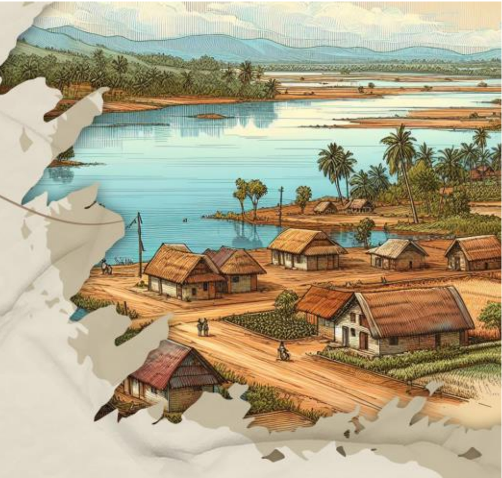

Source Book for Sustainable Tank Cascade Management

HEALTHY LANDSCAPES PROJECT

Source Book for Sustainable Tank Cascade Management

Edited by:

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Foreword

This book examines the challenges and impacts of human activities on the Cascaded Tank-Village System (CTVS) and potential actions to address these problems. The historical hydraulic civilization of Sri Lanka's Dry Zone showcases a remarkable evolution in water resource management through the development of the CTVS, ensuring sustainable water supply and agricultural productivity. Despite its significance, anthropogenic activities currently threaten the existence of the CTVS. There is a strong need for a multi-level, cross-sectoral approach that connects conservation and sustainable use to address critical problems in the CTVS.

The Source Book on CTVS Management aims to guide CTVS users with practical knowledge. The book presents a cross-sectoral analysis of initiatives that can be used as a comprehensive approach to safeguard the CTVS. It offers a comprehensive strategy to protect the critical components of the CTVS, along with examples and hands-on practices. The book aims to build a rationale in practitioners' minds, promoting the strategic use of natural resources in the CTVS and encouraging efforts to address conservation and livelihood development.

The book is structured around chapters encompassing specific topics related to the key roles in the work being done in each component of the CTVS, targeting practitioners. By offering comparative insights, this book aims to initiate a unique dialogue between users, institutions, and all stakeholders. Therefore, this book will be of great interest to policymakers, practitioners, scholars, and NGOs working on the betterment of the CTVS.

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Chapter 01

Components and Functions of Cascaded Tank-Village System

A.N. Kodithuwakku

The Cascaded Tank-Village System (CTVS) is characterized by a network of interconnected tanks situated within a micro-catchment area of Sri Lanka's dry zone landscape. These tanks serve to collect, channel, and utilize water from ephemeral rivulets. This ancient and widely adopted traditional agricultural system is primarily found in Sri Lanka's dry zone. The tank cascade represents a traditional strategy to cope with water scarcity in the region, catering to both agricultural needs and human consumption. This cascade network encompasses various types of reservoirs, including village tanks (*pahala wewa*), forest tanks (*kulu wewa*), temple tanks (*pin wewa*), supplementary tanks (*olagam wewa*), and storage tanks (*ilaha wewa*).

Kulu wewa (Forest tank)

Kulu wewa is strategically situated near or within forests in the upper catchment area with the specific aim of catering to the needs of wildlife. Other to fulfil various purposes, including providing water for wild animals, mitigating silting, filtering debris, storing rainwater, enhancing groundwater levels, facilitating water seepage to irrigation tanks, and sustaining the food chain by offering water, fruits, grass, leaves, and other essentials.

Kayan wewa

Isolated tank with the main purpose of avoiding the salinity and sedimentation.

Olagam wewa

These supplementary tanks are fed by a main tank which in turn provides some water to the fields under the main tank in case of an irrigation water shortage. The fields downstream of them are owned and cultivated by the people living beside the closest *maha wewa*. As the *Olagam* tanks are edging the village forest, they are the water holes for the wild animals. Mainly these tanks are used to supply water requirements of seasonal cultivations of the farmers.

Goda wala (Water hole)

These were meant to be the water holes to provide water source for wild animals and village cattle to quench their thirst, improve the vegetation and microclimate around them and to halt the free flow of water inducing some rain water percolation to improve ground water levels.

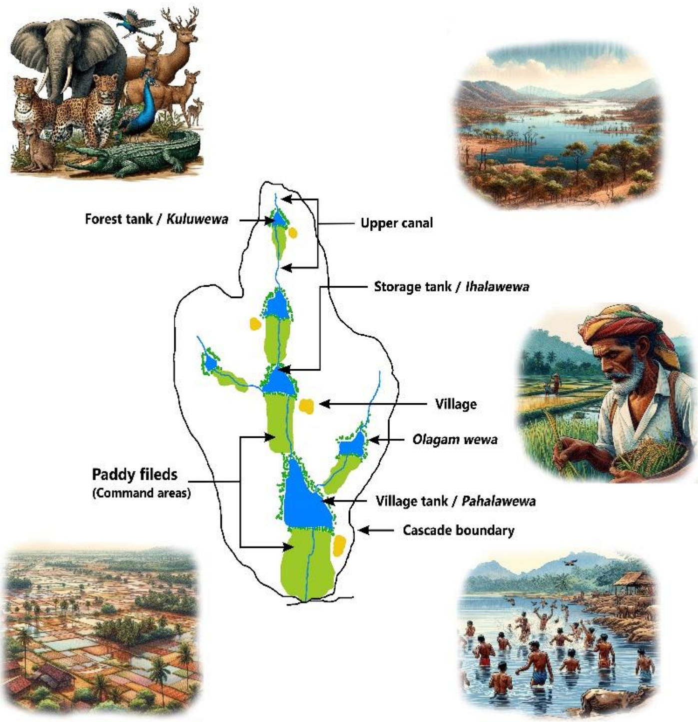
Ihala Wewa **(Storage tank)**

constructed for the storage of water, and is associated with paddy cultivation and other community activities.

Pin wewas **(Temple tanks)**

Those tanks were certainly for religeo-cultural purposes and not for direct economic purposes.

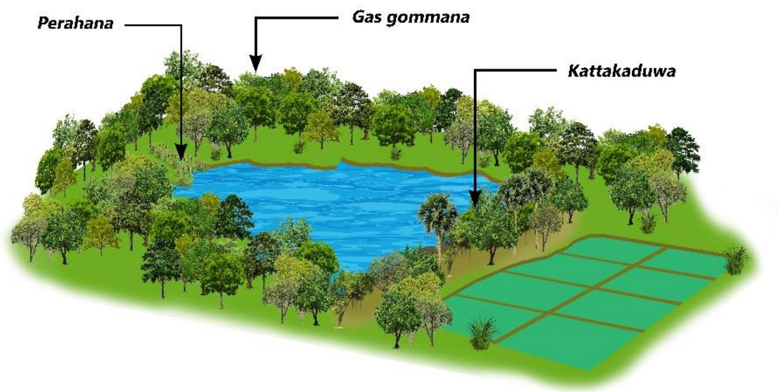
Each of these tanks was established with the special intention of conserving the available water and efficiently use for agricultural activities.



Each tank in a given cascade system adopts geographical and functional features to harmonise with nature. The functional components of a tank perform specific purpose and roles of these components are explained below.

***Gasgommana* (Upstream tree belt)**

This is a patch of land upstream above the bottom of the tank that only absorbs water when it overflows. There is a rich diversity of trees including large trees like *Kumbuk*, *Nabada*, *Maila*, *Damba* and climbers like *Kaila*, *Elipaththa*, *Katukeliya*, *Kalawel*, and *Bokalawel*. This vegetation is natural with seeds floating on the water. *Gasgommana* acts as a wind barrier, reducing evaporation from the tank and lowering the water temperature. It approaches the dam from both sides, and the roots of large trees form water cages that provide breeding and habitat for certain fish species. The woods mark the territory between humans and animals.



***Perahana* (Sediment filter)**

The grasslands developed under the *Gasgommana* filter the flow of sediment from the upper Chena region. *Perahana* forms an effective barrier, retaining eroded soil particles and allowing filtered water to flow into downstream tanks. Reed strips are very important in improving biodiversity. As some of the reeds over grow and lodge in water they are found to be ideal for the wading birds to rest and nest. They also provide shelter and food for small native fish that prefer shallow water. Microbes thrive in reading beds. As species and numbers in different habitats increase, so does their interdependence, and they all function in a completely symbiotic relationship.

Iswetiya or *Potawetiya* (Soil ridge)

An upstream soil ridge constructed at either side of the tank bund to prevent eroded soil entering the tank from upper land slopes.

Godawala (Water hole)

A manmade water hole traps sediment and it provides water to wild animals. This might had been a strategy to evade man-animal conflict.

Kattakaduwa (Downstream reservation or the interceptor)

This is a reserved land below the tank bund. It consists of three micro-climatic environments: water hole; wetland; and dry upland, therefore, diverse vegetation is developed. This land phase prevents entering salts and Ferric ions into the paddy field. The water hole is referred to as '*yathuruwala*' which minimizes bund seepage by raising the groundwater table.

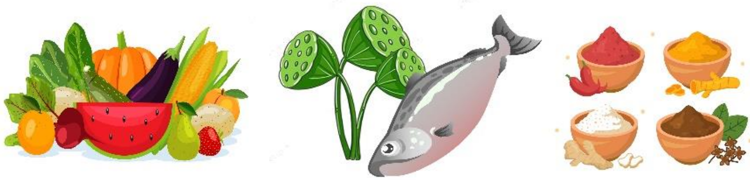
Villagers plant *vetakeya* along the toe of the bund to strengthen the bund stability. It appears to be a village garden, where people utilize various parts of the vegetation for different purposes such as fuel wood, medicine, timber, fencing materials, household and farm implements, food, fruits, vegetables etc. Specifically, they harvest row materials from this vegetation for cottage industries. Some products derived from the vegetation of *kattakaduwa* are plant-based products Mat grass, Hats, bags, baskets Bags, baskets, mats from plants as from *Indi*, *Vetakeya*, Bambo, *Rattan*, *Palmaira*. Wood carving, flower vase, building materials baskets, furniture, mats, bags, baskets, sweets, toddy, ropes, strings etc.

Tisbambe (Hamlet buffer)

This fertile strip of land surrounding the settlement area (*gangoda*) is unowned. It features a scattered growth of tree species such as *mee*, mango, and coconut. Historically, this area served sanitary purposes, functioning as a resting place for buffaloes.

Kiul-ela (Drainage)

This is the old natural stream utilized as the common drainage. Tree species such as *karanda*, *mee*, mat grass, *ikiri*, *vetakeya* etc. and few rare small fish species are also found in water holes along the *kiul ela*. Most importantly it removes salts and iron polluted water and improves the drainage condition of the paddy tract.



The village tank-based farming system had traditionally been three-fold, namely '*gangoda*' (homegarden), 'chena' (shifting cultivation) and '*welyaya*' (lowland paddy cultivation). These crop production systems were considered as a more stable settlement to averse the risk of vagaries of weather and subsistence nature of production.

Gangoda

The traditional village settlement was typically situated very close to a tank, which was the sole water source for the community. The tank provided water for domestic needs, animal husbandry, and agriculture. In many home gardens, permanent and perennial trees such as Coconut (*Cocos nucifera*), Mango (*Mangifera indica*), Lime (*Citrus aurantifolia*), Orange (*Citrus sinensis*), Jack fruit (*Artocarpus heterophyllus*), Drum-stick (*Moringa oleifera*), Pomegranate (*Punica granatum*), Banana (Musa spp.), Ambarella (*Sapondias pinnata*), Lawulu (*Chrysophyllum roxburgii*), Guava (*Psidium guajava*) and teak have been planted. They maintain naturally-occurring perennial plants for their food or timber value. Wood apple (*Feronia limonia*), Tamarind (*Tamarindus indicus*), Margosa (*Azadirachta indica*), *Burutha* (*Chloroxylon Swietina*), *Halmilla* (*Berrya cordifolia*) are common trees found in almost every home garden. However, in recent times, the settlement pattern has changed significantly. As the village population expand and focus more on sophisticated living standards, the traditional clustered settlement could no longer fit within the *gangoda*.

Chena

Chena, is a sequential agroforestry system which grows crops and trees in occupying the same space. A large number of coarse grains such as maize, finger millet, foxtail millet, pulses, such as mung bean, long bean and black gram, and vegetables are cultivated in chenas in a mixed crop system. Coarse grains such as finger millets and maize, sesame, and green gram, beans such as cowpea and long beans, melons such as pumpkins, ash melon, lady fingers, and cucumber, and, chilies which are brinjals are commonly cultivated crops in chenas.

Large trees with food and timber value are normally preserved when clearing the land for chena cultivation. Trees such as Wood apple (*Feronia limona*), Tamarind (*Tamarindus indica*), Capok (*Ceida pentendra*), Weera (*Drypetcs sepiaria*), *Palu* (*Manilkara hexandra*), *Kon* (*Schileichera oleosa*), and *Buruta* (*Chloroxylon swietina*) are generally preserved. In addition to food and other economic value, these huge trees are very important for chena cultivation as farmers make their observation platforms on these trees to avoid elephant attacks. However, due to chena lands being converted to settled rainfed settlements a high degree of land degradation, soil erosion, tank siltation has taken place.

Welyaya **or the command area of the small tank**

The small tank command area comprises two distinct components: the Purana Wela and the *Akkara wela*. The Purana Wela represents the traditional irrigated segment of the village agricultural system. However, due to population growth, new areas have been incorporated into the small tank's command area, known as *Akkara wela*. However, this expansion has not been matched by corresponding increases in the tank's water supply. Consequently, the command area is cultivated only when the tank's storage is deemed sufficient to irrigate the entire commanded region.

Chapter 02

Evolution of Cascaded Tank-Village System (CTVS)

H.A.H. Navodya

The historical hydraulic civilization of Sri Lanka's Dry Zone showcases a remarkable evolution in water resource management through the development of the Cascaded Tank-Village System (CTVS). This ancient and intricate method of water management is one of the world's oldest and most successful resource management practices, reflecting the ingenuity and practical knowledge of early communities. Over centuries, these societies perfected the construction and management of thousands of interconnected tanks, ensuring sustainable water supply and agricultural productivity in a region characterized by unpredictable rainfall and rolling /undulating topography. Despite its significance, the full complexity and sophistication of the CTVS, along with the knowledge behind these systems, have not been fully revealed until the recent past.

Understanding the evolution of the CTVS is crucial, as it not only sheds light on the advanced hydrological and environmental management techniques of ancient Sri Lankan civilizations but also offers valuable insights into sustainable water management practices that can be applied in contemporary contexts. This knowledge is essential for addressing the threats that the CTVS may face in the future, such as climate change, population pressure, and environmental degradation. By learning from the past, we can develop strategies to enhance the resilience and sustainability of the CTVS, ensuring that these systems continue to provide vital water resources and support agricultural productivity for generations to come. This chapter explores the stages of development and the enduring impact of this innovative water management system, emphasizing its relevance and importance for today and tomorrow.

CTVS

Early forms of small reservoirs, known as "*Wewa*" in Sinhalese, are commonly referred to as tanks. The term "tank" originates from the Portuguese word "*Tanque*", which denotes small reservoirs. According to the Agrarian Service Act No. 59 of 1979, there are three types of tanks including “large tanks” (more than 400 ha of Irrigated area), “medium scale tanks” (400-80 ha of Irrigated area) and minor irrigation works have an irrigated command area of 80 ha or less, define as “small tanks". They have also been referred to as "village tanks" in official records and published literature.

Studies indicate that tank-based villages were the most stable settlement systems in the Dry Zone of Sri Lanka, maintaining a proper balance between farming operations and the environment. A tank village comprises four major components: the tank itself, the paddy fields, the homestead or "*Gangoda*," and the "Chena" or shifting cultivation area. The main component is the man-made tank, which collects water from various sources such as catchment runoff, temporary rivulets, or river diversions. Water management in these systems is generally the responsibility of the village community, typically organized by paddy landowners or the entire village.

There are four types of tanks according to their function;

Forest tanks: These tanks were constructed in the jungle areas above the villages to preserve forest ecosystems and maintain water circulation within the entire cascade. Additionally, they provided water for wild animals, reducing the likelihood of these animals descending into farmland and destroying crops in search of water.

Mountain tanks: Supplied water for Chena cultivation, a form of slash-and-burn agriculture, though this practice has been discouraged by Sri Lankan authorities over the years.

Erosion control tanks/ *Pota wetiye*: were designed to trap silt before it reached the main storage tanks, thus preventing sedimentation and ensuring the longevity of the main irrigation tanks. These tanks were constructed to be easily de-silted.

Storage tanks: Traditionally, storage tanks operated in pairs, with one tank in use while the other was being repaired, hence referred to as Twin tanks. Each village had a main village tank that served the local irrigation system, playing a critical role in supporting agricultural activities and ensuring a stable water supply for the community.

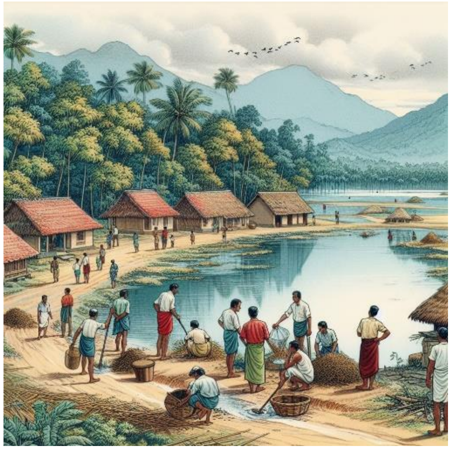
Most village tanks are not isolated units but are part of a network known as the 'CTVS'. This system consists of a series of interconnected tanks within a micro-catchment area of the dry zone landscape, designed to store, convey, and utilize water from ephemeral rivulets. Locally known as '*Ellangawa*', this system has evolved over nearly two millennia to provide water for irrigation, domestic use, animals, and ecosystems. The principle behind this system is the recycling and reuse of water through a network of small to large tanks. Approximately 80% of the small tanks are organized as tank cascades.

A cascade in the dry zone typically comprises about four to ten individual small tanks, each with its own micro-catchment, all situated within a single meso-catchment basin. The country has three primary cascade zones: North and North Central, North Western, and South and South Eastern, encompassing approximately 90% of the 1,162 identified tank cascade systems, with the remaining systems scattered elsewhere.

The advantage of such a system is that excess water from one reservoir, along with the water used in its command area, is captured by the next downstream reservoir, allowing it to be reused. This water is continuously filtered and recycled through subsequent tanks. The seepage and percolation losses in these systems are notably higher than the design rates for small tanks. An integral feature of these cascades is the '*Thaulla*', a constructed wetland that significantly aids in decontaminating water entering the tanks. This suggests that some aspects of the tank cascade system were intentionally designed to enhance return flow and mitigate non-point source pollution.

Past evolution of small tanks in Sri Lanka

Throughout history, numerous communities have developed cultures and lifestyles deeply connected to their natural surroundings and local landscapes. Sri Lanka's ancient water civilization is a prime example of this, although its evolution has been influenced by various social, political, and economic interactions with neighboring countries and foreign invasions. Despite these influences, studies on the historical evolution of small tanks in Sri Lanka have been relatively limited.



The exact origins of irrigation reservoir construction in Sri Lanka are uncertain, but historical evidence suggests that these systems have ancient roots. Some theories propose that reservoirs existed before the arrival of Prince Vijaya, the legendary founder of the Sinhalese nation, with the presence of *naga* symbols on ancient reservoirs implying construction by prehistoric *naga* tribes. However, other scholars argue that there are no historical records to support this, instead suggesting that tank irrigation was introduced by Aryan settlers around the 6th century BC. The *Mahavamsa*, a historical chronicle of Sri Lanka, records that King *Pandukabhaya*, an Aryan ruler, constructed the *Basavakkulama* tank in Anuradhapura in the 5th century B.C.

Following the reign of King *Pandukabhaya* (437-367 B.C), who founded the city of Anuradhapura, 122 kings ruled for 1,477 years until the kingdom moved to Polonnaruwa in 1040 A.D. During this extensive period, the establishment of forests and the construction of ponds, reservoirs, and irrigation systems were considered meritorious acts in accordance with popular Buddhism, which was the predominant faith among the leaders and the majority of the populace. Notable kings such as *Vasabha* (67–111 A.D), *Mahasena* (276–303 A.D), *Dhatusena* (455–473 A.D), *Agbo* II (575–608 A.D), and *Parakrambahu* (1153–1186 A.D) made significant contributions to water resource development, constructing numerous reservoirs and irrigation systems that supported vast paddy fields in the dry zone.

The construction and maintenance of these irrigation systems were monumental undertakings that required substantial expertise. Over centuries, an indigenous knowledge base evolved, enabling effective management and expansion of these systems. Historical commentaries, such as the *Mahavamsa*, indicate that the construction and settlement of approximately 15,000 smaller village tanks likely occurred at various times across different regions of the dry zone, extending up to 1200 and 1300 A.D. By 1300 A.D, most of these tanks were either fully or partly operational.

From 1300 A.D onwards, the decline of central governments and major irrigation systems led to a significant population shift from the dry zone to the wet zone, continuing until around 1500 A.D. Despite the decline and decay of major irrigation systems, the small tank systems continued to operate to varying degrees, relying on their internal organizational strengths.

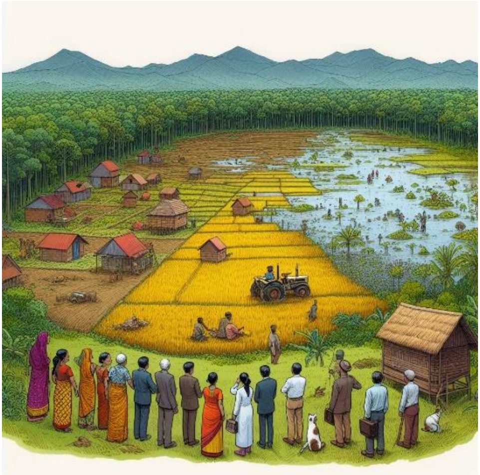
Latest published estimates on the total number of small tanks range from 15,000 to 18,000 these estimates also indicate that nearly 50% are abandoned or in a dilapidated state. The main reasons for abandonment include the use of catchment areas for human activities, incompatible land use or agricultural practices, economic issues, engineering challenges making maintenance non-viable, lack of access roads, distance from human habitations, and location within forest reserves, nature reserves, or wildlife sanctuaries.

Evolution of governance and institutional mechanisms in the CTVS in Sri Lanka

The governance of the CTVS has evolved significantly, shifting from community-led management in the pre-colonial era to central government control in modern times. This transition occurred over three distinct periods: precolonial, colonial, and post-independence. Initially, local communities, including farmers, village headmen, and local chieftains, managed the tanks, making decisions tailored to their needs. Management practices, passed down through generations via oral traditions, rituals, and customs, became well-established. Historical evidence, including scripts and pillar inscriptions from around 1000 A.D., indicates that farmers adhered to laws set by kings or regional leaders for the maintenance of small irrigation systems. These laws and customs evolved into a disciplined system known as '*Rajakariya*', which ensured effective management of the tanks for centuries, supported by socially, morally, and legally enforced requirements.

Village headmen, local chieftains, local elites, or monks led the management of water and cropping, ensuring equitable access and rights through village councils or '*Gamsabha*'. These local governance structures were highly effective and operated with minimal intervention from central authorities. However, the abolition of the '*Rajakariya*' system by colonial administrators in 1832, without a replacement system, led to the neglect and degradation of many CTVS.

During the colonial period, the Crown Land Encroachment Ordinance of 1840 declared land and water rights as crown property, stripping small-scale farming communities of their traditional rights. This resulted in the abandonment and deterioration of many CTVS. From 1832 to 1856, there was no responsible authority for managing small irrigation systems until the Paddy Lands Irrigation



Ordinance of 1856 attempted to restore some community management rights. This ordinance introduced the role of the irrigation headman (‘*Wel widane*’), a community representative who facilitated state administration of land and water. In 1900, the establishment of the Irrigation Department centralized all irrigation management responsibilities, using local communities for labor in maintenance tasks. The department's functions were further defined by a new irrigation policy in 1932, focusing on construction, improvement, and maintenance of irrigation schemes.

In the post-independence period, the institutional framework for managing small irrigation systems became increasingly complex. Responsibilities shifted among various government bodies, including ministries and departments of irrigation, agriculture, and agrarian services. This era saw the rapid expansion of large and medium-scale irrigation projects in Sri Lanka's dry zone, driven by government policies to boost local food production. These large-scale projects were prioritized over small systems like CTVS due to their perceived lower contribution to national food production. Nonetheless, NGO-led campaigns and projects led to the rehabilitation of some small tank systems. The Agrarian Services Act 58 of 1979 introduced a standardized institutional structure for small irrigation systems, replacing the diverse structures that had emerged from various projects. Frequent government changes and shifting policy priorities have resulted in inconsistent management of small irrigation systems, hindering the development of a long-term policy framework. Since 1947, agrarian laws governing small irrigation systems and associated farming practices have undergone four major revisions, with the most recent being the Agrarian Development Act No 46 of 2011.

Over time, the shifts in governance and institutional structures gradually distanced local communities from their traditional roles in managing land and water resources. These changes, along with legal and institutional amendments, diminished community confidence and morale. The government implemented top-down management strategies, often disregarding local perspectives on water use.

Furthermore, the creation of institutional structures based on administrative boundaries resulted in conflicting interests.

Conclusion

In conclusion, the CTVS represents a historically significant and ingeniously designed method of water management that has sustained Sri Lanka's dry zone communities for millennia. The evolution of CTVS showcases the advanced hydrological and environmental management techniques developed by ancient Sri Lankan civilizations. However, shifts in governance and institutional structures over time have distanced local communities from their traditional roles, leading to challenges in maintaining these systems.

Recognizing the resilience and multifunctionality of CTVS, there has been a renewed interest in restoring these systems to their pristine condition. Designated as a Globally Important Agricultural Heritage Site (GIAHS), the CTVS offers valuable insights for sustainable water management practices in the face of climate change, poverty, and environmental degradation. The government and the general public must collaborate to protect and revitalize the CTVS, incorporating traditional knowledge and lessons from previous restoration efforts. By doing so, the CTVS can continue to support diverse ecosystems, local livelihoods, and economic benefits, ensuring the sustainability and resilience of these vital water management systems for future generations.

Chapter 03

Present Status and Challenges for the Sustainability of CTVS

S.M.C.B. Karalliyadda

CTVS are encompassed with ecological, social and agricultural subsystems. These systems can continue to support agricultural productivity, ecological balance, and community well-being in the face of modern challenges. Thus, the sustainability is crucial for its long-term functionality and benefits.

- Sustainability refers to the capacity to maintain or improve systems and processes over the long term without depleting resources or causing severe ecological damage. It encompasses three main pillars:
- Environmental Sustainability: Ensuring that natural resources are used in a way that maintains ecosystem health.

- Economic Sustainability: Promoting economic growth and development while ensuring that resources are used efficiently and responsibly.
- Social Sustainability: Enhancing the well-being of communities, including equity, health, education, and community resilience.

However, in the modern day, the traditional CTVS are facing challenges to maintain its sustainability.

What challenges does CTVS face in the current days

Deforestation

The clearing of forests for agriculture, urban development, and logging reduces forest cover, leading to habitat loss and ecosystem imbalance. This causes gradual decline in forest health, biodiversity, and overall ecosystem functionality. Common causes of deforestation are as follows:

- Agricultural expansion: Conversion of forests into agricultural land, particularly for monoculture crops leading to significant habitat destruction.
- Urbanization/infrastructure development: Roads, dams, and other infrastructure projects fragment forests, disrupt wildlife corridors, and increase human access.
- Illegal logging: Unsustainable and illegal logging practices deplete forest resources, damage habitats, and biodiversity loss.

Consequences of deforestation

Loss of biodiversity:

- Deforestation leads to habitat destruction, species extinction, and a decline in biodiversity.
- Many species cannot survive outside their natural habitats, leading to a loss of both plant and animal life.

Soil erosion and degradation:

- Roots anchor the soil, preventing erosion.
- Without forest cover, soil is more susceptible to erosion by wind and water, leading to loss of fertile topsoil and increased desertification.

Disruption of water cycles:

- Trees absorbing and releasing water.
- Deforestation disrupts this cycle, causing changes in precipitation patterns, reduced water quality, and altered river flows.
- Results include increased flooding and reduced water availability during dry periods.

Global warming and climate change:

- Forests act as carbon sinks, absorbing carbon dioxide from the atmosphere.
- Deforestation releases stored carbon dioxide, significantly contributing to greenhouse gas emissions and global warming.
- Estimated that deforestation accounts for about 10% of global greenhouse gas emissions.

Altered local climate:

- Forests moderate temperatures and maintain humidity levels in local climates.
- Removal of forests can lead to hotter and drier local conditions, affecting agriculture and human habitation.

Impact on local peoples:

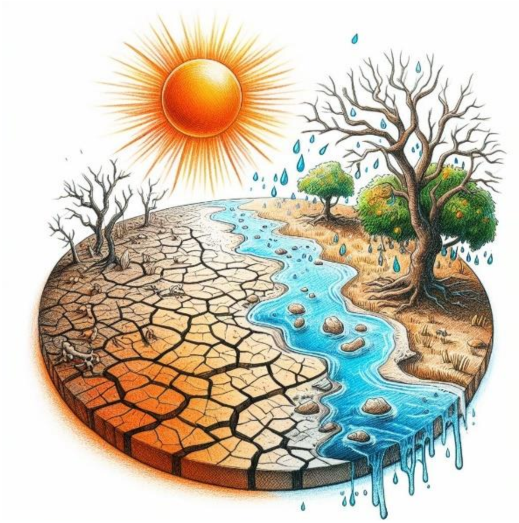
- Many indigenous communities rely on forests for their livelihoods, culture, and identity.
- Deforestation threatens their way of life, leading to displacement and the loss of cultural heritage.

Economic impact:

- Deforestation can provide short-term economic benefits through logging and land conversion for agriculture.
- Often leads to long-term economic costs, including loss of ecosystem services like clean water, fertile soil, and timber resources, as well as potential tourism revenue.

Health issues:

- Deforestation can create environments conducive to the spread of diseases like malaria, as mosquitoes thrive in deforested areas.
- Reduced air quality due to increased carbon emissions and loss of medicinal plants can negatively affect human health.



Addressing deforestation

- Reforestation and afforestation: Planting trees and restoring forests to mitigate the impacts of deforestation and restore habitats.
- Legal and policy measures: Enforcing laws against illegal logging, establishing protected areas, and promoting conservation policies.
- Community engagement and education: Empowering local communities to manage and protect their forests and raising awareness about the importance of forests.

- Sustainable land management: Implementing practices that balance environmental health, economic profitability, and social equity to reduce the pressure on forests. This includes sustainable forestry, agroforestry, and integrated land-use planning.

Degradation of farmlands

The deterioration of rainfed and irrigated farmlands is a significant issue affecting agricultural productivity, food security, and environmental sustainability. This degradation can be attributed to several factors, including soil erosion, salinization, nutrient depletion, and improper management practices. Common causes of farmland degradation are as follows.

- Soil erosion: is primarily caused by water runoff during heavy rains. Lack of vegetation cover and poor soil structure exacerbate the problem. improper irrigation in irrigated farmlands practices can lead to surface runoff and erosion, especially if the soil is not properly managed or protected.
- Salinization: mainly in irrigated areas where excessive irrigation and poor drainage lead to the accumulation of salts in the soil, rendering it less fertile.
- Nutrient depletion: continuous cropping without adequate replenishment of soil nutrients depletes the soil of essential nutrients. Moreover, the intensive farming and excessive use of chemical fertilizers can lead to nutrient imbalances and soil degradation.
- Compaction and reduced soil quality: Heavy machinery and overgrazing compact the soil, reducing its permeability and root growth capacity.

Consequences of farmland degradation

Reduced agricultural productivity:

Both rainfed and irrigated farmlands experience a decline in crop yields due to soil degradation and reduced soil fertility.

Food security:

The deterioration of farmlands threatens food security by decreasing the availability and quality of crops, which is especially critical in regions dependent on agriculture.

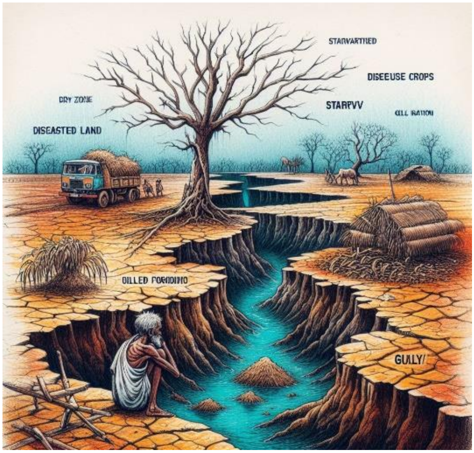
Environmental degradation:

Degraded farmlands contribute to biodiversity loss, reduced carbon sequestration, and increased greenhouse gas emissions.

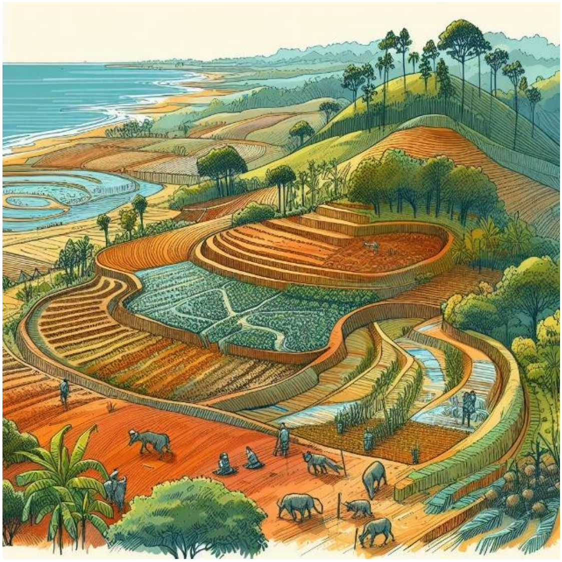
Economic consequences:

Farmers face increased costs due to the need for more inputs (e.g., fertilizers, water) and decreased income from lower yields.

Addressing farmland degradation



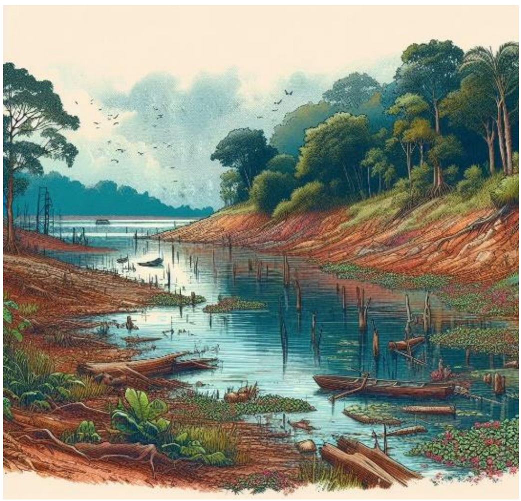
- Improved soil management: Implementing soil conservation practices such as contour plowing, terracing, and the use of cover crops to reduce erosion and improve soil structure.
- Soil fertility management: Utilizing organic amendments (e.g., compost, manure), practicing crop rotation, and integrating agroforestry to enhance soil fertility and structure.
- Sustainable irrigation practices: Adopting efficient irrigation techniques like drip irrigation and scheduling irrigation based on soil moisture levels to reduce water usage and prevent salinization.
- Climate-smart agriculture: Implementing practices that increase resilience to climate change, such as diversifying crops, improving water management, and adopting drought-resistant crop varieties.
- Policy and education: Governments and organizations should provide support through policies that promote sustainable practices, subsidies for conservation techniques, and education programs for farmers on soil and water management.
- Research and technology: Investing in research to develop new technologies and practices for sustainable land management and disseminating this knowledge to farmers.



Degradation of Tank, aquatic habitats and irrigation structures

Deterioration of cascaded tanks, irrigation structures, and aquatic habitats can have significant negative impacts on water resources and the environment.

Tank and aquatic habitat



- Sedimentation: Over time, cascaded tanks can accumulate silt and debris, reducing their storage capacity and efficiency.
- Structural damage: Aging infrastructure can suffer from cracks, leaks, and other forms of physical degradation.
- Water quality: Poor maintenance can lead to contamination of water sources, affecting both human use and ecological

balance. Runoff from agricultural fields, containing pesticides and fertilizers, can lead to nutrient pollution and eutrophication, harming aquatic life.

- Vegetation overgrowth: Inadequate management can lead to excessive growth of aquatic plants and invasive species, further diminishing tank capacity and water quality.
- Habitat destruction: Construction and maintenance activities can destroy or alter natural habitats, reducing biodiversity.
- Altered hydrology: Changes in water flow and distribution can disrupt the natural hydrological cycles of rivers, lakes, and wetlands, impacting species that depend on specific flow regimes.

Irrigation Structures

- Canal erosion: Canals can erode over time, leading to loss of water, reduced flow efficiency, and increased maintenance costs.
- Blockages and sediment build-up: Debris and sediments can block irrigation channels, disrupting water supply and distribution.
- Leakage: Aging and poorly maintained canals and pipes can develop leaks, leading to water loss and inefficient irrigation.
- Deterioration of gates and control structures: Components such as gates, valves, and weirs can become corroded or broken, impacting the control and distribution of water.

Addressing the tank, aquatic habitat and irrigation structure degradation

- Regular Maintenance: Implementing regular inspection and maintenance schedules for tanks, irrigation structures, and habitats to address issues promptly.
- Modernization: Upgrading infrastructure with modern materials and technologies to enhance efficiency and durability.

- Sediment Management: Implementing sediment removal and management practices to maintain storage capacity and water quality.
- Water Quality Monitoring: Establishing comprehensive water quality monitoring systems to detect and address pollution sources promptly.
- Sustainable Practices: Promoting sustainable agricultural practices to reduce runoff and pollution.
- : Engaging in restoration projects to rehabilitate and protect aquatic habitats, including reforestation, wetland creation, and invasive species management.

Chapter 04

Management of Soil Health in Tank Cascade System

M.G.T.S. Amarasekara

Soil as a natural resource

Soil is the loose uppermost layer of the earth. It consists of inorganic particles and organic matter. It also contains air and water in the pore spaces available between solid particles. Soil is derived from weathering of rocks and minerals. It takes about 500 to 1000 years to form one inch of soil. However, it takes only a few years for that single inch to be washed off due to human interference. Therefore, soil is a highly valuable natural resource to be protected. It supplies essential plant nutrients and moisture for plant growth. Hence, it is considered as the natural medium for plant growth. It also provides living environment for many organisms such as higher plants and microorganisms. Therefore, sustenance of whole ecosystem depends on the way of management of soil. So, we really need to look after the soil in our garden.

What is soil health?

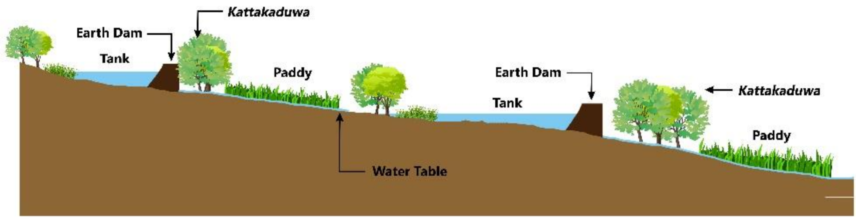
The capacity of the soil to support functions of natural ecosystem is defined as soil health.

A healthy soil should have;

- Sufficient soil depth for plant root development
- Good water storage and drainage
- Sufficient but not excessive amount of plant nutrients
- Free from harmful chemicals for plants
- Good population of soil organisms but a smaller number of pathogens

Landscape of tank cascade system

The landscape of tank cascade system in dry zone Sri Lanka consists of undulating land surface with a large number of small inland valleys. Underlying basement rock in this area is highly impervious and soil depth is shallow to moderate. This condition is highly appropriate for construction of small reservoirs such as village tanks. A tank cascade includes series of interconnected village tanks keeping a regulated flow of water from one tank to another. Highland farming in the cascade system is confined to well drained soils in upper elevations of the undulated terrain while irrigated paddy farming is done in valley bottoms where moderate to poorly drained soils are existed.



Present situation in tank cascade system

Reddish Brown Earth is the predominant soil type in highland areas while Low Humic Glay and Alluvial soils are found in lower elevations in the landscape. Land degradation is a serious problem in tank cascade system in Sri Lanka. Soil erosion is identified as the major reason for land degradation. Higher erodibility of the soils and intensive rainfall events occur in maha season aggravate the situation. It reduces soil fertility due to carrying away of fertile soil particles from farm lands. Tank sedimentation is the other adverse impact of soil erosion because it reduces the capacity of tanks. Water quality of village tanks is also affected badly due to sedimentation. Most of the village tanks in cascade systems have been sedimented 25 – 35% of their original capacity. The increased growth of aquatic plants also a common problem in silted village tanks. This may probably due to poor land management in tank catchment areas. Experiments show that about 40% of the soil productivity would be lost, if erosion caused removal of 5cm thick soil layer. Farmers pay a little attention on adopting soil conservation measures in dry zone agriculture. Thus, productivity of rain fed farming systems in tank cascade system has been remarkably reduced due to soil erosion. Therefore, minimizing soil erosion should be considered as the main priority in any rehabilitation program planning to implement in tank cascade system. Salt accumulation is another problem in agricultural lands in tank cascade system due to low amount of rainfall received annually. In many parts of the dry zone cascade system, salinity is a constraint limiting crop growth and yield depending on the severity of the problem. This problem is more significant in the areas where soils with poor drainage condition. Apart from that soil depth limitations, low soil water availability, hindrance to root penetration and low organic matter content can be considered as limiting factors for crop growth.

How to improve soil health in cascade system

Soil is the core component of the land resource. Therefore, the productivity of land is mainly determined by the quality parameters of soil. Healthy soils always improve land productivity and ultimate output of land resource. Sustainable land management practices include the holistic management of soil, water and the biodiversity. Introducing affordable techniques which can arrest land degradation with conservation agriculture can have a major impact. There are four principles can be adopted to manage soil in healthy manner to reduce land degradation.

1. Maximize soil cover

Protection of soil by using mulch is the first principle of maintaining soil health. Because you need to stop losing of soil, if you really need to protect it. Soil mulch act as a cushion or an airbag to protects soil from rain drops. It will keep raindrop bombs from exploding on the surface of bare soil. A significant protection from rain splash can be obtained if mulch is applied at recommended rate. Mulching also help to absorb more water into the soil and reduce surface runoff to control soil erosion and sedimentation. It also helps to reduce weed growth and to minimize weedicide application in upland farming.

2. Minimize soil disturbances

Minimizing soil disturbances as much as possible is vital in soil health management. Soil disturbances comes in all three varieties (i.e. physical, chemical and biological) should be minimized. Land preparation of rainfed farming is started with the onset of inter-monsoon rains. During this period soil is directly exposed to intensive rainfall that can increase soil erosion in alarming rate. Since four-wheel tractors are commonly used for land preparation, soil compaction can be occurred causing less water absorption into the soil. Intensive land preparation can have severe impact on soil such as deterioration of soil structure and crust formation on the surface.

Therefore, avoiding use of heavy machines and refraining from deep ploughing is advisable to minimize soil disturbances.

3. Maximize biodiversity

Crop rotation, introducing cover crops and livestock management enhances soil health because of adding diverse input material into soil. Ancient chena farming had mixed cropping system with great biodiversity. They cultivated crops like sesame, finger millet, pumpkin, mungbean etc. which requires minimum land preparation and less inputs. However, at present the mixed cropping has been changed to more market based monocropping system with minimum crop diversity. This is an unsustainable farming system that has many negative impacts on soil health. Introduction of hybrid varieties have led to increased use of machinery for intensive land preparation and more inputs such as fertilizer and agro-chemicals. However, soil has less capacity to retain plant nutrients due to poor quality. As a result, considerable amount of nutrients transport towards village tanks with surface runoff. This is the main reason for increased growth of aquatic plants in most of the tanks in cascade system.

4. Maximize living roots

Plant roots can play important role in improving soil health. It reduces soil compaction and minimize soil erosion. Roots of higher plants provide a vast amount of carbon to the soil which supply a great food source to soil microbes. Higher the microbial population higher the soil functions such as nutrient cycling, soil aggregation and disease suppression. The most reliable approach to maximize living roots is to introduce a cover crop after the cash crop has been harvested.

Cost effective and affordable techniques to improve soil health

1. Crop selection based on soil characteristics

Farming is the predominant livelihood pattern in majority of the people living in cascade system in dry zone Sri Lanka. Therefore, land and soil management is directly linked with their farming activities. Selection of most suitable crop for particular land based on its soil characteristics is very effective in terms of healthy land management.

Groundnut prefers well drained loose friable sandy loam soils rich with calcium. However, crop will not tolerate water-logging condition.

Soybean grow well in sandy clay loam soils. This crop is adapted to hardy conditions thus can tolerate moisture stresses as well.

Cowpea can be grown in variety of soil conditions. It tolerates well even in acid soils. It performs well in well drained soils.

Sesame can be grown in even less fertile soils with limited soil moisture condition.

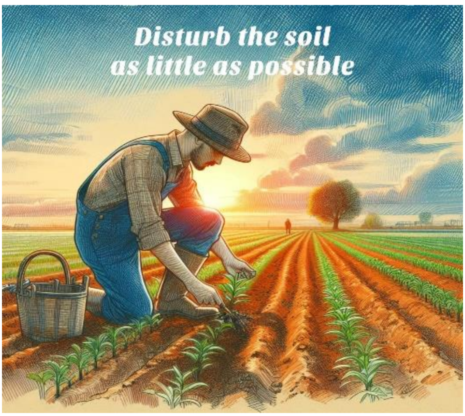
Chilies grow well in light loamy soils. However, it is highly susceptible for water logging conditions. Therefore, it is very important to select a land with well drained soils for chilli cultivation.

Onions can be grown in variety of soil conditions with good soil moisture condition. However, soil should be friable and fertile but without excessive amount of nitrogen which slows down bulb formation.

Finger millet cannot tolerate water logging conditions hence need lands well drained soils.

Maize has an ability to grow wide range of soil conditions but prefer well drained soils. It performs well in deep loamy soils with adequate organic matter content. Maize need a good supply of nitrogen to provide a better yield.

2. Land preparation



We have to do land preparation to provide weed free better environment to plant growth. But excessive tillage is not suitable. Deep ploughing using four-wheel tractors in every season is not advisable. Land preparation should be done along contours at right angel to natural slope of the land.

3. Irrigation

Distribution of tank water towards agricultural lands in the cascade system is mainly done by force of gravity through inter connected canal network. Majority of the farmers use surface irrigation methods which have less than 40% of system efficiency. The uncontrolled water flow in surface irrigation causes a lot of damage to soil structure while increasing soil erosion. However, micro irrigation methods are now becoming popular among resourceful farmers. Hence, low-cost micro irrigation techniques have to be introduced to increase water use efficiency in tank cascade systems.

4. Nutrient management

Reddish Brown Earth is the largest soil occurs in upper and middle aspects of the undulated landscape. This soil is traditionally used for cultivation of other field crops under shifting nature. Therefore, in most of the areas soil has been degraded fully or partially because of inappropriate management. Hence, green manure application is an important aspect to improve soil health. A crop like sun hemp is more suitable as an *insitu* green manure crop / cover crop because it needs less inputs but more beneficial in terms of soil health. Sun hemp is a legume that produces both soil carbon and nitrogen. Since it has well developed taproot system can service even in adverse conditions. However, it has to be introduced soon after harvesting to utilize existing soil moisture efficiently.

5. Soil conservation

Even though land slope is less than 10% in most of the areas in dry zone tank cascade system, suitable soil conservation measures should be adopted. Soil mulching is a significant low-cost soil conservation technique. Land preparation along contours but avoiding up and down ploughing is another cost-effective method of soil conservation during land preparation stage. Contour bunding is low cost but effective conservation measure specially for lands with less slope. These three methods are cost effective techniques for soil conservation and improve soil health in farm lands owned by farmers with less resources in tank cascade system.

Chapter 05

Management of Tank Watersheds and Waters

K.G.S. Nirmanee

Our village tank cascade systems in Sri Lanka have been vital for our farming communities for generations. They provide us with the water we need for our crops and our families. But as times change and more people need water, we need to make sure our tank systems stay healthy and strong. Therefore, we'll learn some easy ways to take care of our tanks and keep them working well for us and future generations.

Understand your water and land

First, let's look at the water and land around us. We need to know how much rain we get, where the water flows, and how it affects our farms. Also, we should understand how our tanks help plants and animals stay healthy.

In watershed management, we're talking about looking after the land and water in a big area where all the rainwater flows. This area is called a watershed, and it's like a big bowl that collects rainwater and sends it to our village tanks. It's important manage this area because the water from these areas ends up in our village tanks. So, we need to make sure the land stays healthy so that our tanks can get enough water. To do this, we need to protect the land from things like soil erosion and keep it covered with plants and trees. This helps to keep the water clean and flowing into our tanks smoothly.

Our tanks are connected in a series, like a chain, where water flows from one tank to another. This helps us store and use water for farming and other needs. We need to make sure that water is shared fairly among everyone who needs it, like farmers and families. By working together and planning carefully, we can make sure our village tanks keep providing water for us and our crops, while also keeping our land healthy for a long time.

Challenges

Village tank cascade systems face several challenges that threaten their sustainability and functionality:

Water scarcity: Increasing water demand due to population growth, urbanization, and agricultural expansion has led to water scarcity in many areas, putting pressure on village tank systems to meet competing needs.

Pollution: Pollution from agricultural runoff, industrial discharge, and improper waste disposal contaminates water sources, affecting water quality in village tanks and posing health risks to communities.

Sedimentation and siltation: Accumulation of sediment and silt in village tanks reduces their storage capacity, decreases water quality, and impedes water flow, leading to reduced effectiveness and increased maintenance requirements.

Encroachment and land use changes: Encroachment of agricultural land, urban expansion, and deforestation in watershed areas disrupt natural water flow patterns, exacerbating sedimentation and altering ecosystem dynamics, affecting the health of village tank systems.

Infrastructure degradation: Aging infrastructure, inadequate maintenance, and lack of investment in repair and rehabilitation lead to structural deterioration of village tanks, compromising their integrity and functionality.

Let's learn some ways to take care of our water and watershed area

Water scarcity is a greater challenge that we are facing now a days with the higher water usage and climate change. Sometimes, we might be using too much water or not taking care of our tanks properly. Therefore, we need to understand how we're using our tanks now to figure out how to make them work better for us. Some people might use more water than we need, which can make our tanks run low or even dry up. This can happen if we don't use water wisely or if there isn't enough rain.

Simple ways to save water

Saving water is very important for making sure our village tank cascade systems keep working well. Here are some simple ways to save water:

Fix leakages: Regular inspections of tanks, pipes, and channels are vital. Leaks, even small ones, can lead to significant water loss over time. Simple materials like clay or cement can be used to patch leaks quickly, preventing water from being wasted.

Use water wisely: Understanding the exact water needs of your crops and animals can help avoid over-watering. Techniques like soil moisture testing can be used to ensure you're providing just the right amount of water. This avoids runoff and ensures water is used efficiently.

Efficient irrigation systems (Micro irrigation): Use micro irrigation to water your crops. These methods give water directly to the root zone area, using less water and reducing waste.

Water at the right time: Watering crops early in the morning or late in the evening helps reduce evaporation. During these cooler times of the day, more water reaches the plants, making irrigation more efficient. Avoid watering during the heat of the day to minimize water loss.

Cover your soil: Using mulch like straw, leaves, or grass clippings to cover soil helps retain moisture and reduce evaporation. Mulch also keeps the soil cooler and can prevent weed growth. Cover crops like legumes can further protect the soil and add nutrients.

Collect rainwater: Setting up rainwater harvesting systems allows you to collect and store rainwater from rooftops and other surfaces. This stored water can be used during dry periods, reducing the need to draw from the tanks. Simple tools like barrels and gutters can be used to collect and direct rainwater effectively.

Plant water-efficient crops: Choosing crops that are suited to the local climate and require less water can reduce overall water demand. Drought-resistant crops can thrive with minimal water, ensuring sustainable farming. Crop rotation also improves soil health and water retention.

Maintain tank structures: Regular maintenance of tanks, channels, and pathways ensures smooth water flow and maximizes storage capacity. Cleaning out silt, debris, and weeds prevents blockages. Strengthening tank walls and channels helps prevent seepage and leakage, maintaining the integrity of the system.

Educate and involve everyone: Sharing knowledge about water-saving techniques with family members and neighbors is crucial. Organize community meetings to discuss water conservation and the importance of maintaining tank systems. Encourage everyone to monitor their water use and contribute to communal maintenance efforts. This collective effort ensures that everyone understands the importance of saving water and works together to protect and sustain the tank cascade systems.

Responsible water use: Adopting responsible water use practices is crucial for conserving water resources and ensuring the sustainability of village tank systems. Farmers can implement water-efficient irrigation techniques, to minimize water wastage and optimize crop water use. Additionally, households can practice water-saving habits, such as fixing leaky taps, using water-efficient appliances, and collecting rainwater for non-potable uses.

By implementing these detailed practices, we can ensure that our village tank cascade systems remain robust and sustainable, providing water for our crops, livestock, and daily needs for years to come.

Talk and work together / working together for change

It's important to talk to each other and make decisions together about our tanks. We all know different things, so let's share what we know and find the best solutions together.

We can't save our tank systems alone. By working together as a community, we can make a bigger impact. Let's talk to our neighbors and share ideas about how to take care of our tank systems. We can also work with local authorities and organizations to get support and resources for our efforts.

Since our tanks are linked together in a chain, like a row of buckets. Water flows from one tank to another, helping us store and use water for farming and other needs. When we work together, we can decide how to use the water from our tanks fairly. By sharing ideas and making plans together, we can make sure our tanks keep providing water for us and our crops, while also keeping our land healthy for a long time. So, let's talk and work together to take care of our village tanks and the land around them!

Changing our activities for the better system

Sometimes, we need to change the way we do things to protect our tank systems. For example, we can avoid using excess chemicals and pesticides that can pollute our water opting for organic farming practices instead. Proper waste disposal and recycling efforts can prevent contaminants from entering water sources and polluting village tanks. Community clean-up initiatives can also help remove trash and debris from waterways and tank areas, improving water quality and ecosystem health.

By making small changes in our daily activities, we can make a big difference for our tank systems.

Sustainable land use: Adopting sustainable land use practices helps minimize soil erosion and sedimentation in village tank systems. Farmers can implement soil conservation measures, such as contour plowing, terracing, and cover cropping, to reduce soil erosion and sediment runoff into water bodies. Protecting natural vegetation and establishing riparian buffer zones along waterways help stabilize soil, prevent erosion, and maintain water quality in village tanks.

Reforestation and afforestation: Reforestation and afforestation efforts contribute to watershed protection and restoration, enhancing the resilience of village tank systems. Planting trees and restoring degraded forest areas help stabilize soil, reduce runoff, and replenish groundwater resources, benefiting water quality and quantity in village tanks. Community-led tree planting initiatives can engage local communities in environmental conservation efforts and promote the sustainable management of natural resources.

Integrated farming systems: Implementing integrated farming systems that combine crop cultivation with livestock rearing and agroforestry practices can promote ecological balance and resource efficiency. Intercropping, crop rotation, and mixed farming systems help improve soil fertility, reduce pest pressure, and optimize water use in agriculture. By diversifying farm activities and minimizing reliance on external inputs, farmers can enhance the sustainability and resilience of village tank systems.

Environmental education and awareness: Promoting environmental education and awareness among farmers and community members fosters a culture of environmental stewardship and sustainability. Training programs, workshops, and awareness campaigns can provide information on sustainable agricultural practices, water conservation techniques, and ecosystem management strategies. By empowering individuals with knowledge and skills, we can cultivate a collective commitment to protecting and preserving our village tank systems for future generations.

By changing our activities for the better and adopting sustainable practices, we can ensure the long-term health and resilience of our village tank cascade systems in Sri Lanka. Together, we can protect our water resources, support livelihoods, and safeguard the environment for the well-being of all.

New Ideas to Save Water in Our Tank Cascade Systems

Alternately Wetting and Drying (AWD)

AWD is a water-saving technique for growing paddy. It helps use water more efficiently while maintaining good crop yields. Here's how it works and why it's beneficial:

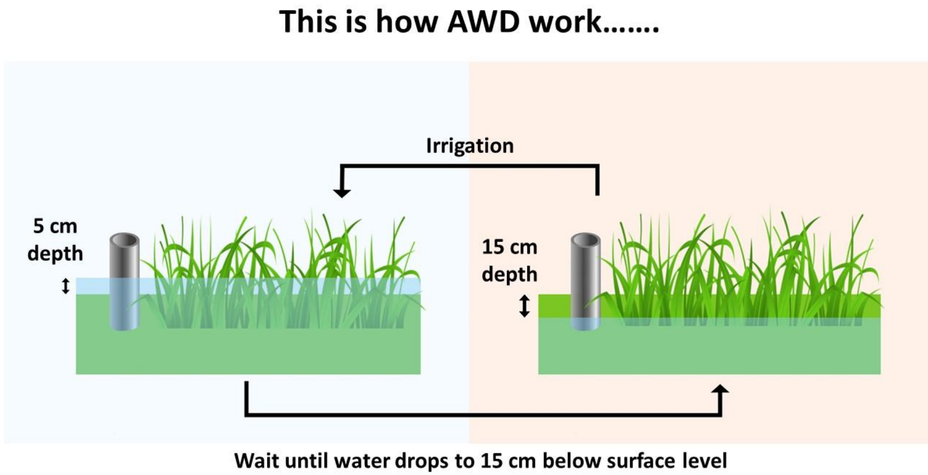
How AWD Works

Instead of keeping the paddy field continuously flooded, you allow the field to dry out for a few days before flooding it again. After the rice plants have been established (about 15 days after transplanting), let the water level drop until it's about 15 cm below the soil surface. This can be checked using a simple field water tube or a small pipe inserted into the ground. Once the water level reaches the 15 cm mark, re-flood the field to a depth of about 5 cm above the soil. Repeat this wetting and drying cycle throughout the growing season, except during flowering when the field should be kept flooded.

Benefits of AWD:

- Saves water
- Reduces methane emissions
- Healthy plants
- Less labor and cost

By using AWD, we can grow rice efficiently while saving water and protecting the environment. This simple method can help ensure we have enough water for our crops now and in the future.



System of Rice Intensification (SRI)

A method that involves planting fewer seedlings, spacing them further apart, and keeping the soil moist but not continuously flooded.

Steps:

- Plant young, single seedlings spaced widely apart.
- Keep the soil moist rather than flooded.
- Use organic fertilizers and practice intermittent irrigation.

Benefits: Uses up to 50% less water, increases yields, and reduces the need for chemical fertilizers.

Aerobic rice cultivation

Aerobic rice cultivation involves growing rice plants under non-flooded conditions, similar to how other cereals like wheat or maize are grown. This method conserves water by maintaining soil moisture without submerging the entire field.

Using micro irrigation systems

Micro irrigation is a great way to save water in our village tank cascade systems. This method delivers water directly to the roots of plants, which reduces water waste and helps our crops grow better. Here's how micro irrigation works and why it's beneficial:

- Drip Irrigation: Water drips slowly to the base of each plant through small tubes and emitters.
- Sprinkler Irrigation: Water is sprayed over the plants like gentle rain through small sprinkler heads.

How to Set Up Micro Irrigation:

- Install tubes: Lay out small plastic tubes or pipes around your fields to bring water to the plants.
- Use emitters or sprinklers: Attach emitters (for drip irrigation) or sprinklers to the tubes to deliver water directly to the plants.
- Connect to water source: Connect the tubes to your tank or water source. You can use gravity or a small pump to move the water through the system.
- Regular checks: Check the system regularly to ensure it's working properly and not clogged.

Tips for Using Micro Irrigation:

- Start small: Begin with a small area to see how it works and get comfortable with the system.
- Water timing: Water your plants early in the morning or late in the evening to reduce evaporation.
- Maintain the system: Clean the emitters and tubes regularly to prevent blockages and ensure smooth water flow.

Using micro irrigation systems helps us make the most of the water in our tank cascade systems. It's a simple and effective way to save water, grow healthy crops, and ensure we have enough water for everyone in the community.

Smart irrigation systems

Smart irrigation is an advanced and efficient way to manage water usage in our tank cascade systems. By using technology, we can ensure that crops receive the right amount of water at the right time, reducing waste and enhancing productivity.

Smart irrigation involves using technology to automate and optimize the watering of crops. This includes sensors, weather data, and automated systems that adjust watering schedules based on real-time conditions.

Key components of smart irrigation

- Soil Moisture Sensors: These sensors measure the moisture level in the soil and send data to a central system. They help determine when the soil needs water, preventing over-watering and under-watering.
- Weather Sensors: Local weather sensors collect data on temperature, humidity, rainfall, and wind speed. This information helps adjust irrigation schedules based on current weather conditions, ensuring efficient water use.
- Automated Irrigation Controllers: Controllers use data from sensors and weather stations to automate irrigation systems like drip or sprinkler systems. They ensure that crops are watered only when necessary, saving water and reducing labor.
- Mobile Apps and Remote Monitoring: Farmers can use mobile apps to monitor and control irrigation systems remotely. This allows for quick adjustments and real-time monitoring, even when farmers are not in the field.

Benefits of Smart Irrigation

- Water Conservation: Smart irrigation uses data to water crops precisely, reducing water wastage and ensuring every drop is used efficiently.
- Improved Crop Health: By providing the right amount of water at the right time, smart irrigation helps maintain optimal soil moisture levels, promoting healthy plant growth.
- Cost Savings: Reducing water usage lowers water costs. Additionally, less labor is needed to manage irrigation, saving time and money.
- Increased Yields: Efficient water use and improved crop health lead to higher yields and better-quality produce.
- Environmental Protection: Smart irrigation reduces runoff and soil erosion, protecting the environment and preserving soil health.

Implementing these water-saving methods can greatly enhance the efficiency and sustainability of tank cascade systems. By using technology and traditional practices, farmers can ensure that water resources are used wisely, supporting agricultural productivity and community livelihoods. Working together, we can protect our water resources and ensure their availability for future generations.

Chapter 06

Forest and Biodiversity Use Optimization

U.G.A.I. Sirisena and Nalaka Geekiyanage

Why do we need forests and their biodiversity in tank reservations?

Tank Cascade Systems combine natural and man-made ecosystems, giving us many benefits. Reservoir catchments collect rainwater, and forests act like sponges, soaking up the water and slowly releasing it to fill the tanks throughout the year. This slow release helps control water flow, reducing the risk of floods and dam bursts during heavy rains. Forests also filter sediments from runoff before they reach the tank, maintaining the reservoir's capacity and water quality.

Trees and soil in the catchment area clean pollutants and impurities, especially salts from *Kivul Ela* and upstream paddy fields, improving water quality. During dry periods, forests are less likely to catch fire compared to grassy areas, reducing the risk of wildfires and protecting people and natural habitats. Reservoir catchments provide homes for wildlife like elephants. Stream reservations and forest corridors help these animals migrate to feeding grounds, reducing human-wildlife conflicts.

These catchments offer recreational activities like hiking, fishing, boating, and wildlife viewing, which boost the social and economic well-being of nearby communities. As tourism in tank cascade systems grows, forests offer huge opportunities. Forests in tank reservations include wetlands and riparian zones, providing habitats for various plants and animals. Protecting these ecosystems is crucial for maintaining biodiversity and balance.

Many medicines are derived from natural compounds found in plants, animals, and microorganisms. Continued exploration of biodiversity could lead to the discovery of new drugs and treatments for diseases such as future pandemics. Traditional medicine is mostly depending on medicinal plants that thrive in these forest and other naturalized ecosystems. Biodiversity ensures a wide range of crops and livestock breeds, which is crucial for food security. Diverse genetic resources can help develop new varieties that are more resistant to pests, diseases, and climate change. Biodiverse ecosystems support pollinators such as bees, butterflies, and birds, which are essential for the reproduction of many food crops.

Living near forested catchments is beneficial because they regulate temperature, humidity, and rainfall through processes like evapotranspiration. Forests are central to our cultural and heritage values, making them vital for both the environment and our connection to the land.

What are the challenges and threats for the existence of forests and biodiversity?

Forests and biodiversity in tank cascade systems today face many threats and challenges. Deforestation is a major problem. People clear forests to grow crops, raise livestock, and burn forests for opening fresh grasses and hunting. Large scale human settlements that include expanding human settlements and other infrastructure also lead to forest loss. Poaching, especially of endangered species, makes the problem worse. Logging, whether legal or illegal, for timber, firewood and other products further reduces forest areas in tank cascade systems. Deforestation also affects other species such as pollinators, natural enemies of pests, and other higher animals associated with the plants. Some species of animals such as insects are highly species specific and without their host plants they cannot survive and may get lost forever. Climate change poses another significant threat. Rising temperatures change where species can live and put stress on plants and animals. More frequent and severe storms, droughts, and wildfires damage forests, trees and inhabitant animals. Prolonged dry and wet seasons disrupt the life cycles of plants and animals, making it hard for them to survive. Pollution harms forests and associated ecosystems in many ways. Excessive use of agrochemicals may pollute tank water and soil, harming the animals live in such places. Whereas trees may remediate pollution, some plants species will be harmed. Soil pollution from heavy metals and pesticides affects plant growth and soil health. The invasive species threaten forests by displacing native plants and animals and altering ecosystems. New diseases brought by these species can kill native plants and animals. With increase of population in tank cascades, however, many communities rely on forests for fuel, food, and income, leading to 'overuse'. High demand for forest products leads to further exploitation. Weak enforcement of environmental laws, corruption, and land ownership conflicts make it hard to protect forests. Lack of awareness and education about the importance of forests and biodiversity worsens these problems. Many people don't understand the vital role forests play, and there is often a lack of knowledge and skills needed for sustainable forest management.

How can we protect the forests and biodiversity in tank catchments?

In our country's dry zone landscape, there are large continuous areas of forests that form part of the tank cascade systems. These forests are crucial because they connect different tanks together. People cultivate rice and corn in these areas, which are favorite foods for both humans and wildlife. However, balancing the needs of humans and animals requires innovative ways of coexistence. In the past, when the population was lower, our ancestors understood the importance of conserving forests and biodiversity. They recognized the benefits forests bring to agriculture and human well-being. Unfortunately, the current generation doesn't fully appreciate the value of forests and biodiversity. Therefore, it's vital to engage and educate communities about conservation efforts. We can achieve this by organizing workshops, training sessions, and field days for local communities. These events teach sustainable land management practices and emphasize the importance of protecting tank catchments. Additionally, for the tech-savvy younger generation, mobile apps and online platforms can facilitate community engagement and active participation in conservation activities, as well as reporting illegal activities. To safeguard tank cascade systems, our legal and policy instruments must recognize the importance of these systems across a beyond administrative boundaries. Coordination among stakeholders is essential, facilitated by mechanisms such as cascade management committees. Protected areas, including tank catchments, should be established to safeguard critical habitats and species. Regulations need to be enforced to prevent illegal activities like logging, poaching, and land encroachment. Technology plays a significant role in monitoring and enforcing regulations. Interest groups can use satellite imagery and Geographic Information Systems (GIS) to monitor vegetation changes and enforce regulations effectively. External funding for restoration and conservation is crucial for preserving these ecosystems. Deforested and degraded areas can be restored with community participation, ensuring that suitable species are planted in appropriate places. Habitat restoration projects should prioritize areas such as riparian zones and wildlife corridors to enhance biodiversity and ecosystem resilience. Economic incentives distributed specifically for conservation efforts within reservoir catchments can help keep local communities engaged. Researchers and universities can assist by monitoring forest cover, habitat fragmentation, and biodiversity indicators. Together, these measures ensure the protection and sustainable management of forests and biodiversity in tank catchments.

Who should protect the forests and biodiversity?

Protecting forests and biodiversity involves many groups working together. Governments at different levels play a big part by making and enforcing rules to protect forests and wildlife. They also make sure that resources are used wisely and that areas where plants and animals live are looked after well. Local people who live near forests and in places like the tank cascade systems care a lot about keeping nature safe. They use their knowledge and ways of doing things to help take care of forests and wildlife. It's important for them to be involved in activities that help nature, like using land in a smart way and working together to manage resources. Non-Governmental Organizations (NGOs) and groups of farmers also help a lot by gathering resources, raising awareness, and doing projects to protect nature. They work closely with local communities and governments to solve environmental problems and encourage sustainable development. Private sector companies that depend on forests need to use resources wisely and do not harm the environment. They can help by using sustainable methods, getting certifications, and supporting projects that protect nature. Scientists and researchers study forests and wildlife to understand how they work. Their research helps us make good decisions about how to protect nature and manage natural areas. International organizations and agreements bring countries together to protect forests and wildlife worldwide. They give support and help to places facing environmental problems. Religious leaders and politicians also have a role to play in protecting nature. They can use their influence to raise awareness and support conservation efforts. People engaged in ecotourism help by promoting responsible travel and supporting local communities that depend on forests for their livelihoods. Everyone can help protect forests and biodiversity by doing simple things like using less, recycling, and reporting illegal activities that harm nature. Taking part in volunteer programs and community projects also makes a big difference. Together, we can make sure nature stays healthy for us and for the future.

What will happen if we do not protect the forests and biodiversity in tank catchments?

In the future, the failure to protect forests and biodiversity in tank cascade systems will undoubtedly result in significant and far-reaching consequences. Continued deforestation will lead to the loss of critical habitats for many plant and animal species. The clearing of forests for agriculture, settlements, and infrastructure will not only disrupt ecosystems but will also fragment habitats, severely reducing biodiversity. Poaching and logging will exacerbate these impacts, driving endangered species perilously close to extinction and depleting invaluable natural resources at alarming rates. The climate change will intensify these threats, fundamentally altering habitats and imposing additional stress on already vulnerable plants and animals. More frequent and severe weather events, such as storms, droughts, and wildfires, will ravage forests, hindering their ability to regenerate and causing irreversible damage. Shifts in temperature and precipitation patterns will disrupt the balance of ecosystems, making them inhospitable to many species, leading to extinction. Widespread contamination of water sources and soil due to the excessive use of agrochemicals and other pollutants will harm aquatic life and impede plant growth, exacerbating the crisis. Invasive species will continue their spread, displacing native plants, animals and their interrelationships. The introduction of new diseases by these invasive species will pose additional threats to the survival of native species. With the increasing human population in tank cascade systems, the pressure on forests for resources such as fuel, food, timber and income will only escalate. The overexploitation of forest resources will lead to the depletion of natural resources and further degrade ecosystems. The lack of enforcement of environmental laws, coupled with widespread corruption and land ownership conflicts, will hinder conservation efforts, allowing unsustainable practices to run uncontrolled. The reduced forest cover and its degradation mean the rainfall will erode exposed soils to channel systems and tanks reducing their storage capacity. Flash floods, dam bursts will be common phenomena. The soil fertility in agricultural fields will be eroded encouraging even more excessive use of fertilizers. The pervasive lack of awareness and education regarding the critical importance of forests and biodiversity will undoubtedly exacerbate these already dire circumstances. Countless individuals remain oblivious to the pivotal role that forests play in maintaining ecosystem balance and providing essential services such as clean air and water. Without the requisite knowledge and skills for sustainable forest management, communities will inevitably struggle to protect and manage their natural resources effectively. Healthy, nutritious, and diverse diets that once flourished healthy populations will continue to deprive of poor health. Overall, the unsustainable practices will disintegrate the ecological balance in among the different components of individual tanks and within tank cascade systems.

Chapter 07

Sustainable Livelihood Options and Potential Identification Techniques

A.I.Y. Lankapura

Introduction

The Cascaded Tank Village Systems (CTVS) of Sri Lanka, crucial in the dry and intermediate zones, serve as vital socio-ecological networks that intricately link agriculture, environment, and culture. These systems, defined by a series of small tanks and water management practices, support diverse ecological, agricultural, and socio-cultural subsystems. The stability of these systems is currently under threat, significantly influenced by shifts in livelihoods, which are fundamental to their ongoing health and functionality. This chapter will introduce the concept of sustainable livelihoods, the critical factors that underpin them, and provide practical methods for identifying viable livelihood options. The aim is to implement sustainable livelihood practices that secure the continuity of the CTVS, thereby maintaining their essential role in socio-ecological sustenance.

Key concepts

Sustainability in CTVS

Sustainability, broadly defined, is the practice of using natural resources in a manner that meets current needs without compromising the ability of future generations to meet their own. It includes the careful balance of economic, environmental, and social factors to ensure long-term stability and health of the planet and its diverse communities. In essence, sustainability is about thinking and acting with foresight, making decisions that are economically viable, environmentally sound, and socially responsible.

In the specific context of the Cascaded Tank Village System (CTVS) of Sri Lanka, sustainability translates into managing the small tank systems in ways that preserve their functionality and benefits over time. This involves mainly maintaining the ecological balance, ensuring agricultural productivity, and safeguarding cultural heritage. The aim is to integrate ecological conservation with agricultural/livelihood and socio-cultural activities, allowing for a symbiotic relationship where each subsystem supports the others sustainably. This approach is crucial because the viability of CTVS directly impacts the livelihoods and well-being of local communities, supporting both their economic stability and cultural traditions. Therefore, achieving sustainability in CTVS is essential for the health of the environment and the ongoing prosperity of the people who depend on it.

Understanding livelihoods

In simple terms, a livelihood comprises the means and activities involved in securing the necessities of life—food, water, shelter, and clothing. Specifically, within the context of the Cascaded Tank Village System (CTVS) in Sri Lanka, livelihoods typically include a variety of agricultural and non-agricultural activities. Residents engage in crop farming, such as paddy and other field crops, along with livestock rearing, including dairy and poultry. Inland fisheries and aquaculture also play significant roles, complemented by off-farm labor in both agricultural and non-agricultural sectors, as well as involvement in cottage industries like handicrafts, trading, and operating small to medium businesses. These diverse activities collectively form the economic backbone of the CTVS communities, reflecting their adaptation to the local environmental and socio-economic conditions.

Sustainable livelihood strategies, on the other hand, go beyond merely providing for basic needs. These strategies aim to do so in ways that are sustainable, meaning they do not compromise the ability of future generations to meet their own needs. In the CTVS context, this involves optimizing the use of natural resources in farming, promoting practices that maintain soil health, water quality, and biodiversity, and diversifying income sources to reduce vulnerability to economic or environmental shocks. Sustainable livelihood strategies also incorporate the protection of local ecosystems and cultural traditions, ensuring that development is not only inclusive but also respectful of cultural heritage and ecological balance. This holistic approach supports not only economic stability but also the social and environmental resilience of the community.

Desired outcomes of sustainable livelihood strategies

The aim of sustainable livelihood strategies is to foster outcomes that support both the current and future well-being of the community. These outcomes are centered around several key areas:

- Sustainable use of natural resources: This ensures that agricultural practices, whether it be crop farming, livestock rearing, or aquaculture, are conducted in a manner that maintains the health of the local ecosystem. Practices such as using organic farming methods help preserve soil fertility, water quality, and biodiversity.
- Income stability: By diversifying livelihood activities households can achieve a more stable and sustainable income. This diversification helps buffer against economic shocks, such as crop failures or market fluctuations.
- Enhanced well-being: Sustainable livelihood strategies contribute to overall well-being by providing not only financial stability but also by ensuring food security and health. For instance, this is achieved through access to nutritious food, clean water, and a healthy living environment.
- Reduced vulnerability: By strengthening the community's ability to manage and respond to socio-economic and environmental stresses and shocks, such as natural disasters, economic downturns, or health crises, sustainable livelihoods reduce vulnerability and increase resilience.
- Food security: Ensuring that all community members have reliable access to sufficient, safe, and nutritious food sources year-round. This involves not only increasing food production but also improving food storage, processing, and distribution systems to reduce loss and waste.

By aiming for these outcomes, sustainable livelihood strategies not only enhance the current quality of life but also secure the foundation for future generations within the CTVS. This holistic approach is essential for the continuity and resilience of the Cascaded Tank Village Systems and the diverse communities they support.

Building blocks of sustainable livelihoods

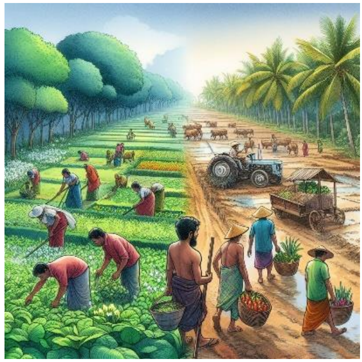
Livelihood assets

Livelihood assets, or capitals, are essential resources that communities utilize to sustain and enhance their livelihoods. These assets are fundamental to developing strategies that ensure sustainable livelihoods, capable of supporting both present and future generations. In the Cascaded Tank Village System (CTVS) of Sri Lanka, the main types of livelihood assets include Human, Social, Natural, Physical, Financial, and Information capital. Each of these assets plays a critical role in supporting the resilience and sustainability of livelihoods within the community, helping to adapt and succeed in the face of environmental, economic, and social changes.

a. Human capital

Human capital refers to the personal attributes that individuals bring to their livelihood activities, including educational attainments, knowledge, skills, attitudes, and health condition. In the context of the Cascaded Tank Village System (CTVS) of Sri Lanka, where agriculture plays a central role, human capital is crucial for achieving successful and sustainable outcomes. For instance, a farmer's education level can influence their ability to apply advanced agricultural techniques, while their health directly affects their capacity to work the land effectively. Skills in modern farming methods and knowledge of sustainable practices can greatly enhance productivity and sustainability, leading to better crop yields and less environmental degradation. Moreover, positive attitudes towards innovation and cooperation can foster community initiatives and collective action, which are vital for managing shared resources like water systems. In CTVS, where agriculture and community are tightly interlinked, the enhancement of human capital is essential. Identifying gaps in education, skills training, health services, and fostering a proactive attitude towards sustainable practices are critical steps. Addressing these gaps ensures that individuals are not only more productive but also contributors to a resilient agricultural system. Thus, investing in human capital is not just about enhancing individual capabilities but also about uplifting the entire community's potential for sustainable development.

b. Social capital



Social capital refers to the networks of relationships and associations that individuals can draw upon to achieve their livelihood goals. In the Cascaded Tank Village System (CTVS) of Sri Lanka, this involves memberships in various community groups, which may include both traditional, physical gatherings and modern, virtual assemblies through platforms like social media. These networks facilitate information sharing, cooperative efforts, and mutual support, essential for effective marketing, resource management, and crisis response in agricultural settings. For farmers in CTVS, strong social capital means better access to information about innovative farming techniques, more reliable markets for their produce, and a support system during adverse conditions such as natural disasters or economic downturns. Enhancing social capital by encouraging greater involvement in both physical and virtual community networks can significantly improve the resilience and sustainability of agricultural livelihoods. Identifying and strengthening weak links in these social networks is vital for promoting a community environment where sustainable agricultural practices thrive and contribute to improved livelihood outcomes.

c. Natural capital

Natural capital covers the environmental resources that are fundamental to livelihoods, particularly in agricultural settings like the Cascaded Tank Village System (CTVS) of Sri Lanka. Key components of natural capital include sufficient irrigation water, which the CTVS structures are specifically designed to ensure, along with fertile land, favorable weather conditions, and a stable environment conducive to farming. However, these systems often face challenges such as damage from wild animals, including elephants, monkeys, peacocks, and wild boars, which can significantly impact agricultural productivity. For farmers relying on the CTVS, the availability and quality of these natural resources directly influence their ability to sustain agricultural livelihoods. Sufficient water and fertile soil are critical for growing crops, while favorable weather conditions can determine the success or failure of a harvest. Conversely, the threats posed by wildlife not only risk crop damage but also pose a persistent challenge to maintaining this balance of natural capital. The inability to control or predict these aspects makes them particularly critical; losing them can severely disrupt agricultural activities.

Therefore, safeguarding and sustainably managing natural capital is essential for ensuring the ongoing viability and success of livelihoods within the CTVS.

d. Physical capital

Physical capital includes the tangible assets that support productive activities and enhance the efficiency and safety of livelihood operations, particularly in agriculture-based systems like the Cascaded Tank Village System (CTVS) of Sri Lanka. Key elements of physical capital include accessible input and output markets, well-maintained road systems for transport, robust irrigation systems that ensure water availability, modern amenities such as internet connections vital in this digital era, and protective measures like electric fences to safeguard crops from wild elephant attacks. The availability of farming machinery to increase agricultural productivity and proper storage facilities to preserve harvests and reduce losses also are critical capitals. For farmers within the CTVS, these physical assets are indispensable. Efficient road systems facilitate the smooth transport of goods to markets, enhancing economic opportunities. Reliable irrigation systems and farming machinery are vital for effective and efficient crop production. Internet connectivity opens up access to vital information on weather forecasts, new farming techniques, and market prices, which are essential for making informed decisions. Proper storage facilities ensure that produce is kept in optimal conditions, reducing waste and increasing profitability. The absence of these components can severely affect productivity and sustainability, highlighting the importance of investing in and maintaining these assets to support the livelihoods of local communities effectively.

e. Financial capital

Financial capital covers the economic resources that individuals and communities possess, which are crucial for initiating, maintaining, and expanding livelihood activities. In the context of agriculture-based livelihoods in the Cascaded Tank Village System (CTVS) of Sri Lanka, financial capital includes readily available money, savings, wealth in the form of productive assets, and access to both formal and informal credit facilities. For farmers and other community members within the CTVS, financial capital is essential for purchasing seeds, equipment, and other inputs necessary for agricultural production. It also provides a buffer against uncertainties and risks, such as crop failures or market fluctuations, allowing for recovery and adaptation without compromising long-term sustainability. Additionally, access to credit enables significant investments in improving productivity and adopting new technologies, which are critical for enhancing yields and entering new markets. The lack of financial capital can severely restrict these opportunities, making it harder for communities to advance and sustain their livelihoods. Therefore, strengthening financial capital is fundamental to achieving sustainable agricultural and economic growth in the CTVS regions.

f. Information capital

Information capital refers to the access and utilization of data and knowledge that enable individuals to make informed decisions crucial for their livelihoods. In agriculture, where decisions are often time-sensitive and impact the success of crop yields and market profits, having reliable and timely information is essential. For example, this includes real-time market price data, which helps farmers decide when and where to sell their produce for the best profit, as well as accurate and up-to-date climate and weather forecasts, which are vital for planning agricultural activities effectively. For farmers within the Cascaded Tank Village System (CTVS) of Sri Lanka, effective use of information capital can significantly enhance their agricultural operations. It allows them to optimize planting and harvesting times, use water and resources more efficiently, and reduce risks associated with weather variability and market fluctuations. The lack of such information can lead to suboptimal decision-making, resulting in lower productivity and economic losses. Therefore, enhancing access to information capital is critical for improving the resilience and sustainability of agricultural livelihoods in the CTVS, ensuring that farmers are well-equipped to respond to both opportunities and challenges in their environment.

Policies, processes, and institutions

Policies, processes, and institutions cover the frameworks and structures that govern interactions and decision-making within communities, influencing how resources are managed and how services are provided. These can be divided into structures such as government bodies, private sector entities, non-governmental and community-based organizations, and processes, which include the laws, policies, cultural norms, and institutional operations that guide and shape everyday activities. In the context of the Cascaded Tank Village System (CTVS) of Sri Lanka, these elements play a critical role in shaping sustainable livelihoods. Government policies control the usage of production inputs, land rights, and subsidy allocations, which directly affect agricultural productivity and sustainability. NGOs may provide critical support and advocacy for sustainable practices, while private sector partnerships can introduce innovative technologies and practices. Additionally, the cultural norms and local institutions influence how resources are shared and conserved, impacting the long-term viability of livelihood strategies. Effectively, the interaction of these policies, processes, and institutions can either facilitate or hinder the development of sustainable livelihoods, depending on how well they are aligned with the needs and realities of the local communities.

Vulnerability context

The vulnerability context refers to the external conditions and situations that affect people's ability to achieve sustainable livelihoods. It encompasses shocks, seasonalities, and critical trends that can suddenly or gradually impact livelihoods. Shocks might include natural disasters like floods or droughts, or economic events like market crashes. Seasonalities pertain to predictable changes over the year that affect agricultural outputs such as monsoon seasons or harvest periods. Critical trends might involve slower-moving changes, such as land degradation, population growth, and aspects like climate change. In the Cascaded Tank Village System (CTVS) of Sri Lanka, these vulnerability factors deeply influence the sustainability of livelihoods. Shocks can destroy infrastructure and deplete resources, seasonal changes can affect water availability and crop yields, and long-term trends may gradually undermine the natural resource base essential for farming. Understanding and managing this vulnerability context is crucial to developing livelihood strategies that are resilient enough to withstand and adapt to these challenges, thereby ensuring sustainable development and stability for local communities.

How to identify and develop sustainable livelihood strategies

Identifying and developing sustainable livelihood strategies within the Cascaded Tank Village System (CTVS) of Sri Lanka involves a systematic approach to understanding current practices and enhancing them for long-term sustainability. This process can be broken down into several key steps:

Step 01: Identify the existing livelihood strategies Start by cataloging the current livelihood strategies employed within the CTVS. This includes all agricultural and non-agricultural activities that community members engage in to support their livelihoods.

Step 02: Assess current strategy performance Evaluate how well these strategies are performing in terms of delivering sustainable livelihood outcomes such as income stability, enhanced well-being, reduced vulnerability, food security, and sustainable use of natural resources. This assessment helps determine the effectiveness of current strategies and identifies areas needing improvement.

Step 03: Maintain or improve sustainable outcomes

If existing livelihood strategies within the Cascaded Tank Village System (CTVS) are effectively delivering sustainable outcomes, the focus should shift to maintaining and enhancing these strategies. This step involves a comprehensive evaluation of the supporting livelihood assets; human, social, natural, physical, financial, and information capital to understand their role in current successes and identify key areas for improvement.

Integrating techniques such as "livelihood asset mapping" and "SWOT Analysis" can provide comprehensive insights and strategic direction in here. Here's how these techniques can be applied:

Integrating livelihood asset mapping: Livelihood asset mapping is essential for a detailed assessment of the current availability and condition of the various types of livelihood assets. This mapping will reveal not only the strengths and sufficiency of each asset but also highlight areas requiring strategic investment and improvement, ensuring all assets effectively support sustainable livelihood strategies.

Applying SWOT analysis: Conducting a SWOT Analysis for the existing livelihood strategies allows for a structured evaluation of their internal strengths and weaknesses, alongside external opportunities and threats. This analysis can be aligned with the insights gained from livelihood asset mapping to enhance its utility:

- Strengths: Identify which assets or strategies are currently working well and why. Understand the factors that make certain assets particularly effective.
- Weaknesses: Determine the limitations within current assets or strategies. Identify which assets are underperforming or are inadequately supporting the livelihood strategies.
- Opportunities: Look for external factors or upcoming trends that could be leveraged to improve or expand on current strategies, such as new market opportunities or supportive policies.
- Threats: Recognize external challenges or risks that might undermine the assets or strategies, including economic downturns, environmental changes, or policy shifts.

Using SWOT analysis in conjunction with livelihood asset mapping allows for a holistic view of how current strategies can be maintained or improved. Prioritizing enhancements in critical assets is essential. Additionally, a close examination of how current policies, processes, and institutions support these strategies will help in advocating for beneficial changes and preparing for potential policy shifts. Simultaneously, assessing the vulnerability context, such as potential environmental shocks or market changes, and developing contingency plans are crucial to ensure these livelihood strategies are resilient and adaptable to future challenges. This proactive approach not only secures current livelihood strategies but also strengthens the foundation for sustainable development within the community.

Step 04: Develop new strategies if needed

If the evaluation reveals that current livelihood strategies within the Cascaded Tank Village System (CTVS) do not effectively support sustainable outcomes, it becomes necessary to either enhance these strategies or develop new ones. This step starts with a thorough reassessment of the existing livelihood assets; human, social, natural, physical, financial, and information capital to pinpoint any shortcomings or gaps. Identifying which essential assets are lacking or insufficient is crucial for understanding the barriers to sustainability. The next phase involves detailed planning to improve these assets, determining which can be readily enhanced and which require more significant changes or investments. For instance, if a lack of advanced agricultural skills is identified, implementing training programs or workshops can increase human capital. Similarly, improving access to modern farming technologies or better financial services can strengthen physical and financial capital, respectively. Additionally, this step includes a careful analysis of how the existing and potential new strategies align with current policies, processes, and institutions, ensuring that these strategies are viable under the prevailing regulatory and support frameworks. It also necessitates developing plans to cope with potential shifts in these external conditions and the broader vulnerability context, such as climate change impacts or market volatility, which could influence the success of new strategies. Ultimately, if it is determined that the current resource endowment cannot support successful execution of existing strategies, transitioning to alternative livelihood strategies that are feasible with the available or minimally improved assets becomes essential. This strategic shift ensures that the livelihood strategies not only meet immediate needs but are also sustainable and resilient in the face of future challenges.

Regardless of the current performance of livelihood strategies, it is essential to stay proactive. Planning additional strategies or further developing existing ones can help secure sustainable outcomes against future uncertainties and changes. This proactive approach ensures that the livelihood strategies not only meet current needs but are also resilient enough to adapt to future challenges.

This framework provides a clear path for stakeholders in the CTVS to enhance their livelihood strategies, ensuring that they are sustainable, resilient, and capable of supporting the community's long-term goals.

Chapter 08

The Roles of Community, Traditions / Social Norms and Leadership in Cascade Tank Village System Governance

J.D.T.D. Jayakody & S.M.C.B. Karalliyadda

The Cascade Tank Village System (CTVS) of Sri Lanka stand as a unique example of a complex resource system bound by hydrological and social relationships. It holds a profound significance owing to its innovative technology, equitable distribution, and essential services they provide. CTVS has been a fundamental feature of civilization in Sri Lanka, serving to be the lifeblood of dry zone communities over millennia and still irrigating approximately 25% of the paddy lands in the country, while providing multiple ecosystem services.

Historically, local community groups have adeptly managed these shared resources, showcasing a profound integration of livelihoods and lifestyles. The CTVS emphasizes not only human and social capital but also the importance of natural capital, including animals, trees, and diverse ecosystems, ensuring equitable resource distribution within the community. For centuries, the CTVS has thrived on a foundation of self-control and self-discipline among its members, underscoring its resilience and sustainability.

Role of community

Collective action and community engagement

Community involvement is fundamental to the sustainable management of shared resources like the village tanks. These communities often exhibit simple lifestyles, with traditions and norms passed down through generations, fostering behaviors that support the system's governance and performance. In the past with limited resources and challenging circumstances, effective management of both the village tanks and their communities becomes paramount. Over centuries, these systems have evolved, and local communities have consistently managed village tanks and their associated ecosystems; hence, they have been recognized as “communally” managed systems.

Collective action and community engagement play a pivotal role in the sustainable governance of shared resource systems with interactions across multiple social and spatial scales Communities with strong social ties and a sense of shared responsibility develop more effective governance mechanisms. The intricate knowledge that local communities possess about their resources, customs, and needs is invaluable. Community engagement fosters a sense of ownership over development initiatives, ensuring that they are culturally appropriate and sustainable.

Active involvement in decision-making, maintenance, and system upkeep is essential for the long-term viability of these systems. Participatory decision-making processes, community consultations, and capacity-building initiatives empower local residents, enhancing the overall governance of the CTVS.

Identifying existing pathways where people naturally cooperate is essential to foster collective action across multiple social and spatial scales, ensuring the governance of CTVS in a contemporary context.

Social capital

Strong social capital within communities fosters cooperation in resource management, with collaborative efforts in maintaining tanks, distributing water, and resolving conflicts. Furthermore, for effective governance; active participation of all community members, including marginalized groups such as women and indigenous populations. Inclusive decision-making that incorporates diverse voices leads to more sustainable outcomes, enhancing the legitimacy and effectiveness of governance mechanisms. It acts as a guardian, protecting the natural capital within these systems. So, improving the social capital is crucial to enhance the performance in the system.

Knowledge exchange

In the Cascade Tank villages, elders and community leaders possess valuable insights into local ecosystems and traditional water harvesting techniques. This knowledge informs contemporary management practices and is crucial for the sustainable management of the CTVS. Educated community members, elders, formal leaders, and monks play significant roles in knowledge exchange. Participatory methods such as traditional events like *kiri itharawima* which involve grouping of the whole community to one place to celebrate the harvesting and to worship god for protection are effective for transferring this knowledge from one generation to another, ensuring continuity in effective governance. It is important to provide guidance and training to facilitate this knowledge exchange within the community.

Community organizations

Community organizations, such as farmer associations, women's groups, and youth societies, play a key role in knowledge exchange and participatory actions within these villages. These organizations effectively implement regulations and governance mechanisms. For instance, in the "*pal rakima*," system each member of the farmer group takes turns overseeing activities, with penalties for non-compliance. The "*dada potha*" system imposes taxes on those who do not adhere to regulations or cultivate beyond their allotted areas.

Traditions and social norms

Social norms, the unwritten rules guiding behavior, provide a framework for collective action, maintaining order and cohesion within the village system. Traditional practices, such as communal work parties and established water allocation mechanisms, for ensuring the equitable water distribution and system integrity. Traditional taboos and social sanctions have long been used to regulate access and usage of the tank systems. For instance, certain ceremonial rituals and practices are deeply embedded in the maintenance and management of the tanks. Furthermore, there are some traditional practices that are mostly unique to the CTVS are can be still found in some villages. Some examples are *mutti namima mangallaya*, *kiri ithirawima*, *nanumura mangallaya* that are still following in these villages. These practices engage the community and maintain governance through respect and adherence to traditions.

Cultural values underpin traditional resource management systems, guiding attitudes towards nature and community responsibilities. In Cascade Tank villages, cultural beliefs regarding water as a sacred resource and collective stewardship inform governance practices. Norms of reciprocity, based on mutual aid and cooperation, govern water-sharing arrangements and collective labor efforts, strengthening social cohesion and resilience to environmental challenges. Furthermore, rituals and supernatural beliefs further enhance community engagement and collective action, reducing the likelihood of conflict and promoting participatory efforts among community members.

Conflict resolution

Traditional societies often have established mechanisms for resolving conflicts within communities. In Cascade Tank villages, customary practices like community assemblies and mediation by village elders facilitate conflict resolution over water allocation and usage rights, preserving social harmony and cooperation. Social norms and traditions also play a crucial role in conflict management. Through traditional practices, community engagement helps manage conflicts effectively between parties.

The *Bethma* system, designed to ensure equal water distribution during hardships, is a prime example of social cohesion and cooperation. This system allocates upper paddy fields of head-enders to all cultivators proportionally during water scarcity, ensuring everyone can cultivate. The *vel vidane* divides the paddy fields to meet water needs while preserving wildlife, showcasing effective conflict resolution and social cohesion. The traditions and norms have helped to reduce potential conflicts among the community and the engagement of people continues to enhance this management.

Leadership

Facilitating cooperation and conflict resolution

Effective leadership is essential for fostering trust, facilitating communication, and promoting collective action within CTVS. Village leaders or elders play crucial roles in mediating disputes, enforcing rules, and mobilizing community participation in governance activities. Participatory forms of leadership, emphasizing inclusion and collective decision-making, are often more effective in achieving sustainable outcomes.

Formal and informal leadership

Formal leaders within the community, such as the *vel vidane*, monks, and traditional doctors (*wedamahaththaya*), play crucial roles in leading the community in various situations. Informal leaders, including educated individuals, women, and notable farmers, also contribute significantly by engaging the community and maintaining social cohesion Moreover, they involve in the exchange of knowledge and traditions and customs within these communities which lead to sustainable system governance.

In conclusion, the roles of community, traditions/social norms, and leadership are integral to the governance of the CTVS. These elements foster collective action, effective resource management, and conflict resolution, ensuring the sustainability and resilience of this unique system. Educating the community, raising awareness, and providing training are crucial for effective management. Additionally, fostering interactions between younger generations and village elders and leaders is vital for understanding and transferring knowledge about the system. A combination of traditional and modern knowledge is essential for the effective governance of the system.

Chapter 09

Legal and Institutional Framework and Mechanisms / Processes in CTVS Governance

N.M.K.C. Premarathne

Law and order for the Cascade Tank village Systems (CTVS)

The importance of law for the sustainable management of Cascaded Tank Village Systems (CTVS) is multifaceted, encompassing environmental, social, and economic dimensions. The existing law and governing systems are complex. Thus, requires proper awareness and ultimate efforts from various entities to ensure their effective use for achieving the sustainability in CTVS. In nutshell, law and order help to ensure the continued functionality and benefits of CTVS.

Why you should aware about the law and order related to CTVS

As practitioners, identifying key institutions and understanding their legal backgrounds is important to you to access them when decision making for the sustainable management CTVS. Because, this compliance ensures that all actions are within legal boundaries, promoting coordinated efforts, protecting resources, and sustaining CTVS for future generations.

Why law is important to you as a practitioner? These are a few reasons.

- As a professional practitioner of CTVS you should aware about the legal system related to TCS management, because always you are dealing with CTVS.
- Sometimes people in CTVS may do wrong things.

- The wrong things in CTVS are influenced or affected to the other people/things.
- To protect other people by doing correct things or ruling according to ethics, you should aware about the law.
- Most of people do not consider the law and order or lack of idea, which is common.
- The legal system does the important roll to control our self and overall CTVS.

The following benefits are highlighted as the merits of proper awareness on law and order.

Coordination and integration of efforts

Identifying key institutions involved in CTVS management ensures that there is a coordinated approach to managing the system. These institutions typically include government agencies, local authorities, community organizations, and non-governmental organizations (NGOs). Understanding their legal backgrounds helps in integrating their efforts towards common goals, avoiding overlaps, and ensuring that all aspects of CTVS management.

Clarity in roles and responsibilities

Clear identification of institutions and their legal mandates clarifies the roles and responsibilities of each entity. This reduces confusion, enhances accountability, and ensures that each institution knows its specific duties. For example, the department of irrigation might be responsible for water allocation, while the central environmental agency might oversee the protection of biodiversity and pollution control within the CTVS.

Legal enforcement and compliance

Knowing the legal backgrounds of the relevant institutions helps in understanding the enforcement mechanisms available. It allows stakeholders to ensure compliance with laws and regulations governing CTVS management. Legal frameworks provide the practitioners to enforce rules on resource management within the CTVS.

Access to resources and support

Institutions with legal mandates often have access to government resources and support. Identifying these institutions helps practitioners access funding, technical assistance, and other forms of support necessary for sustainable CTVS management. For example, department of agriculture can provide technical guidance for sustainable farming practices, while avoiding the malpractices.

Conflict resolution

Disputes on use and management of resources are common in CTVS. Identifying key institutions and understanding their legal backgrounds provides a framework for conflict resolution. Legal mandates often include provisions for mediation, arbitration, and other dispute resolution mechanisms, ensuring that conflicts are resolved fairly and efficiently. For instances, the practitioners should refer to the corresponding institutes and have a significant awareness about the limitations/ roles of each institute and themselves as the decision makers.

Contributing to ensure development and policy implementation

Institutions play a critical role in developing and implementing policies related to CTVS. Understanding their legal backgrounds and aims ensures that your activities are compatible with them. This helps in creating realistic, enforceable, and aligned activities in TCS which compatible to legal and regulations.

Community engagement and empowerment

Institutions with a legal mandate for CTVS management often have mechanisms for community engagement. Identifying these institutions and their legal frameworks helps in mobilizing community participation, ensuring that local knowledge and needs are incorporated into management practices. Legal provisions can empower communities to take an active role in managing and protecting their CTVS. For instance, Cascade Management Committee is such legally accepted body which represent all stakeholders.

Support for monitoring and evaluation

Effective monitoring and evaluation are critical for the sustainable management of CTVS. Institutions with legal mandates typically have the authority and resources to conduct regular monitoring and evaluation. Understand on this requirement facilitate, the practitioners to support/ conduct monitoring activities systematically and that data to be used for management practices.

What are the typical activities in TCS that requires law and legal oversight

As you know, ecosystem services provided by CTVS are multifaceted, benefiting various users in multiple ways. Fishing supports food security and local economies, while water bodies are vital for irrigation, industrial purposes, and tourism, though they are often threatened by pollution. Forests around CTVS provide materials and medicinal resources, yet they face overuse challenges, necessitating conservation efforts. Diverse plant and animal species offer livelihoods and income but are endangered by human-elephant conflicts (HEC) and habitat loss. Cultivations and land use require strict legal oversight to prevent illegal exploitation. Business operations range from small-scale local enterprises to large-scale commercial activities, each impacting CTVS differently. Community members derive income, living, happiness, and overall well-being from these systems. Administrations, including civil and government agents, play critical roles, adhering to cultural norms and hierarchical structures. NGOs contribute significantly to development and resource management, ensuring sustainable use of CTVS resources for the benefit of all stakeholders.

Since all these relationships are complex and interlinked, it is vital to protect the resources, avoid the degradation and all forms of malpractices. Disputes over resource use, whether between community members or different sectors, require clear legal mechanisms for resolution to maintain harmony and fairness. Developmental efforts must be guided by robust regulations to balance progress with environmental preservation. Law also addresses poverty and social issues by ensuring equitable resource distribution, enhancing livelihoods, and improving well-being. Challenges from users, such as overuse or non-compliance, are mitigated through stringent governance and enforcement. Natural issues like droughts and floods necessitate legal frameworks for disaster management and resilience building. Overall, effective law and governance are critical to managing CTVS sustainably, resolving conflicts, and meeting the expectations of all stakeholders, thereby ensuring the long-term viability and productivity of these essential systems.

Key institutions typically involved in CTVS

The executive, legislative, and judiciary branches play crucial roles in the sustainable management of CTVS. The executive branch, through various government departments and agencies, implements policies and regulations related to resources such as water management, agricultural practices, and environmental protection to ensure the proper functioning of CTVS. The legislative branch creates and enacts laws that establish frameworks for the conservation and equitable use of resources within these systems, reflecting the needs and rights of local communities. The judiciary ensures that these laws and regulations are interpreted and applied fairly, resolving disputes and upholding justice when conflicts arise over water use or environmental impact. Together, these branches provide a balanced and structured approach to managing CTVS, ensuring sustainability and long-term viability through coordinated governance and legal oversight.

Thus, it is important to identify the roles of key institutes, acts and regulations as practitioners. Therefore, this chapter provides details about such institutes and laws.

The acts such as Fauna and Flora act, Forestry act, Land reforms act, land development act, National environmental acts are the relevant acts to the management of the CTVS. These acts have given the authorities (e.g. departments such as forestry, wildlife), to decide the human activities and the procedures to follow when deal with particular resources. Thus, proper understanding on the provisions, limitations and prohibitions will be important to the practitioners.

Importantly, the penalty code, criminal procedure is given the power to punish in violations of laws, thus better to read them and get an awareness. Not only that, the human rights, such as fundamental rights and freedoms to all citizens, including the right to life, liberty, equality, and freedom of expression, association, and assembly are important to consider when performing your actions. For instance,

Right to life: The right to life is the most fundamental human right, and it is enshrined in Article 11 of the Sri Lankan Constitution. This right protects individuals from arbitrary deprivation of life by the state or other actors.

Right to liberty: The right to liberty is enshrined in Article 12 of the Sri Lankan Constitution. This right protects individuals from arbitrary arrest, detention, or imprisonment. It also guarantees the right to fair trial and due process of law.

Right to equality: The right to equality is enshrined in Article 12(1) of the Sri Lankan Constitution. This right prohibits discrimination on the basis of race, religion, caste, sex, language, or place of birth.

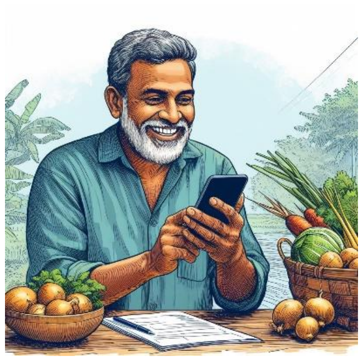
Freedom of expression: Freedom of expression is enshrined in Article 14(1)(a) of the Sri Lankan Constitution. This right protects individuals' freedom to express their opinions and beliefs, including through the press and other media.

Freedom of association: Freedom of association is enshrined in Article 14(1)(b) of the Sri Lankan Constitution. This right protects individuals' freedom to form and join associations, including political parties, trade unions, and NGOs.

Freedom of assembly: Freedom of assembly is enshrined in Article 14(1)(c) of the Sri Lankan Constitution. This right protects individuals' freedom to peacefully assemble and hold demonstrations.

Therefore, what you should do as the practitioners,

- Find the related act (e.g., download online, buy the printed copy from local administrative offices and sales outlets, follow the circulars issued to you, call and request from government agencies, district Secretary office, publication beuro)
- Read and identify the expected legitimate behaviour as per your role (e.g., as the officer, as the doer, as the victim)
- Act/plan / raise / solve / accuse / appeal/ prohibit / charge to the dispute as per the act



Example 1) in a violation, the Police is the major institution where you inform of violation of laws. The other institutions such as wildlife conservation department and forestry department, and Irrigation department may also play a vital role on regarding that complains but eventually they will call upon police investigations or refer to the court.

Example 2) If the violation comes under the subject of a government agency, that will be considered as a criminal offence. Thus, it needs to identify this before the action. If you are going to involve into a personal issue / dispute as the officer, care taker in social advisory you should refer to the civil procedure and instruct in that manner.

Importantly, you need to know to refer to the correct institute and acts. For instance, the Central Environmental Authority (CEA) of Sri Lanka is the primary government agency responsible for environmental protection in the country. It was established in 1981 under the National Environmental Act No. 47 of 1980. The CEA's mission is to "protect and conserve Sri Lanka's environment and natural resources for the benefit of present and future generations “. Thus, when you have disputes on developing and implementing national environmental policies and plans, regulating environmental pollution and waste management, monitoring environmental quality, you should refer to CEA. Similarly, you need to find the corresponding act or agency

Conclusion

Identifying the key institutions involved in CTVS management and understanding their legal backgrounds is essential for a coordinated, effective, and sustainable approach. It ensures clarity in roles, facilitates access to resources, enables legal enforcement, supports conflict resolution, and promotes community engagement. By leveraging the legal mandates and capabilities of these institutions, stakeholders can work together to ensure the long-term sustainability of CTVS.

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