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Tank cascade system: A nature-based solution for achieving climate resilience in Sri Lanka's dry zone

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The Tank Cascade System (TCS) is an ancient, man-made rainwater harvesting and irrigation system unique to Sri Lanka's dry zone. An ecosystem in itself, the TCS consists of an intricate network of small to large 'tanks' positioned along a gradient and connected through a series of canals. Within the system, paddy fields and dense forests coexist providing habitats for socio-ecologically significant species. Historically, the system has been crucial in drought and flood mitigation. Furthermore, fully functioning TCSs harvest copious amounts of rainwater, which is primarily used for irrigation to enable year-round crop production by the farming communities of the cascade landscape. The system's important role in food security, rural livelihoods and local culture led to its designation as a Globally Important Agricultural Heritage System in 2017. Despite the TCS's significance, the system has been deteriorating, and its sustainability is threatened by widespread tank neglect, rapid land use changes and biodiversity loss –the impacts of which are exacerbated by the effects of climate variability. There is national interest in safeguarding the TCS, though. The system has been recognized in Sri Lanka's 2016-2025 National Adaptation Plan for Climate Change Impacts and within the 2021 Nationally Determined Contributions as an important Nature-based Solution (NbS) for strengthening national climate resilience. However, there is little evidence of this national support translating into on the ground action and of effective solutions to the challenges threatening TCS sustainability. This case study aims to fill these evidence gaps by sharing findings from research and project activities carried out under the Healthy Landscapes project. With a special focus on mainstreaming biodiversity and strengthening cascade ecology, the project rehabilitated and promoted the sustainable management of the TCS. This case study will highlight pathways for TCS rehabilitation to strengthen its function as a NbS, including associated challenges and further opportunities. As the cascade landscape community plays an important role in climate adaptation and resilience within the country's dry zone, we also emphasize the importance of investigating their perceptions of current national policy and formulating localized adaptation strategies that benefit climate resilience, food security and rural livelihoods.

Keywords: Biodiversity, climate resilience, ecosystem rehabilitation, food security, nature-based solution, rural livelihoods, Sri Lanka

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Introduction

The Tank Cascade System (TCS) is an ancient, man-made rainwater harvesting and irrigation system predominately found across Sri Lanka's dry zone (Jayasena et al.,2011). Each system consists of an intricate network of small to large 'tanks', as well as a mosaic of other small-scale socio-ecological land use systems where human activities and nature interact, e.g., smallholder farming systems, natural forests and ecologically sensitive areas such as the *kattakaduwa*- a reserved area of land between a tank bund and a downstream paddy field that serves multiple functions, including the filtering of runoff to prevent pollutants from entering paddy fields (FAO, 2017; Ratnayake et al., 2022). The TCS provides provisioning, regulating, cultural and supporting ecosystem goods and services that have sustained generations of cascade landscape communities and local wildlife, e.g., water for irrigation, local climate regulation and a recreational space (Ratnayake et al., 2022). Due to its distinctive landscape, ecological features, and important role in local culture and rural livelihoods, the TCS was designated as a Globally Important Agricultural Heritage System by the FAO in 2017 (FAO GIAHS, 2017). The system has also been recognized in Sri Lanka's National Adaptation Plan for Climate Change Impacts (2016-2025) and Nationally Determined Contributions (NDCs) as an important Nature-based Solution (NbS) for strengthening national climate resilience (Ministry of Environment, 2021; Ministry of Mahaweli Development and Environment, 2016; UNEP Secretariat, 2023).
Despite the TCS's socio-ecological significance and substantial national support to safeguard it, TCSs have been deteriorating and their sustainability is threatened by widespread tank neglect, rapid land use changes and biodiversity loss –the impacts of which are exacerbated by the effects of climate variability (Kariyawasam et al., 2021; Ratnayake et al. 2023; Ratnayake et al., 2024a; Ratnayake et al., 2024b; Vidange et al., 2021). To address these challenges and more, the 'Managing Agricultural Landscapes in Socio-ecologically Sensitive Areas to Promote Food Security, Well-being and Ecosystem Health', or Healthy Landscapes project (HLP) in short, brought together multiple local, national and global-level partners to rehabilitate TCSs and ensure their sustainable management. The HLP utilized a landscape approach, enhancing the entire TCS or cascade landscape rather than focusing on a single land use system (considered the field level) or ecosystem service in isolation from the rest of the TCS.

Objective and Methodology

This case study was developed based on methods and activities carried out under the HLP, all of which prioritized the mainstreaming of biodiversity and the strengthening of cascade ecology, i.e., the interactive relationships between living organisms (flora and fauna), including humans, and their physical environment (soil, water and geo-morphology) within the tank cascade system boundary as well as its surrounding area of influence (Dharmasena, 2020). The HLP activities were designed to align with one or span across multiple of the four action areas: (1) Renovating TCSs- rehabilitating TCSs to meet changing human needs, while enhancing agrobiodiversity and minimizing pressure on the environment; (2) Raising Awareness- establishing the concept of 'cascade ecology' among the project's beneficiaries and stakeholders, as a basis to guide sustainable management of the TCS; (3) Building Partnerships- fostering collaboration and building capacity among and across all levels of stakeholders to support the sustainable management of the TCS and; (4) Strengthening Policy- engaging key partners to strengthen TCS sustainability through improved policy formulation and implementation. Overall, this case study highlights pathways for TCS rehabilitation that both strengthen its function as a NbS and ensure the sustainable management of the system.

Results

The HLP produced multiple results, benefiting biodiversity, food and nutrition security, rural livelihoods, and climate resilience in cascade landscapes (Mendonce et al., 2024). Table 1 highlights four project results and their associated landscape-level impacts.

Table 1. Selection of Healthy Landscapes project field-level results and their associated landscape-level impacts.

Field-level results	Landscape -level impacts
5 tanks were renovated	• The Thumbikulama tank is in the upper cascade of the Belankadawala TCS and is the third largest tank in the system. It is crucial for recharging tanks lower down the system and as a wildlife water hole. • Well water levels in surrounding villages were maintained during prolonged drought between 2023-2024 (HLP, 2024).
300 farmers were trained in sustainable land management (SLM) and are applying knowledge on 1,000 ha of agricultural lands	• Soil moisture conservation maintains upland (rainfed) farm productivity, despite seasonal droughts. • SLM practices minimize soil erosion, and subsequent tank siltation and sedimentation, maintaining tank storage capacity and ensuring proper functioning of the system (Ministry of Environment and HLP, 2024).
500 ha of forests and ecologically sensitive micro-land uses were restored, and community seed banks (CSBs) were established through government-community collaboration	• Restored vegetation in ecologically sensitive micro-land uses contributes to the ecological balance of the TCS, restoring wildlife habitats and improving water quality and safety (HLP, 2024). • CSBs help maintain well-adapted, traditional agrobiodiversity in the TCS, e.g., finger millet (*Eleusine coracana*) is drought tolerant, grows in degraded soils, and is resistant to common pests and diseases.
Identified key TCS ecosystem services prioritized by local community and farmers' views on climate change pressures	• Today, traditional TCS management is replaced by more centralized governance structures, but a large part of the success of TCS related policy implementation depends on local community involvement. • Identifying community priorities and perceptions helps formulate improved policies for TCS sustainability (Ratnayake et al. 2022; Ratnayake et al., 2024a).

Conclusions

The TCS has sustained local communities and landscape environs for centuries, however climate change and unsustainable land use practices threaten the productivity and sustainability of the cascade landscape. Restoring and sustainably managing TCSs ensures the provision of their ecosystem services for both current and future generations of cascade landscape communities, supporting climate resilience, food and nutrition security and rural livelihoods in the dry zone of Sri Lanka. For national- level policies aimed at safeguarding the TCS to be more effective at the cascade landscape- level, they must be localized, prioritizing the ecological restoration of the system and striking a balance between productivity and the sustainability of these landscapes. Further, localized strategies for climate adaptation, resilience and sustainable land management in cascade landscapes must ensure that local governance and communities living in TCS are meaningfully engaged and supported to provide input into the design and effective implementation of such strategies. In doing so, community ownership and stewardship is enhanced, ensuring the longevity and effectiveness of these strategies and broader TCS management.

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