriculture	Application of generic extension programs does not consider the

Constraint	Relevant On-going Work and Opportunities	Potential Gap
resiliency and profitability of farming in some tank villages	ministry through NGOs Promotion of organic farming by the Agriculture Department Promotion of home gardening by the community forestry management project (UNDP project) and Department of Agriculture Agro-biodiversity conservation program by the Biodiversity Secretariat	unique characteristics of heritage agriculture associated with the CTVS (e.g. maintenance of biodiversity etc.). Lack of seed production support program for traditional varieties. Lack of access to niche markets by the community. Lack of an organization to access the available opportunities.
Wildlife damage to crops	Electric fencing program by the Wildlife Conservation Department for Human Elephant conflict areas	Adoption of biological barriers such as palmyra, cactus, sisal or combination of them is essential due to difficulty of maintaining electric fence on long run. Need of restoring wild tanks (*kuluwew*) for wildlife has not been recognized.
Lack of Interest in agriculture by youth	No program currently documents agri-cultural heritage associated with the CTVS	Agricultural heritage related income generation opportunities for youth aiming tourism are not recognized. Traditional knowledge has not been documented for passing on to next generation.
Farmer concerns related to CTVS are not adequately reflected in local development plans	Existing active Farmer Organizations participate in local consultations	Inadequate measures in place to promote awareness by the local political leaders on natural resource and heritage management issues associated with the CTVS.

9.2 Description of Key Strategies that need to be undertaken to address the Threats and Challenges cited in Chapter Seven

A series of multi-sectoral review and planning workshops were conducted during August to October 2015 to identify key challenges and threats and the priority actions that need to be considered to address them. A more detailed Dynamic Conservation Plan will be prepared for this purpose.

One of the key concepts contemplated by the foregoing dialogue is the development of the 'happy village' that involves proactive resolution of key structural constraints that the modern tank village is now confronted with, while at the same time encourage the sustainability of beneficial community practices that enhances both individual and social development. The traditional or local knowledge is gradually disappearing as new knowledge is being grasped by the youth community.

The local or Indigenous Knowledge (IK) refers to the unique, traditional local knowledge existing within and developed around the specific conditions of a community indigenous to a particular geographical area, covering all aspects of life including management of the natural environment upon which their livelihoods and survival depend (Louise Grenier, 1998). The IK provides the basis for techniques and practices for many aspects of rural life such as agriculture, health care, food preparation, education, natural resource management, social activities etc. It is the information base for a society, which facilitates communication and decision-making. The knowledge is dynamic, and is continually influenced by internal creativity and experimentation as well as by contact with external systems. The indigenous knowledge is the wealth that the people of a given community have gathered over time, and continue to develop. Thus, it is time tested and based on experience gained over centuries, hence adapted to local culture and environment, and dynamic and changing continuously.

As IK is predominantly embedded in practices and experiences, it is most commonly exchanged through personal communication and demonstration, from master to apprentice, from parents to children, from neighbour to neighbour and from traditional leaders to the community. Families had become experts and specialists for different purposes. Some examples are *Wedadura* (physician), *Yakadura* (healer), *Kammalkararaya* (blacksmith), *Dadayakkaraya* (hunter) and *Gamarala* (village headman). They gave their education to next generation through instructions, apprenticeships and learning through observation. They preserved their knowledge by writing on palm leaves and through folk media (Dharmasena, 2007).

The indigenous knowledge has not been documented for passing on to next generation. Thus, it is essential to establish a repository system to collect, classify and compile this disappearing knowledge system for future generation.

Two levels of work are suggested. The first would be the Palugaswewa DS Division to be declared as representatives of the system as a GIAHS. The second would be national level effort to establish policies that would help enable the dynamic conservation of heritage agriculture. In both levels, a Multi-sectoral approach would be crucial because we are not simply dealing with regular agricultural needs, but also cultural pride and conservation. Both young and old should be involved in preparing plans.

Site level work in Palugaswewa DS Division would include:

- Rehabilitation of tanks according to their function and environmental services;
- Restoration of tank ecosystem and village commons to revitalize the heritage;

- Promote practicing traditional irrigation and agricultural practices, which are in harmony with present context;
- Encourage villagers to practice and preserve the traditional healthy food habits and local medicines;
- Establish a cultural centre with a folk museum to enlighten the indigenous technology and preserve the traditional knowledge;
- Develop forests of medicinal herbs in suitable areas
- Heritage mapping, documentation of farming; and communication thereof including the incorporation of cultural aspects in the formal education curriculum;
- Enhance access to both mainstream and niche market support through interventions guided by the value chain approach such as post-harvest handling, value addition and processing;
- Tap the community ecotourism potential of the tank and associated forest and agricultural biodiversity and cultural practices.

National level work would include the following:

- Review and amend policies that tend to constrain dynamic conservation of agri–cultural heritage. Such policies include those that inadvertently removed incentives for localized seed supply systems, natural methods for soil fertility enhancement and the maintenance of ecological buffer systems etc;
- Prepare a Compendium of agricultural heritage systems in Sri Lanka; such compendium would aim to inventory and identify the essential features of remarkable systems as sources of biodiversity, as well as lessons on strategies for climate change adaptation;
- Establish a national system for official recognition and support to agricultural heritage as a part of the overall cultural heritage of the country (both tangible (tanks) intangible heritage (agricultural practices);
- Launching of information campaigns that would incorporate a discussion of heritage agriculture and CTVS as part of public discourse on innovations in agriculture, biodiversity conservation, climate change adaptation, cultural heritage and ecotourism.
- Establish a repository system for indigenous knowledge of various parts of the country

In both site specific and national level actions, the participation of women and youth in the decision making processes, implementation, monitoring and learning will be given optimum emphasis.

9.3 Resource Mobilization Plans to support the strategies including leveraging actions with other National and International Funding

Ideally, this can be a combination of the following sources in support of the Dynamic Conservation Plan:

a) Internal financing (national Government and local authorities);
b) External financing (small grants, loans from bilateral and multilateral partners, etc.);
c) Innovative financing (e.g. private sector, voluntary sector).

Financing will also need to be consisted of short term and long term financing support from national and local sources;

- Based on dynamic conservation plan, introduce the concept of GIAHS into proposed plans and budgets of agencies for the succeeding years.

- Obtain immediate "in-kind" technical support from agencies based on their mandates and using available resources. Examples are:
    - Ministry of Culture - Support to conduct cultural mapping in pilot site
    - Plant Genetic Resources Centre - Identify germplasm in the gene banks (Plant Genetic Resources Center) that are coming from the site and reintroduce selected varieties.

- Conduct studies and investigations on indigenous knowledge system disappearing at present and establish a repository system

Support from external sources

- Short-term grants from Grant Facilities and Scientific Institutions can provide small but immediate funding to support small scale piloting of concepts. Examples are :
    - GEF SGP (they are supporting cascade level work on biodiversity)
    - Small Startup Technical Assistance Grants from Donors (IFAD, FAO, etc.)
    - Research Grants from National and Global Scientific Institutions (CGIAR)

- Long term funding, the strategy is to be part of ongoing project preparation of relevant projects by key Ministries. Examples are:
    - Ministry of Agriculture –Department/Division on International Projects
    - IFAD and other donors – Identify relevant projects under preparation and be part of this project ; Also contribute to the development of their CoSOP (e.g. IFAD Country Strategy Operations Plan)

- Long term funding from the Climate Change Fund (CCF) is an example
    - There is a need to assemble information on Carbon sequestration potential, vulnerability assessments and CC adaptation potential
    - Partnerships with Department of Agrarian Department of Irrigation Ministry and IWMI will provide greater leverage

9.4 Dynamic Conservation Work Plan for the proposed GIAHS

Table 12: Dynamic conservation work plan

#	Main Activity	Sub Activities	Responsible Agency
1	Rehabilitation of tanks	1. Preparation of plans and estimates 2. Repairing and renovation of headworks 3. Development of downstream water management system	Department of Agrarian Development
2	Restoration of tank ecosystem and village commons	1. Participatory planning of tank ecosystems 2. Collection of planting materials 3. Tree planting programme in *kattakaduwa* and *gasgommana* 4. Restoration of *godawala*, *iswetiya*, and *yathuruwala*	Department of Agrarian Development
3	Traditional water management and farming practices in paddy fields	1. Awareness and training 2. Particpatory planning 3. Traditional rice farming programme 4. Monitoring and assessment	Department of Agrarian Development, Provincial Department of Agriculture
4	Promotion of traditional knowledge in rain-fed farming	1. Traditional soil and moisture conservation measures 2. Traditional crop cultivation 3. Traditional pesticides and fertilizers	Provincial Department of Agriculture,
5	Participatory forestry development programme	1. Identification of lands for natural forest and mapping 2. Awareness on the role and benefits 3. Agreement with Forest Department 4. Establishment of herbal gardens (*Aushda Uyan*) 5. Establishment of community forests with fruit, food, medicinal plants species	Forest Department
6	Traditional food habits and local medicines	1. Awareness on local foods and medicines 2. Home garden improvement with herbal plot and traditional vegetables 3. Health clinics 4. Local food exhibition	Ministry of Health, Nutrition and Indigenous Medicine
7	Establishment of the Community Heritage Centre, '*Govijana Uruma Kendraya'*	1. Construction of the building complex 2. Establishment of the museum unit for agricultural heritage 3. Establishment of the library for traditional knowledge	Ministry of Cultural Affairs & National Heritage

#	Main Activity	Sub Activities	Responsible Agency
		4. Establishment of aquarium for inland indigenous endangered fish species 5. Establishment of the 'Open Thetre' with audio-visual facilities 6. Organizing cultural events aiming to tourists (local and foreign)	
8	Establishment of the Rural Market Centre '*Kada pila*'	1. Plan and estimate for the rural market center 2. Construction of the building complex 3. Agreement between DS and villagers on trading process 4. Monitoring and assessment	Divisional Secretariat, Palugaswewa

KEY REFERENCES

1. Avsadahamy, U.B., 2003. Wewa (in Sinhala), (first ed.) Siri Printers, Hingurakgoda, Sri Lanka
2. Ceylon Today, 2016. HSBC & IUCN Restore Kapiriggama Tank cascade System. 11.12.2016
3. Cooray, P.G. (1984) An introduction to the geology of Sri Lanka. National Museums, Sri Lanka, Colombo.
4. Department of Agrarian Development, 2002. Database of The Department
5. Deraniyagala, S.U, 1992. The prehistory of Sri Lanka, parts I, II. Archaeological Survey Department, Colombo.
6. Deraniyagala S.U, 2002. A note on man and water in Sri Lanka: from prehistory to history. In: Mendis DLO Water Heritage of Sri Lanka. Sri Lanka Pugwash Group, Colombo, 258 pp; to order it: pugwash@sltnet.lk
7. De Silva, K.M. (1977) Sri Lanka: a survey. C Hurst and Co Ltd, London.
8. Dharmasena, P.B. (1985) Optimum utilization of the storage in village tanks. Trop. Agric 14: 95-108.
9. Dharmasena, P.B. (1989) System loss studies of village tanks. Trop. Agric, 145: 1-10.
10. Dharmasena, P.B., 1993. Man-environment interactions in tank-village home gardens: The trends in vegetation, Proc. of the 4th Regional workshop on Multipurpose Trees, (Ed.) H.P.M. Gunasena, University of Peradeniya, Sri Lanka. pp 90-101.
11. Dharmasena, P.B., 1995. Kattakaduwa; A potential land for Agro-forestry system development in sri lanka, Proc. 6th Regional Workshop On Multipurpose Trees. (Ed.) HPM Gunasena, University of Peradeniya, Sri Lanka. 17th – 19th August, 1995. P 96-104.
12. Dharmasena, P.B., 2004. Exploring tank village farming system in the dry zone. Journal of Soil Science Society of Sri Lanka. 16:17–28
13. Dharmasena, P.B., 2004. Small tank heritage and current problems. Village tank categorization. M.M. Aheeyar (Ed.), Small Tank Settlements in Sri Lanka, Kobbakaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka
14. Dharmasena, P.B., 2007. Indigenous agricultural knowledge in sri lanka: Back to practice. Paper presented at the Workshop on Grass Root Innovations (GRI) organized by NERD held at Galadhari Hotel, Colombo on 17-18th September 2007.
15. Dharmasena, P.B., 2010a. Evolution of Hydraulic Societies in the Ancient Anuradhapura Kingdom of Sri Lanka. In Landscape and Societies: Selected Cases, (Eds.) Martini I Peter and Chesworth Ward. Springer Publication. p. 341-352
16. Dharmasena, P.B., 2010 b. Essential components of traditional village tank systems, Paper presented at the Seminar on Cascade Irrigation Systems for Rural Sustainability held on 9th December 2010 at SLFI, Colombo, organized by Plan Sri Lanka.
17. Dharmasena, P.B., 2010 c. Agriculture, environment and food security in Sri Lanka. Proc. of the National Conference on Water, Food Security and Climate Change in Sri Lanka, Vol.1, (Eds) P. Weligamage, G.G.A. Godaliyadda and K. Dinapala. IWMI. P. 47-56.
18. Dharmasena, P.B., 2013. Unveiling the Latent Potential of Biodiversity of the Rural

Tank-Village System in Sri Lanka, Proceedings of the First National Conference on Livelihoods, Biodiversity and Ecosystem Services organized by Biodiversity Secretariat of the Ministry of Environment and Renewable Energy and IUCN, held on 26-27 September 2013 at SLFI, Colombo 7, Sri Lanka

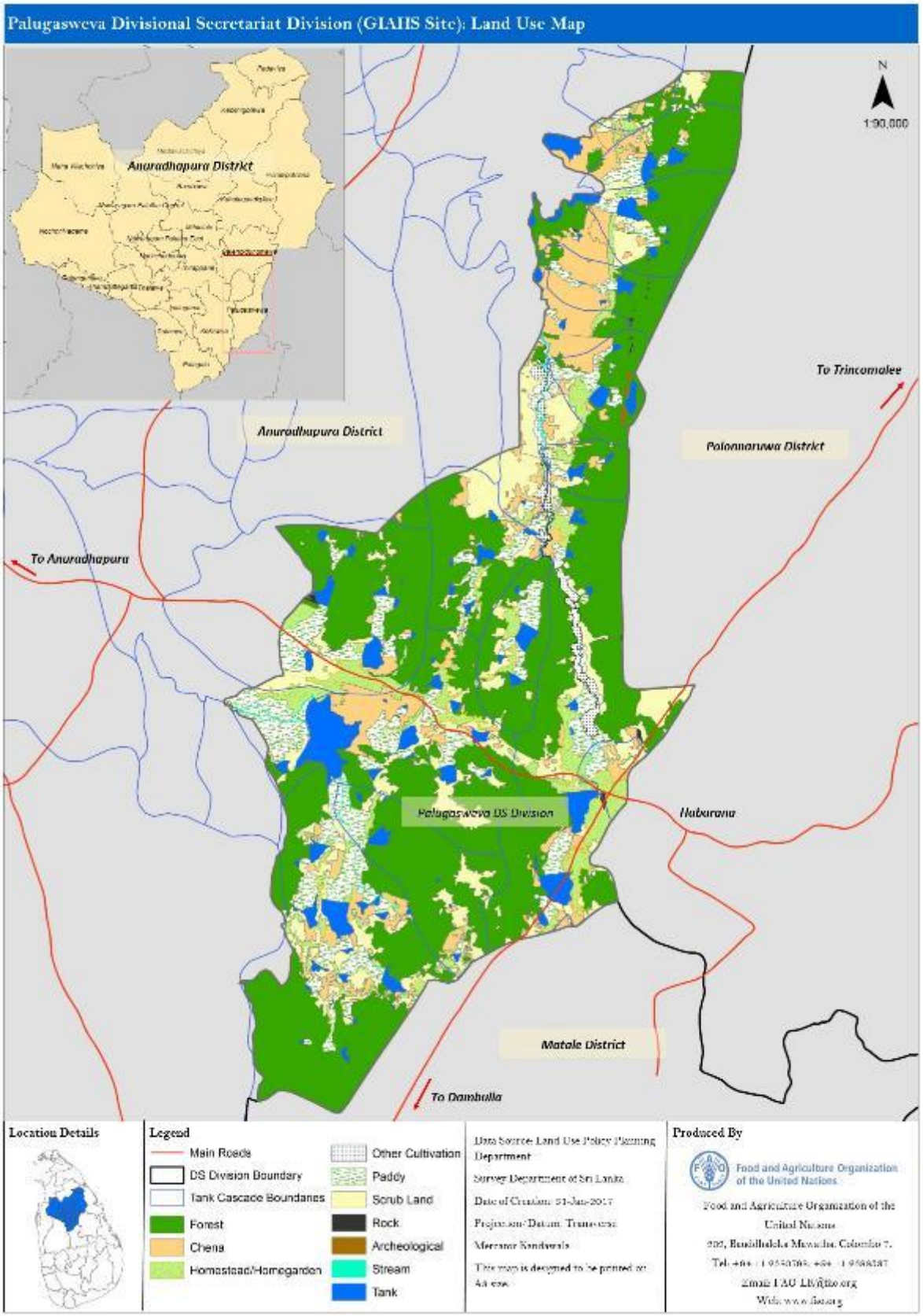
19. Dharmasena, P.B., 2009. Dry Zone tank-village: A system for reducing the impact of drought, Proc. of the Workshop on Role of Community in Adaptation to the Climate Change Crisis. (Eds) Gunaratne, L.H.P., W.A.P. Weearakkody, K.S. Hemachandra and P.Y. Yapa, Swedish Cooperative Centre and PGIA, Peradeniya. p. 125-136.
20. Dharmasena, P.B., 2016a. Bio-pesticides and Bio-fertilizers: Aid to eco-friendly farming, Technical Note, EU-SDDP Project, FAO
21. Dharmasena, P.B., 2016b. Management of Tank Cascade Systems For Sustainable Use: Experience from NCP, Paper presented at the World Water Day Workshop of he Department of Agriculture, Sri Lanka held at the Plant genetic Resources Center, Peradeniya on 29th March 2016
22. Dharmasena, P.B., 2017. Overview of small tank cascades: Evolution, present status and future scenarios, Presentation made at Policy Dialogue on Restoration and Management of Small Tank Cascade Systems on 14 February, 2017 at Bandaranaike Centre for International Studies (BCIS), Colombo, Sri Lanka
23. Gangadara, K.R. and Jayasena, H.A.H. (2005) Was rainwater harvesting in the dry zone of Sri Lanka a technically adapted methodology by the ancients? An analysis based on rainfall vs. number of tanks and tank surface area. Paper presented at the 12th International Rainwater Catchment Systems Association Congress, New Delhi, India. 15-18 November 2005.
24. Gunawardana, R.A.L.H. (1971) Irrigation and hydraulic society in early medieval Ceylon past and present, Paper presented at the special seminar on irrigation civilization at the Twenty-Eighth International Congress of Orientals, Canberra, 6-12 January 1971.
25. Groenfeldt, D.; Alwis, J.; and Perera, J. 1987. Strategies for improving minor irrigation systems in Sri Lanka, IWMI Working Paper No.6. Colombo: International Water Management Institute.
26. Haley, F.A., 1993. The Laws and Customs of the Sinhalese – Kandyan Law. 1923. Reprinted, Navrang, New Delhi.
27. Jayasena, H.A.H. and Gangadara, K.R. (2006) The evolution of AINS in the Middle East and tank cascade system (TCS) in Sri Lanka was it parallel? Proc. 4 th International conference AINS (Aflaj, Qanats, Karez), King Abdulaziz University, Jeddah, Saudi Arabia 02-05 April 2006.
28. Jayasena, H.A.H. and Selker, J.S. (2004) Thousand years of hydraulic civilization-Some socio-technical aspects of water management, Proceedings of the workshop on Water and Politics- Understanding the role of Politics in Water Management, World Water Council, Marseilles, France, 225-236 pp.
29. Jayatilaka, C.J., Sakthivadivel, R., Shinogi, Y., Makin, I.W. and Witharana, P. (2003) A simple water balance modeling approach for determining water availability in an irrigation tank cascade system. J Hydrol., 273: 81–102.

30. Knox, Robert, 1681.An Historical Relations of the Island of Ceylon. Richard Chiswell, London.
31. Li, Q. and Gowing, J. (2005) A daily water balance modeling approach for simulating performance of tank-based irrigation systems. Water Res. Management, 19: 211–231.
32. Louise Grenier, 1998. *Working with Indigenous Knowledge,* A Guide for Researchers. IDRC.
33. Madduma Bandara, C.M., 1985. Catchment ecosystems and village tank cascades in the Dry Zone of Sri Lanka: A time- tested system of land and water resource management. In J. Lundqvist, U.Lohm and M.Falkenmark (eds), Strategies for river basin management, pp 099-119, D. Reidel Publishing Company.
34. Madduma Bandara, C.M., 1995. Tank cascade systems in Sri Lanka: Some thoughts on their development implications, K.A. Haq, C.M. Wijayaratne, B.M.S. Samarasekera (Eds.), Summaries of papers presented at Irrigation Research Management Unit seminar series during 1994, Colombo, Sri Lanka, IIMI (1995), p. 14
35. Madduma Bandara, C.M., 2009. Village tank cascade systemsof Sri Lanka: A traditional technology of drought and watermanagement. Paper presented at the Annual Workshop onDisaster Reduction Hiperbase - –sian Application (DRHAsia)held from 8-9 January 2009 Tokyo, Japan.
36. Mahatantila, K., Chandrajith, R, Jayasena, H.A.H. and Ranawana, K.B. (2007) Spatial and temporal changes of hydro-geochemistry in ancient Tank Cascade Systems (TCS) in Sri Lanka: Evidence for a constructed wetland. Water and Envir. Journal 22(1): 17-24.
37. Matsuno, Y., Tasumi, M., van der Hoek, W., Sakthivadivel, R. and Otsuki, K. (2003) Analysis of return flows in a tank cascade system in Sri Lanka. Paddy Water Envir. 1: 173-181.
38. Munasinghe, J.U., M.A.A.B. Dilhn, and T.V. Sundarabarathy, 2009. Utilization of aquatic plants: A method to enhance the productivity of water in seasonal tanks in Anuradhapura District. Proceedings of the National conference on Water, Food security and Climate Change In Sri Lanka. BMICH, Colombo, June 9-11, 2009 Ed. P.Weligamage, G.G.A.Godaliyadda and K. Jinapala.IWMI.
39. NARESA, 1991. Natural Resources of Sri Lanka: Conditions and Trends, Colombo, Sri Lanka, NARESA
40. Nayakekorala. H.B., 2010. Traditional Practices of soil Management in Agriculture in Sri Lanka. Economic Review , April / May 2010
41. Nicholas, C.W. and Paranavithana, S. (1951) A Concise History of Ceylon, University of Ceylon Press, Colombo, Sri Lanka.
42. Nicholas, C.W. (1954) The irrigation works of King Parakramabahu I, Cey. Hist. J., 4: 52-68.
43. Nicholas, C.W. ,1959. History of Ceylon Vol.1. Ch.6, University of Ceylon.
44. Nicholas, C.W. (1960) A short account of the history of irrigation works up to the 11th Century. Journal of the Royal Asiatic Society (new series) VII: 43-69.

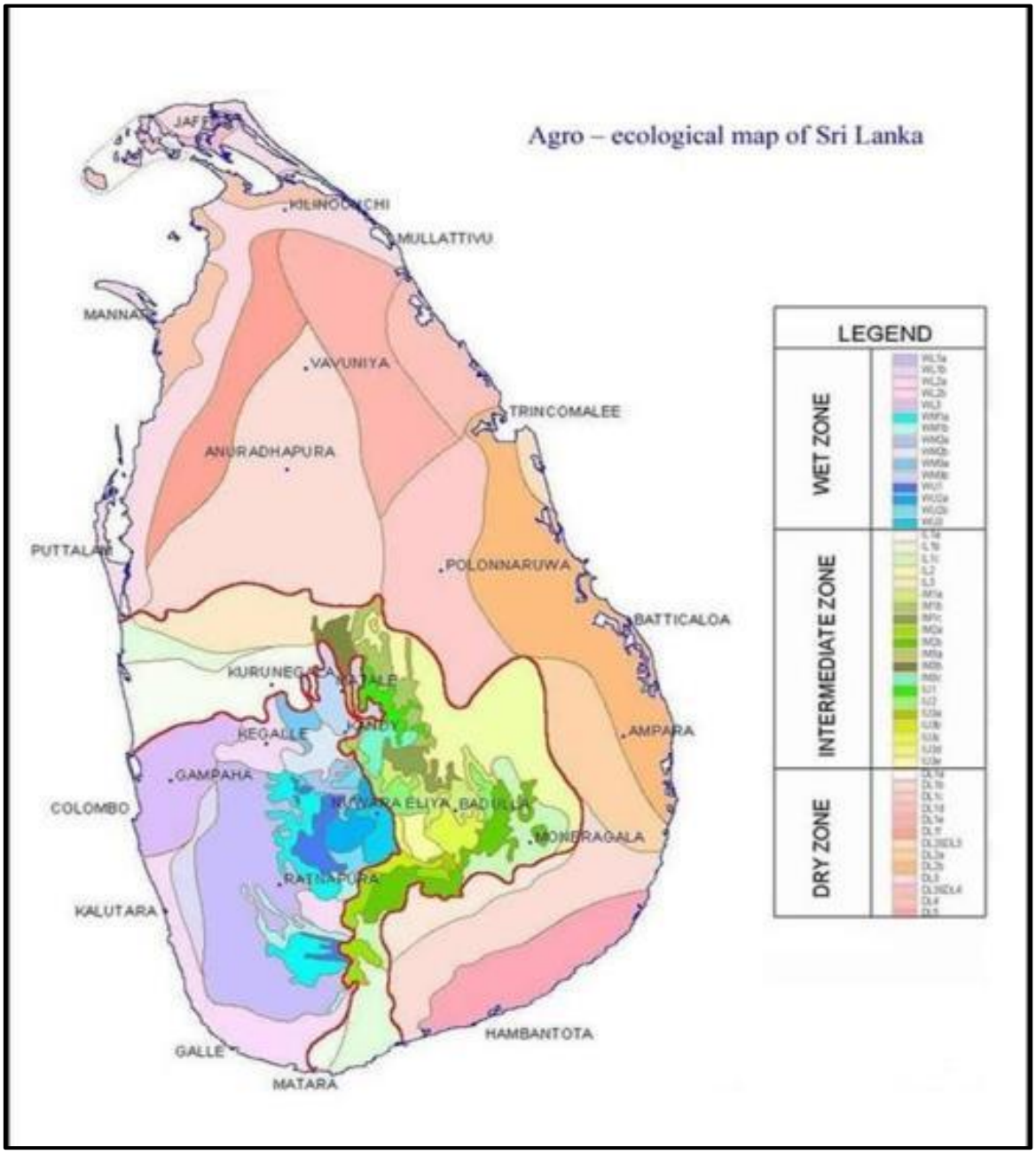
45. Panabokke, C. R. 1999. The small tank cascade systems of the Rajarata: Their setting, distribution patterns, and hydrography. Mahaweli Authority of Sri Lanka, Colombo, Sri Lanka, 39 pp
46. Panabokke, C.R.,R. Sakthivadivel and A.D.Weerasinghe, 2002. Small tanks in Sri Lanka: Evolution, Present Status and Issues. International Water Management Institute.
47. Panabokke, C.R., 2010. Evolution of the Indigenous Village Irrigation Systems in Sri Lanka.Economic Review. 36 (1&2): 3-9, Peoples' bank, Sri Lanka
48. Paranavithana, S., 1960. The withdrawal of Sinhalese from the ancient capitals. History of Ceylon, vol 1, University of Ceylon, Peradeniya, PP 713–720
49. Piyadasa, R.U.K., Lionel Weerakoon, Manuj Weerasinghe, Raj Somadewa, M.P. Vipulasena and Prbhath Vitharana, 2012. Study Report on Rehabilitation and Conservation of Palugaswewa Cascaded Tank System, Department of Agrarian Development, PP 140.
50. Punyawardena, B.V.R., 2010. Identification of the potential of growing seasons by the onset of seasonal rains: a study in the DL region of the North Central dry zone. Journal of the National Science Foundation of Sri Lanka. 30(1-2), pp.13–21. DOI: http://doi.org/10.4038/jnsfsr.v30i1-2.2557.
51. Sandika A. L. and.n.r.P. Withana, 2010. Economic Analysis Of Chena Cultivation In Monaragala District, Sri Lanka. Proceedings of the 15th International Forestry and Environment Symposium, 26-27 November 2010. Published by Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka. 350).
52. Siriweera, I., 2005. *Sri LankaweKrushi Ithihasaya* – (Agricultural history of Sri Lanka).
53. Somasiri, S., 2010. Physiography and Landforms, In 'Soils of the Dry Zone of Sri Lanka: Morphology, Characterization and Classification', (Eds.) R.B. Mapa, S. Somasiri and A.R. Dasanayake, Special Publication No. 7. Soil Science Society of Sri Lanka. P. 27-58.
54. Thennakoon, M.U.A., 1986. Drought hazards and rural development, Central Bank of Ceylon (Sri Lanka), Colombo, Sri Lanka (1986)
55. Thennakoon, M.U.A., 2000. Evolution and role of small tank cascade systems in relation to the traditional settlement patterns of Rajarata, Proceedings of the workshop on Food Security and Small Tank Systems in Sri Laka, (Ed.) H.P.M. Gunasena, National Science foundation, Colombo, P 13-32.
56. Thennakoon, M.U.A., 2005. Ellangawa (Sinhala Version), Godage and Sons, Colombo, Sri Lanka
57. Upawansa, G.K., 2000. Testing indigenous techniques to protect crops from wild animal damage. Compas Newsletter – July 2000.

ANNEXES

Annex 1: Land use map of the proposed GIAHS site



Annex 2. Agro-ecological map of Sri Lanka



Source: Natural Resources Management Centre, Department of Agriculture, Sri Lanka

Annex 3. Wild fruit and vegetable species found in the CTVS

Mora (Dimocarpus longan)

Damba (Syzygium assimile)

Palu (Manikara hexandra),

Weera (dryptes sepiaria)

Beli (Aegle marmelos)

Siyambala (Tamarindus indica)

Veli anoda (Annona squamosa)

Niyan vetakolu (Luffa cylindrica)

Kiri dambala (Dolichos kiblab Linn),

Thumba karavila (Momordica dioica)

Nayi miris (*Capsicum chinense*

Goraka thakkali

Thibbatu thakkali

Annex 4. Importance of traditional rice varieties found in the CTVS

Sources:
https://en.wikipedia.org/wiki/Traditional_Rice_of_Sri_Lanka
http://www.cicagri.com/index.php?page_cat=products&code_title=167&ex_four=195

Name of the rice variety	Importance
Suwandel	• This is an exquisitely delicious white rice with a fragrant aroma. It is believed to promote fair and glowing skin; improve the functioning of the excretory system; improve vocal clarity; and help control diabetes. It is also said to support a balanced growth of body. • Its special milky taste makes it an ideal choice for festive occasions and ceremonies. • The nutrient composition of *suwandel* consists of 90% carbohydrate; 7% crude protein; 0.7% crude fat; and 0.1% crude fiber. It is also known to contain higher amounts of glutamic acid and higher concentrations of vitamins than more common rice varieties. • Nutritional, aphrodisiac, sweetens the voice
Rathdel	• This is a delicious red rice that is said to provide relief to those suffering from cirrhosis. Porridge and soup made with *rathdel* is believed to help fight viral fever. It is recommended for rashes caused by mental stress and said to provide relief for ailments in the urinary system. It also believed to help flush toxic excretory matter and cool the body. Roasted and ground *rathdel* raw rice tempered with ghee is said to be an effective remedy for purging. It is also said to prevent the formation of stones in the bladder and gall bladder. Porridge made out of *rathdel* rice, *sarana* (*Boerhavia diffusa*), sugar, raisins and fresh cow's milk is recommended for those suffering from tuberculosis and lung ailments.
Kalu heenati	• Its name literally means dark, fine grain. • *Kaluheenati* is a highly nutritious red rice with medicinal properties, perfect for daily consumption and is recommended traditionally for lactating mothers. It is believed to enhance physical strength and with its high fiber content it helps regulate bowel movement. It is also said to be effective in keeping diabetes under control, as well as controlling the toxic effects of snake bites. The porridge made from *kalu heenati* rice is recommended for hepatitis patients. • Controls diabetes, Cure for snake bites, Good for expecting

Name of the rice variety	Importance
	mothers, prescribed for hepatitis, diarrhea, first rice meal for babies
Kuruluthuda	• This is a delectable and nutritious red rice variety, which is rich in proteins and fiber. It has a pleasant taste. • *Kuruluthuda* is said to improve bladder functioning.
Kuruwee	• A type of red rice with small grains. It helps increase immunity and the crop is tolerant to drought
Suduru samba	• This traditional variety is the most palatable and smallest grain size Samba available at present. It is also the most expensive local variety of rice, due to its high demand but low paddy production. It is believed to be an aphrodisiac
Kahata wee	• It helps increase immunity and it is nutritious
Pachchaperumal	• The word '*pachchaperumal*' means The Lord Buddha's color and this rice variety is considered a divine rice in traditional Sinhalese culture. It was often used in alms giving. • This is a wholesome red rice variety, which, when cooked takes on a deep rich burgundy color. It is rich in nutrients and in proteins, and is an excellent choice for daily meals. • *Pachchaperumal* is believed to be a perfect diet for those with diabetes and cardiovascular disease.
Elankalian	• It helps increase immunity and it is nutritious
Madathawalu	• This is another traditional red rice variety that is highly recommended in Ayurvedic treatment to strengthen the immune system.
Hetadawee	• The duration of the rice crop is 60 days, hence the common name. • It is a red rice variety, which is said to help control diabetes and provide relief for burning sensations and to cool the body. It is believed to relieve ailments caused by biological imbalances; improve physical strength, and also said to be an effective remedy for purging, blood vomiting and bleeding disorders.
Hondarawalu	• It survives against climate change impacts such as droughts, heavy rains, and floods, • Nutritional, treatment for gangrene, jaundice, good for expecting mothers
Girisa	• It survives against climate change impacts such as droughts, heavy rains, and floods,
Heenati	• It survives against climate change impacts such as droughts, heavy rains, and floods,