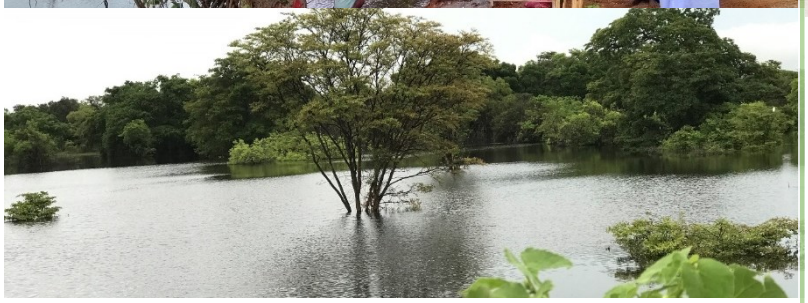
Consultancy Service for Undertaking Studies on Value Chain Development and Valuation of Ecosystem Services

FINAL REPORT

Assignment 01: Generation of case study of the process and assessment of cost-benefit of VTCS restoration: Case of ecological restoration of Thumbikulama Tank



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The UNEP-GEF project on Healthy Landscapes: Managing Agricultural Landscapes in Socio-Ecologically Sensitive Areas to Promote Food Security, Wellbeing and Ecosystem Health Project in Sri Lanka

Submitted by

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EXECUTIVE SUMMARY

This assignment was carried out as a part of component 01 of HLP to support achievement of output 1.2; physical and ecological components of selected VTCSs restored as pilot models. There are eight activities to be accomplished for the successful completion of output 1.2 This study completes activity 1.2.8; generation of case study of the process and assessment of cost-benefit of VTCS restoration. As the case study, we selected the ecological restoration and associated process of the Thumbikulama Tank.

During this study, we identified key ecosystem services offered by VTCS in four categories; provisional services, regulatory services, cultural services and support services. This was done through a literature review and participatory interactions with the community and other stakeholders. To evaluate the case study and the process and cost benefit of VTCS restoration, we chose a qualitative and quantitative approach. The assessment and valuation procedure were designed during the initial stage of this study, especially the design of discrete choice experiment used to estimate the economic value of ecosystem services. Discrete choice experiment is commonly used to estimate the economic value of environment goods and services. The sample size of the choice experiment was 1001 households in Bellankadawala VTCS. Values of direct costs and benefits were estimated based on their quantity and market price. Current status of the ecosystem services was assessed based on attributes and their levels used in the choice experiment and community's perceived responses. Finally, we conducted an extended benefit-cost analysis (EBCA) of the ecological restoration of a VTCS using the example of the restoration of the Thumbikulama tank. The results of the assessment of the current status of ecological services in VTCSs formed the basis for the selection of different scenarios for EBCA.

We identified five key ecosystem services under each category of ecosystem service based and used throughout the entire assessment. It was found except supply of irrigation water, rest of the provisional services were supplied with a moderately sufficient capacity. The community most valued provision of water for cultivation among the other provisional services. They were willing to forgo LKR 61,290.56 per household annually if irrigation water supply is maintained uninterrupted during both Maha and Yala seasons. The cascade community were willing to pay for restoration of regulatory services up to their maximum levels. They highly valued regulation of human elephant conflict naturally by VTCSs. They are willing to pay the highest value for it among the other regulatory services. They didn't value support services much and were in favor of other offerings of ecosystem services by VTCS. However, they valued cultural services over the status quo. The community is willing to pay more for restoration of social cohesion, aesthetic value and amenity as cultural services. They are ready to forgo a maximum of KLR 85,126.10 for higher levels of social cohesion, humanity and corporation restored.

The EBCA revealed that even though the downstream is not yet developed, the benefit of Thumbikulama Tank restoration is substantially greater than its investment and the maintenance cost. It would be further high if actions are taken to develop the downstream of the tank which will further provide sufficient livelihoods to the community. Ecological benefits of Thumbikulama tank restoration are currently immerging and visible. Some of the examples are sufficient control of human elephant conflict in the area, immediate provision of habitants to many animals, recharge of water table and tanks in the dawn stream, increasing honey bee population and more wild bee honey production. Consequently, we recommend to take immediate actions and policy decisions

to expedite ecological restoration of VTCS. Further, authorities' attention is drawn to take immediate actions to develop downstream of Thumbikulama tank and complete the restoration process.

BACKGROUND OF THE CONSULTANCY

1. Healthy Landscapes: Managing Agricultural Landscapes in Socio-ecologically Sensitive Areas to Promote Food Security, Well-being and Ecosystem Health Project (HLP) is executed by UN Environment as the GEF agency which is worth 2.00 US$ Mn as direct funds and 9.05 US$ and co-financing. The executing partners are respectively, the Ministry of Mahaweli Development and Environment, Mahaweli Authority of Sri Lanka, Ministry of Agriculture, Department of Agriculture, and Bioversity International. HLP is currently being implemented through the South Asia Corporative Environment Program (SACEP) under the direct supervision of the Ministry of Environment, SRI LANKA as the GEF focal point.

2. The project development objective (PDO) of HLP is Mainstreaming biodiversity using an integrated sustainable land management approach to ensure, development, health and environmental co-benefits that are achieved by implementing it via four components which the details are summarized in Table 01.

Table 01. Four components of HLP together with their original outcomes and outputs

Component	Outcome	Output
1. Implementation of biodiversity-based options that improve sustainable landscape management in socio-ecological sensitive areas	1. Sustainable landscape management approaches in support of improved ecosystem services and ecohealth outcomes adopted in prominent socio-ecological sensitive areas of Village Tank Cascade Systems (VTCS)	1.1. Socio-ecological and biophysical system properties mapped and defined in 2 project landscapes
		1.2. Physical and ecological components of selected VTCSs restored as pilot models
		1.3. Biodiversity-based agroecological and sustainable land management practices implemented in the two selected VTCS pilot schemes
		1.4. Goods, services and functions of VTCS identified and mainstreamed
2. Strengthened institutions, policies and integrated landscape planning of village tank cascade systems (VTCS) in socio-ecological sensitive areas	2. Improved enabling environment for sustainable integrated landscape planning, management and monitoring of ecohealth outcomes	2.1. Awareness raising and capacity building of key partner institutions, local organizations and communities in participatory integrated landscape management planning of VTCS for improved ecohealth outcomes
		2.2. Relevant national policies and legislation for enabling environment for the sustainable integrated landscape management reviewed and revisions recommended to the Government
		2.3. Participatory sustainable integrated landscape management planning platforms developed at district and local level
3. Partnerships, awareness raising and capacity building for better sustainable integrated landscape management in support of improved ecosystem services and ecohealth outcomes	3. Improved evidence base, capacity and awareness on biodiversity-agriculture-ecohealth linkages in cascade landscapes	3.1. Concept of Cascade Ecology established through workshops, symposia and other knowledge products
		3.2. Knowledge mainstreamed to national extension, research institutions, including universities, and policy makers on cascade ecology and landscape management, ecosystem services and ecohealth approaches

4. Knowledge, information management and monitoring and evaluation	4. Project implementation based on results based management and application of project lessons learned in future operations facilitated	4.1. Gender sensitive project monitoring system operating and providing systematic information on progress in reaching expected outcomes and targets
		4.2. Project-related best practices, knowledge products and lessons learned systematized and published for a variety of audiences and stakeholder groups

3. The total life cycle of HLP was originally 36 months. The actual start date and the ending dates of the project were respectively, 1st April 2019 and 31st March 2023. The MTR of HLP commenced during the last quarter of 2022 where necessary recommendations were made based on the progress of project implementation and the limitations faced by the project amidst the Global COVID-19 pandemic and local economic crises. Consequently, some necessary changes to the project design were made at its output and activity levels with a no cost extension (NCE) up to 31st March 2024.
4. Based on the TOR, this assignment is confined to component 1 of the project giving attention to output 1.3 and output 1.5 which were later relabeled as output 1.2 and output 1.4 after amalgamating output 1.2 (Table a) with output 3.1 (Table a). The consultant is responsible for working on activities 1.2.8 and 1.4.2 supporting outputs 1.2 and 1.4 which are illustrated in Table 02.

Table 02. Activities under output 1.2 and 1.4 with the amendments proposed by the MTR

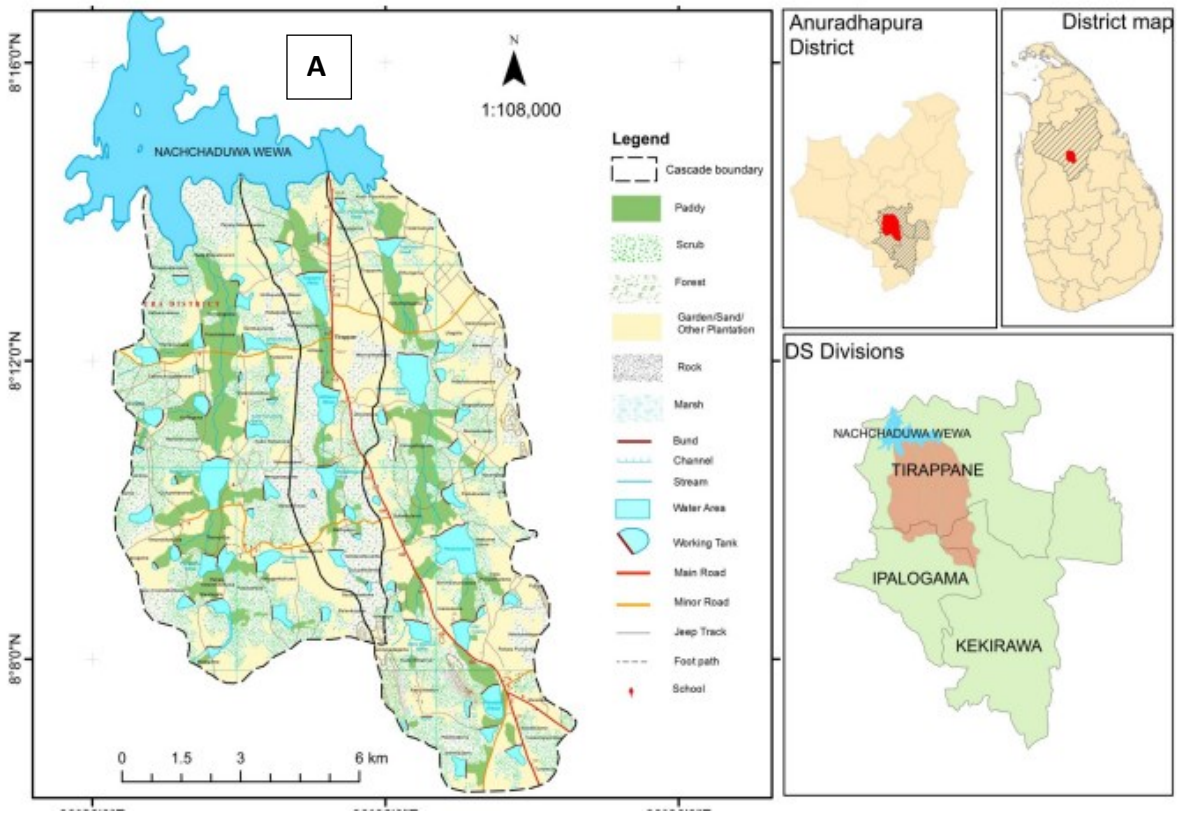
Component 1 – Implementation of biodiversity-based options that improve sustainable landscape management in socio-ecological sensitive areas	
Outcome 1 – Sustainable landscape management approaches in support of improved ecosystem services and ecohealth outcomes adopted in prominent socio-ecological sensitive areas of Village Tank Cascade Systems (VTCS)	
Output	**Activity**
Output 1.2 - Physical and ecological components of selected VTCSs restored as pilot models	**Activity 1.2.1** Participatory planning of rehabilitation and restoration of VTCSs
	Activity 1.2.2 Repair and renovation of tank headworks, bunds, spills and carryout tank boundary surveys, tank bed surveys, sedimentation surveys and do partial de-silting of tanks
	Activity 1.2.3 Development of downstream water management system
	Activity 1.2.4 Promote conservation practices in immediate upstream landscapes
	Activity 1.2.5 Collection of tree and other planting materials and establishment of community nurseries
	Activity 1.2.6 Restoration of godawala, kiul-ela, iswetiya and yathuru wala and establishment of medicinal and underutilized plants
	Activity 1.2.7 Tree planting program through *shramadana* campaigns in *kattakaduwa, kiul-ela, godawala, gasgommana*, homegardens and herbal gardens and spice crop gardens
	Activity 1.2.8 Generation of case study of the process and assessment of cost-benefit of VTCS restoration
Output 1.4 Goods, services and functions of VTCS ecosystems identified and mainstreamed	**Activity 1.4.1** Promote ecotourism linked to conservation and sustainable use in VTCS including cultural values e.g., visiting and lodging facilities, safety equipment, promoting and enhancing fruit and vegetable diversity within home gardens in targeted eco-

	and agrotourism development villages at Hiriwadunna and Manewa Kanda ecotourism sites
	Activity 1.4.2 Establish market centers for local products (at least 01 Helabojun or one stop shop center) and value chains for prioritized agricultural food and medicinal products in VTCS

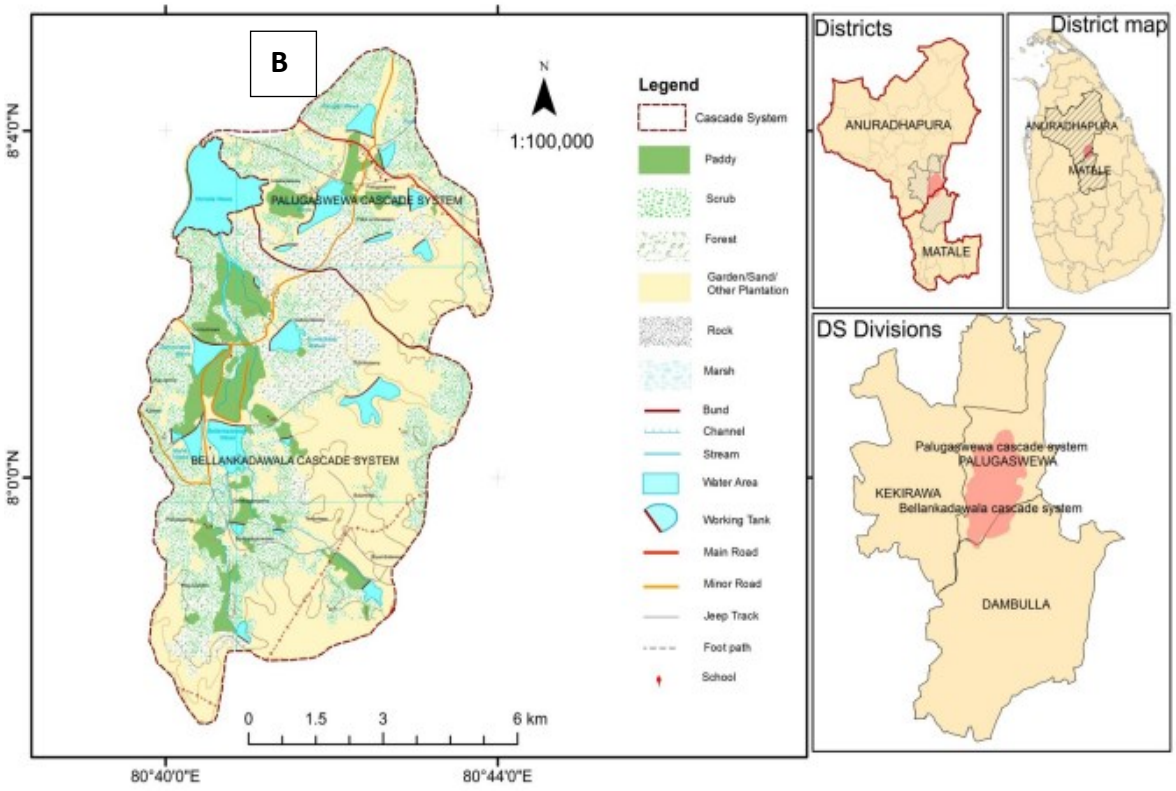
5. The project is operating in two project sites, Nachchaduwa site and Horivial site where there are 109 tanks distributed in five divisional secretariate divisions (DSD), which further details are given in Table 03 and Figure 01.

Table 03. Number of tanks, extents and coverage of two pilot project sites; Nachchaduwa site and Horivila site

Major Reservoir	Tank cascade system	DS Divisions	No. of tanks	Extent (ha)
Nachchaduwa	Mahakanumulla	Ipalogama, Thirappane	29	4717
	Thirappane	Thirappane, Ipalogama, Kekirawa	10	2206
	Ulagalle	Thirappane, Kekirawa	28	5127
Horivila	Palugaswewa	Palugaswewa	14	2022
	Bellankadawala	Palugaswewa, Dambulla	28	4995
TOTAL			109	19067



Source: HLP Project documents



Source: HLP documents

Figure 01. Maps of two pilot project sites; A – Nachchaduwa site and B – Horivila site

Scope of the consultancy

The consultant will undertake activity 1.2.8 and sub-activities of activity 1.4.1 and activity 1.4.2 (Table b) that support completing output 1.2 and output 1.4 while it supports achieving outcome 1 efficiently and effectively under component 1 of the HLP. In this context, the consultant has been assigned a list of responsibilities stipulated in the TOR leading to six deliverables

Responsibilities

1) Provide support to the Project Manager (PM) in the overall task of planning, implementation and reporting of value addition, Marketing linkage development and business plans for agricultural crops and ecosystem goods in Project sites.
2) Assist the PM in the financial, technical and administrative management of the value chain and Marketing programmes in the project sites.
3) Prepare guidelines and training manual on producer groups, ecosystem services, Marketing and Value addition for project beneficiaries.
4) Support application of participatory approach in project site level implementation
5) Support organizing training programmes and counselling activities to producer groups ensuring the consisting group planning and value chain activities; and
6) Assist PM in preparing quarterly activity plans, and financial reports for submission to UN Environment.
7) Conduct studies on the valuation of cultural services in the targeted eco- and agro-tourism development villages at Hiriwadunna and Manawa Kanda ecotourism sites

Key deliverables

1) Report on baseline Status of multi- Sector value chain and Marketing illustrations
2) Report on review of value chain Marketing options for improving livelihood options of the VTCS
3) Preparation of training documents for stakeholder and community capacity building to integrate value chain and Marketing options of the VTCS
4) Provide resource contribution for stakeholder capacity building programs on integrating value chain and marketing
5) Generation of case study of the process and assessment of cost – benefits of VTCS restoration.
6) Assessment reports of evaluation ecosystem services for human health
7) Assessment report on valuation of cultural services in the targeted eco- and agro-tourism development villages at Hiriwadunna and Manawa Kanda ecotourism sites

The consultant identified that the responsibilities and deliverables are linked to activities 1.2.8 and some sub-activities that support activities 1.4.1 and 1.4.2 which is illustrated in Table 04. consequently, we identify four (4) key activities leading the four studies that will be carried out under the specified activities of HLP generating expected deliverables given in the TOR

Table 04. Mapping key responsibilities and deliverables stipulated in the TOR into the specified activities in the Healthy Landscape Project (HLP) and identifying key activities carried out through the consultancy assignment.

Key activity of HLP	Responsibility as per TOR	Key activity is done through the assignment	Deliverable as per TOR	Remarks
Activity 1.2.8	6	A. Generation of case study of the process and assessment of cost-benefit of VTCS restoration	5	Assignment 01
	6	B. Conduct study on assessment of ecosystem services for human health	6	Assignment 02
Activity 1.4.1	7	C. Assessment and valuation of cultural services arising from targeted eco- and agrotourism development villages at Hiriwadunna site	7	Assignment 03
Activity 1.4.2	1, 2, 3, 4 and 6	D. Conduct study on the analysis of multi-sector value chain and market illustrations	1, 2, 3 and 4	Assignment 04

Assignments 1 falls under activity 1.2.8 which would lead to deliverable five (5) presented in this report. The rest of the deliverables generated from other assignments are submitted as separate reports.

INTRODUCTION

Sustainable landscape management approaches in support of improved ecosystem services and ecohealth outcomes adopted in prominent socio-ecological sensitive areas of Village Tank Cascade Systems (VTCS) is the first outcome of the HLP which will be screaming through the activities done in Component 01 - Implementation of biodiversity-based options that improve sustainable land management in socio-ecological sensitive areas. Component 01 generates four outputs viz. Socio-ecological and biophysical system properties mapped and defined in two Project landscapes, Physical and ecological components of selected VTCSs restored as pilot models, Biodiversity-based agroecological and sustainable integrated land management practices promoted in the two selected VTCS pilot schemes and Goods, services and functions of VTCS ecosystems identified and mainstreamed. This assignment relates to output 1.2 which is achieved through eight key activities as finalized at the MTR of HLP done in July 2022.

The ancient village tank cascade system is currently under-functioning as a result of its heavy dilapidation over decades. However, its role in climate-resilient and mitigation is unforgettable and the opportunity to refunction it as an effective solution for the current climate change impact on the dry zone of Sri Lanka is highly significant. Thus, prompt actions are needed to restore the dilapidated VTCS is important. Familiarization of the goods and services provided and awareness of the importance of the cascade tank ecosystem and its conservation is an important first step in VTCS restoration planning for which an attempt is taken through activities of HLP. Activities 1.2.1 – 1.2.8 are devoted to restoring physical and ecological components of selected VTCSs as polit models which aim at replicating into other cascades of the country under future development activities towards climate resilience and mitigation. The output 1.2 will be fully achieved after activities 1.2.1 – 1.2.8. The project has completed participatory planning of rehabilitation and restoration of 8 tanks with the participation of the community and relevant agencies such as DAD, Forest Department and Irrigation Department etc. Estimation on the restoration of eight tanks has been completed together with a tank boundary survey, tank bed survey and sedimentation survey. Repair and renovation of tank head works, bunds and spills have been carried out in a few selected tanks viz. Bellankadawala, Thumbikumama etc. Development of downstream water management has been completed in Bellankadawala which will be implemented in both Vidane Wewa and Thumbikulama tanks. Conservation of upstream practices has been completed in a few tanks viz. Bulugahawewa, Thumbikulama. Collection of trees and planting materials to be introduced into different components of VTCSs have been completed and ten (10) community nurseries have been established to satisfy the demand for such materials in current and future VTCS rehabilitation and restoration processes. Restoration works of godawala, kiul-ela, iswetiya and yathuru wala and establishment of medicinal and underutilized plants have been completed in a few tanks viz. Thumbikulama, Kapugama and Dumbuluwagama tanks. The project has carried out tree planting in in kattakaduwa, kiul-ela, godawala, gasgommana covering a few tanks such as Tubmikulama, Bellankadawala and Bulugahawewa tanks. However, activity 1.2.8 is yet to be carried out which will complete achieving output 1.2 satisfactorily.

The main aim of assignment 01 is to complete activity 1.2.8 – Generation of a case study of the process and assessment of cost-benefit of VTCS restoration. A simple cost-benefit analysis would not be appropriate which considers only the costs and benefits of provisional services valued upon market process. We need to consider the economic value of costs and benefits associated with VTCS restoration that will be captured through an extended cost-benefit analysis. Valuation of nonmarket goods and services is complicated and will be an intensive exercise. We will consider

all types of ecosystem services arising from VTCS restoration and incorporate them in the cost-benefit analysis.

METHODOLOGY

Study location:

The location of the study is the coverage of Thumbikulama Tank in Bellankadawala Cascade in Paludaswewa Devisional Secretariate Division, North Central Province, Sri Lanka. This tank is located in the upper cascade of the Bellankadawala cascade called as “Olagam” tank. The nearest village to the tank is Ulpatha, where nearly 40 households live. The community's main source of income in this area is agriculture, which includes both lowland and upland cultivation. The orientation of the Thumbikulama tank in the Bellankadawala cascade is shown in Figure 02. The Thumbikulama tank is marked by a read circle. Figure 03 shows the restored Thumbikulama tank filled with water during the prolong draught season reported in 2023.

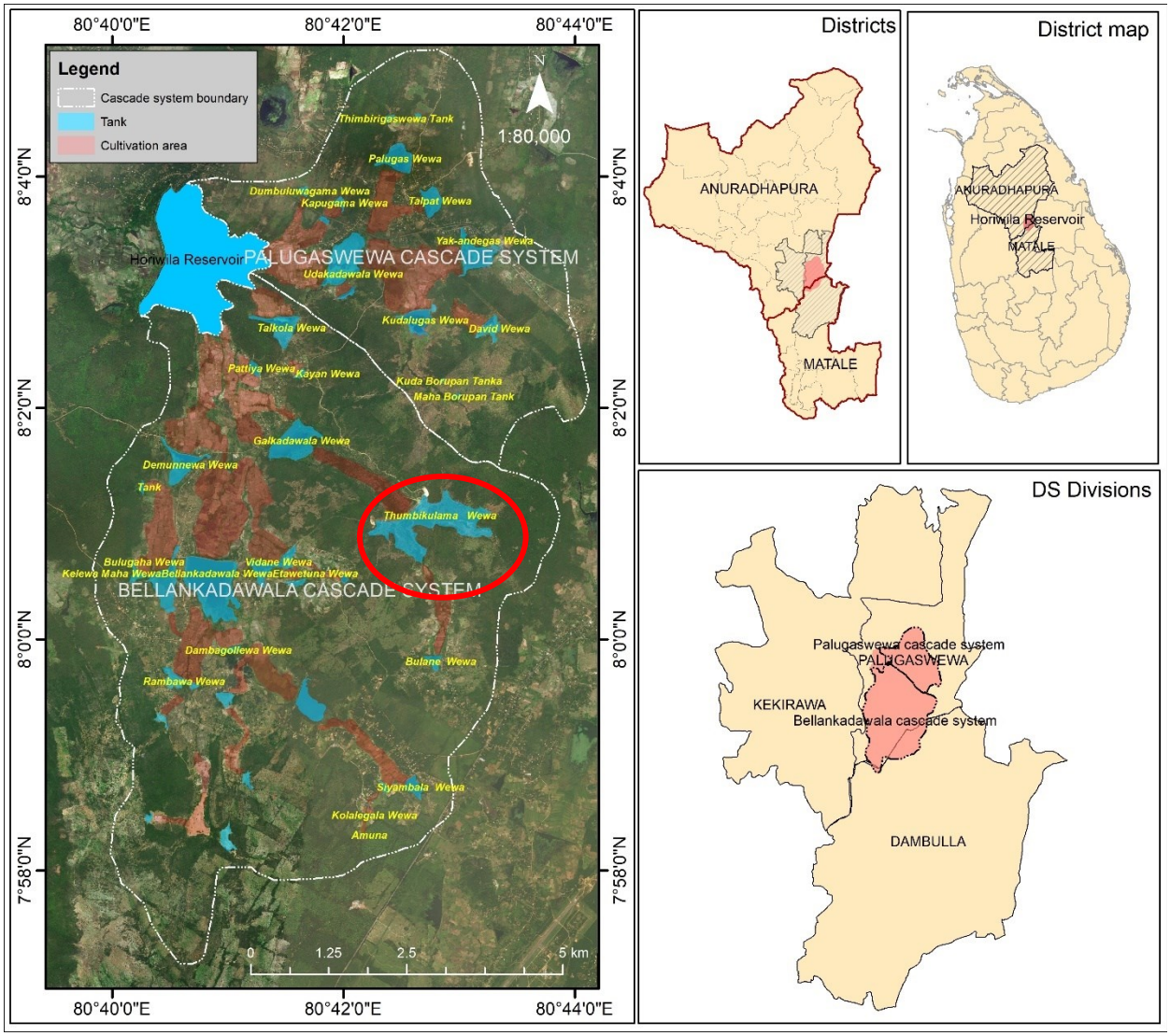


Figure 02. The orientation of Thumbikulama tank in the Bellankadawala village tank cascade; ***Source:*** *Dr. Harsh Kadupitiyas' map repository*.

Figure 03. Thumbikulama tank after partial restoration and filled with water during the prolong drought season in 2023. ***Source****: site visit by the consultant)*

Potential of Thumbikulama tank to be developed as a pilot site for cascade restoration:

The upstream of this tank has been almost completely restored during the period 2022 – 2023 as an activity of HLP. It can provide water for 600 - 750Ac of low lands and 600Ac of uplands. Furthermore, it recharges tanks situated the downstream in the cascade, respectively Galkadawala Tank, Pattiya Tank, Kayan Tank and Horiwila reservoir. This tank is consisted of all components of a tank in a VTCS except the human settlement called "Gangoda". This is a primary feature of an "Olagam" tank. The downstream with low lands and upland of the tank has been abandoned over a long period time (nearly 30 years) since the tank bud has been severely damaged due to a heavy flood in 1983. Since then, it has been existing as a dilapidated and abandoned tank system until it was restored under the HLP. This has been fully functional in the history, before the tank bund was broken as pointed out by the community. During the site visits, the consultant personally observed ruins of previously cultivated paddy lands, cannel systems and sluice gates etc. which confirmed what the community mentioned.

Compared to the other tanks identified by the project for restoration, Thumbikulama tank has the highest potential to be developed as a pilot model since most of the tank components remained undisturbed. Upstream of most of the other tanks in this cascade can be observed heavily disturbed by unauthorized encroachments for which short-term solutions cannot be brought during life span of HLP. Although the dawn stream is currently keeping unutilized, there is a huge potential to be developed it as a typical downstream under a tank in a VTCS. Therefore, Thumbikulama tank and its components can be regarded as the best available option that can be developed as a pilot sustainable village model (SVM) in the future. SVM is a key stagey of HLP that support restoration of VTCSs.

Approach of the study:

The complex functionality of a VTCS makes it impossible to quantify and comprehend the economic benefit of restoring a tank with a traditional benefit cost analysis. The expenses primarily relate to the upkeep of the repaired tank system and restoration efforts. While there may be hidden indirect and intangible costs associated with restoration, the majority of costs are direct and tangible. Some of the direct benefits of VTCSs are well known and tangible with a market price. However, its' indirect benefits and some indirect benefits are not well defined and are intangible. They are mostly not taken into account when considering the economic benefit of VTCS. In addition, the benefits of VTCS appear as ecosystem services, each falling under provisional services, regulatory service providers, cultural services and support services, most of which are non-market commodities and intangible. They are usually neglected in a usual benefit-cost analysis and therefore the actual value of tank renovation is not sufficiently disclosed. However, they must be taken into account when understanding the real benefit of restoring VTCSs. Therefore, we conduct an extended benefit-cost analysis that considers both tangible and intangible costs and benefits. We occupy standard valuation methods for estimating both the use value and the non-use value of both costs and benefits of restoration a VTCS which the procedure is depicted in Figure 04.

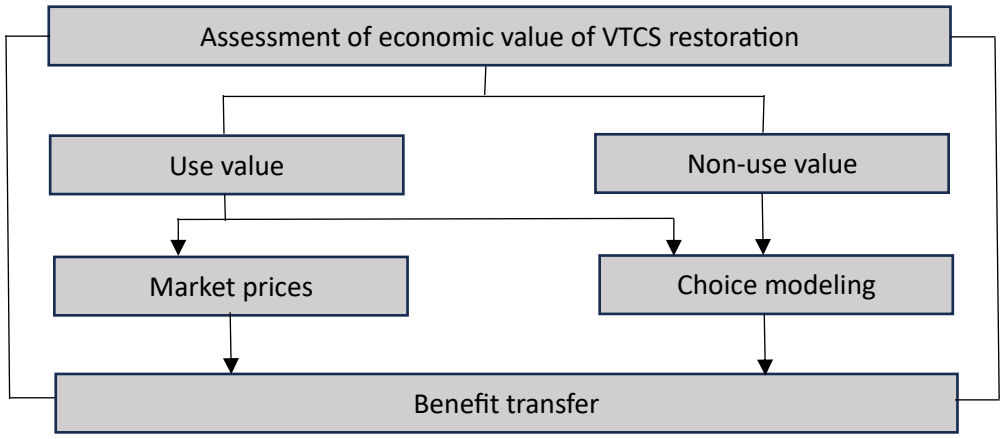


Figure 04. Methodological approaches of estimating use and non-use values of costs and benefits.

Items with a market value are assessed based on the market prices while non-market items were valued by choice modeling. Choice modeling is predominantly used for estimating both use value[1] and non-use value of commodities in modern literature.

Experimental procedure

The study's approach is complex and comprehensive, so it is conducted in two phases: the Design phase and the Assessment phase. If the true economic value of tank restoration is to be discovered, it is necessary to thoroughly comprehend and precisely define the intricate functionality of the VTCS and the products and services it offers before they are valued.

[1] Morrison, M., & Bennett, J. (2000). Choice modelling, non-use values and benefit transfer. *Economic analysis and policy*, *30*(1), 13-32.

Designing phase:

Data and data collection tools

We collected all information (primary and secondary data) necessary to design the assessment procedures of estimating use and non-use value of all costs and the benefits of VTCS restoration. We identified and listed all costs and benefits associated with the restoration and maintenance of a VTCS. All identified cost and benefit items were precisely defined and attributed to the respective assessment methods in Figure 04. We completed the design of the evaluation process of the extended benefit and cost analysis in this phase. Past studies emphasis the importance of taking faire time to accurately design an extended benefit-cost analysis for evaluation of the total economic advantage of such a complex ecological system. Although choice modeling offers various advantages, it is crucial to design the experiment carefully, considering the specific context, cultural aspects, and characteristics of the community (Nijkamp et al., 2008)[2]. More attention was given to the design the choice experiment where all data collection instruments were developed preciously during the design phase.

Costs and benefits: Both costs and benefits were identified through a comprehensive literature survey and field data collection with Key informant interviews (KII) and Focus group discussions (FGD). A list of stakeholders who participated in preliminary field data collection is provided in Table 05. The consultant and a few experts were engaged in data collection in the designing phase and a few snapshots taken while data were collected are depicted in Figure 05.

Table 05. The list of stakeholders who participated in preliminary field data collection during the designing phase.

Stakeholder	Method	Remarks
1. HLP staff	FGD, Secondary data (02)	Costs on restoration and maintenance
2. HLP field assistant – Palugaswewa	KII (02)	Cost of maintenance, benefits from restoration, sources of information
3. DAD	FGD, Secondary data (01)	Cost on restoration and maintenance in the long run, responsibilities, contribution of the communities and community practices, Benefits and sources
4. Office bearers of farmer organizations (President, secretory and other)	KIIs (04)	Contribution for restoration and maintenance, Benefits to the community, different sources of costs and benefits, process of costs and benefit sharing
5. Members of farmer organization	FGD (01)	Society role in restoration and maintenance, Benefits/ income generating activities from the tank and the system. Farm and off farm cost and benefit components. Other tangible benefits and costs, Intangible benefits and costs.

[2] Nijkamp, P., Vindigni, G., & Nunes, P. A. (2008). Economic valuation of biodiversity: A comparative study. *Ecological economics*, *67*(2), 217-231.

6. Key community members	KIIs (11)	Community role in restoration and maintenance, Benefits/ income generating activities from the tank and the system. Farm and off farm cost and benefit components. Other tangible benefits and costs, Intangible benefits and costs.
7. DOA – Agricultural Instructors	KII (01)	Costs and benefits associated with agricultural activities
8. Subject experts	KIIs (08)	Costs and benefits associated with ecosystem services arising from VTCS

Figure 05: Consultant and the team engage in design phase data collection

Sampling: We used snow ball sampling to select informant for FGDs and KIIs since we wanted informants with a faire knowledge about VTCS, its history, functions and ecosystem services.

Based on the preliminary analysis of initial field data and secondary data, a fleet of costs and benefits were identified together with respective methods of estimations as illustrated in Table 06 that is a very important component in the benefit-cost analysis

Table 06. Costs and benefits associated with the restoration of VTCS

Irem	Mode	Method of estimation
COST ITEMS		
Cost of restoration – HLP/ DAD contribution	Tangible: Monitory	Estimates and actuals from reports maintained by HLP and DAD
Cost of restoration - community	Tangible: Monetary + Labor	Books of farmer organization, KIIs, FGD
Cost of maintenance – HLP/ DAD contribution	Tangible: Monetary	Estimates and actuals from reports maintained by HLP and DAD
Cost of maintenance - Community	Tangible: Monetary + Labor	Books of farmer organization, KIIs, FGD

Cost of agricultural production (both upland: Maiz, Ground nut and onion; and low land: Paddy; livestock)	Tangible: Monetary + Labor + Material	Survey data/ Case studies/ farm records
Cost of non-agricultural product: products from forests (bee honey, herbal products etc.), products from tanks and its components (mainly inland fisheries)	Tangible: Monetary + Labor + Material	FGD/ KIIs/ Case studies
Crop loss by elephants and other wild animals	Tangible: Monetary	FGD/ KIIs
Social cost of Human Elephant Conflict (Humal elephant death, construction and maintenance of elephant fences etc.)	Intangible/ Tangible: Monetary	Literature survey, FGD, KII and secondary data.
BENEFIT ITEMS		
Income from agricultural production (both upland: Maiz, Ground nut and onion; and low land: Paddy; livestock; fisheries)	Tangible: Monetary + Labor + Material	Survey data/ Case studies/ farm records
Income from non-agricultural product: products from forests (bee honey, herbal products etc.), products from tanks and its components (mainly inland fisheries)	Tangible: Monetary + Labor + Material	FGD/ KIIs/ Case studies
Benefit from other provisional services provided by VTCS	Intangible: Monetary	Choice Experiment
Benefits from regulatory services arising from VTCS	Intangible: Monetary	Choice Experiment
Benefits from support services arising from VTCS	Intangible: Monetary	Choice Experiment
Benefits from cultural services arising from VTCS	Intangible: Monetary	Choice Experiment

During the initial field data collection, we have identified and defined ecosystem services under four classes; provisional services, regulatory services, support services and cultural services and illustrated in Table 07 Furthermore they were prioritized based on the community's viewpoint which gave the basis to select attributes for choice experiments. They were either market or nonmarket goods and services arising from a VTCS.

Table 07. Ecosystem services identified and prioritized during the design phase activities

Ecosystem service	Rationale	Rank
Provisional services		
Crop, animal and fisheries production	Major benefits from VTCS are crop, animal and fisheries production which provides main livelihood for the cascade community. Therse are tangible and market commodities.	1
Supply water for cultivation	Availability of irrigation water for paddy cultivation in two seasons; Yala and Maha. In some tanks water is available for paddy cultivation in a third season. This a non-market tangible benefit.	2
Supply water for washing/bathing/ livestock/other uses	Availability of water for washing, bathing and animal production. This is a nonmarket tangible benefit	3
Supply Drinking water from the tank	Availability of quality drinking water in the tank. This is a nonmarket commodity which is a tangible benefit.	6

Supply non-agricultural food products	Availability of different plant parts and animal products for collection and use for consumption and selling. Some examples are leafy vegetables, yams, tubers, flowers, bee honey, eggs, meat etc. Restrictions apply for hinting wild animals. Most of them are mark products that brings tangible benefits. They may provide livelihoods for cascade community	4
Supply nonfood products	Availability of materials such as firewood, reeds, cane, fibers and medicinal materials which are not edible. However, they provide inputs for some cottage industries such as making kitchen utilities, mat industry, arurvedic products and ornaments. They are tangible benefits that are either nonmarket of market items.	5
Regulatory services		
Recharging water table and maintain water flow	VTCS supports maintenance of ground water table and stream flow. With the restoration of upstream of Thumbikulama tank, the community experience water level recharged and remain adequately year-round. This is a nonmarket commodity which brings intangible benefits.	1
Water purification	The total VTCS filter water coming into the tank and going dawn from the tank by special arrangements of it's components. This is a nonmarket commodity which brings intangible benefits.	6
Erosion and flood control	Elements of VTCS dampening extreme flood events. This is a nonmarket commodity which brings intangible benefits.	2
Regulate climate	VTCS develop resilience to the climate change and mitigate its adverse impacts. This is a nonmarket commodity which brings intangible benefits.	3
Control human elephant conflict	VTCS regulates elephant movements and provide water, food and lodging for elephants and other wild animals and prevents intrusion into villages and cropping lands. This is a nonmarket commodity which brings intangible benefits.	4
Support services		
Providing habitats	VTCS provides habitats to the wild animal and support their existence. With the restoration of Thumbikulama tank it has provided habitats for wild elephants, crocodiles, indigenous fish species tec. That support their existence and bequest value. This is a nonmarket commodity which brings intangible benefits.	2
Pollination	Components of VTCS harbors honey bee population and other types of pollinators which support pollination. This is a nonmarket commodity which brings intangible benefits.	4
Maintain biodiversity	VTCS maintains both terrestrial and aquatic biodiversity and genetic diversity. Variety/ number of species/ types of plant and animals will be considered. This is a nonmarket commodity which brings intangible benefits.	1

Soil nutrient cycling	VTCS and arrangements of its component support nutrient recycling. Functions of Kattakadywa, Gasgommana and Isvetiya supports nutrient recycling. This is a nonmarket commodity which brings intangible benefits.	3
Biomass and organic matter production	VTCS and arrangements of its component viz. Gasgommana, Kattakaduwa and cropping lands support biomass and organic matter production.	6
Biological control of plant pests and diseases	Components of VTCS harbors and maintain natural predators, parasites, pathogens, and competitors that can be used to manage plant pests and diseases effectively while minimizing environmental impact. Biological control is a vital component of sustainable agriculture and integrated pest management. This is a nonmarket commodity which brings intangible benefits.	5
Cultural services		
Recreational	Nature-based opportunities for recreation play an important role in maintaining mental and physical health, e.g. walking and playing sports, recreational fishing, scenic beauty etc. This is a nonmarket commodity which brings intangible benefits.	1
Aesthetic value and amenity	VTCS has a variety of landscapes that provides an aesthetic value and amenity for the cascade community and visitors. This is a nonmarket commodity which brings intangible benefits.	2
Ecotourism	This is visiting local and foreign tourists in VTCS for traditional values, experience, adventure and home stay etc. while cascade environment is being protected. This is being currently practiced in Hiriwadunna village in Paludaswewa DS division. This is a market commodity which brings tangible benefits.	3
Traditional knowledge and education	Traditional knowledge on various aspects viz. farming system, engineering technology, irrigation technology, farming practices etc. uniquely connected with VTCS that has a bequest value. This is a nonmarket commodity which brings intangible benefits.	5
Rituals	Spiritual practices, customs and belief among the community in VTCS adhering at various occasions. This is a nonmarket commodity which brings intangible benefits.	6
Social cohesion, peace, humanity and cooperation	VTCS has a subculture that creates social inter relations, peace, harmony and corporation among the cascade community that support wellbeing of the community. This is a nonmarket commodity which brings intangible benefits.	4

Design of the choice experiment

We designed four different choice experiments to separately estimate the economic value of provisional services, regulatory services, support services and cultural services. We did not estimate their value in a single-choice experiment because a large number of attributes are required

to adequately represent all four types of ecosystem services in the choice experiment, which makes the data collection process inefficient. With a large number of attributes, the burden on informants in data collection would be very high, which would distort the accuracy and reliability of their answers to choice questions.

Selection of attributes: This was done based on the prioritization by the commodity nature of the commodity. We excluded crop, animal and fisheries production from the list of provisional services and rest of the services were considered in the choice experiment as attributes. We used all five regulatory services as attributes in the choice experiment used to estimate economic value of regulatory services. Of identified six support services, we excluded biomass and organic matter production, assigned the lowest community priority, and included all five other services as attributes of the respective choice experiments. Ecotourism was not considered in the choice experiment designed to estimate the economic value of cultural services because the value of ecotourism is estimated separately in the consultancy assignment. All attributes and their levels used in four choice experiments are given in Table 08.

Table 08. Attributes and their levels used in choice experiments to estimate economic value of ecosystem services arising from VTCS.

Attribute	Code	Levels		
		L1	L2	L3
Provisional services				
ES1 – Supply water for cultivation	Water_Irri	Not even adequate for Maha	Adequate only for Maha and not sufficient for Yala	Adequate for both Maha and Yala
ES2 - Supply clean water for drinking	Water_drnk	Cannot drink at all	Can drink after putification	Clean an can drink directly
ES3 - Supply water for washing/ bathing/ livestock/ other uses	Water_other	Adequate for about eight months or less	Adequate for about ten months	Adequate for the entire year
ES4 - Supply nonfood products (Reeds, firewood, medicinal materials etc.	Nonfood	Low supply	Moderate supply and doesn't meet the demand	High supply and meet the demand
ES5 - Supply food materials (Bee honey, yams, leafy veg. etc.)	Food	Low supply	Moderate supply and doesn't meet the demand	High supply and meet the demand
Regulatory services				
ES6 - Recharge water table and maintain the flow	Gwater_Reg	Well water sufficient for 8 months or less	Well water sufficient for about 10 months	Sufficient for entire year
ES7 - Water purification	Clean_Water	Income water into the tank is polluted	Incoming water into the tank is somewhat polluted	Incoming water into the tank is not polluted
ES8 - Erosion and flood control	Flood_Cont	Not sufficiently control	Moderately sufficiently control	Sufficiently control

ES9 - Regulate climate	Reg_Climate	Not sufficiently regulate	Moderately sufficiently regulate	Sufficiently regulate
ES10 - Control human animal (elephant) conflict	Hum_Animal	Not sufficiently control	Moderately sufficiently control	Sufficiently control
Support services				
ES11 - Provide habitats for plants and animals	Habitat	Limit a very few species	Limit to several species	No limitation and provide habitats for many species
ES12 - Maintain biodiversity	Biodive	Very low (less than 4 bird spp. can be seen)	Moderate rich (About 8 bird spp. can be seen)	Very rich (More than 12 bird spp. can be seen)
ES13 - Soil nutrient cycling	SN_cycl	Not sufficiently take place	Moderately sufficiently take place	Sufficiently take place
ES14 - Pollination	Polli	Not sufficiently take place (very few number of bees seen in croplands)	Moderately sufficiently take place (some number of bees seen in croplands)	Sufficiently take place (high number of bees seen in croplands)
ES15 - Biological control of pests and diseases	Bio_cont	Not sufficiently take place	Moderately sufficiently take place	Sufficiently take place
Cultural services				
ES16 - Recreation	ReAct	Less	Moderate	High
ES17 - Aesthetic value and amenity	SBM	Less	Moderate	High
ES18 - Traditional knowledge and education	Edu	Less (very few people in the community)	Moderate (some people in the community)	High (majority of the community)
ES19 - Rituals	Rituals	Followed by very few people in the community	Followed by some people in the community	Followed by the majority in the community
ES20 - Social cohesion, peace, humanity and corporation	Scohesion	Less	Moderate	High

All attributes and their levels translated into the local language were included in the questionnaire to asses the current status of them in VTCSs (Annexture A).

Monetary attribute: The same monitory attribute was use in all four choice experiments. It was defined as how much a household in a VTCS willing to bare in a year on behalf of restoration and maintenance of the VTCS. There were five levels of the monetary attribute respectively LKR 2,000.00, LKR 4,000.00, LKR 6,000.00, LKR 9,000.00 and LKR 12,000.00.

Design choice cards: We designed all four choice experiments using both `support.CEs` and `Rchoice` in RStudio. Fore all designs, there were 45 choices in five blocks. Each block consisted of randomly assigned nine choice sets. Each choice set had two options to select. A sample choice

card used in the choice experiment to estimate provision services is given in Figure 6 which the original choice set presented to the community during data collection in assessment phase in given in Annex C.

Questionnaire design

A common semi structured questionnaires were designed to collect data in all four choice experiments. These questionnaires consisted of six sections respectively, A: Demographic information, B: Knowledge section about VTCSs, its functions and ecosystem services, C: Section about perceptions of the community about restoration of VTCSs. D: Section to capture current status provisions of identified ecosystem services of VTCSs. E: Section of choice questions and F: Section about crop, animal and fisheries production in VTCSs. The only difference in four choice experiment was that each choice experiment used different sets of choice cards. Pretested and finalized questionnaire is given in Annex A.

Attribute	Choice A	Choice B	None of the options are selected
Supply water for cultivation	Adequate for both Maha and Yala	Adequate only for Maha and not sufficient for Yala	
Supply water for washing/ bathing/ livestock/ other uses	Adequate for about eight months or less	Adequate for the entire year	
Supply clean water for drinking	Clean and can drink directly	Can drink after purification	
Supply nonfood products (Reeds, firewood, medicinal materials etc.	High supply and meet the demand	Moderate supply and doesn't meet the demand	
Supply food materials (Bee honey, yams, leafy veg. etc.)	Moderate supply and doesn't meet the demand	Low supply	
Amount a house hold willing to bare per year for restoration and maintenance of VTCS	LKR 2,000.00	LKR 4,000.00	
Your Choice			

Figure 06: First choice set in the first block used in the choice experiment to estimate economic value of provisional services.

Assessment phase:

This phase devoted for assessing relevant costs and benefits of restoration and maintaining VTCS that were identified during the design. We use all assessment process and data collection instrument developed in the design phase to collect data and all assessment anticipated in this study. All data analysis and reporting also carried out in this phase.

Data and data collection:

Data: We will collect both secondary data and primary data required to estimate identified costs and benefits of restoration of VTCS. Secondary data sources that we used were available literature on similar studies and documents available with the stakeholders viz. HLP office, DAD, Farmer organizations etc. Primary data were the data that were not precisely available in secondary sources which were collected using different tools.

Tools of data collection: We do a comprehensive desk review to recover required secondary data from the secondary data sources. Primary data are collected by accommodating a semi-structured enumerator-driven questionnaire survey for choice modeling, field observations and participatory assessments with KIIs and FGDs. Survey questionnaires and checklists used for data collection were designed during the designing phase followed by pretesting and enumerator training.

The survey, KIIs and FGDs were carried out by a set of well-trained enumerators with the close supervision of the consultant. All field observations were done by the consultant personally during filed visits. All data collection activities were organized with the assistance of the HLP staff.

Sampling:

Study population: Study population is the cascade community and the stakeholders in the HLP project implementing area and those who directly and indirectly involved in restoration work of VTCSs. The sampled population of the choice experiment is the community in Bellankadawala CTVS.

Sampling method: We used a two-stage sampling scheme for drawing samples for the choice experiment. The first stage was the cascade level where primary sampling unit is a GN division. We selected all GN divisions in the Bellankadawala VTCS. The second stage of sampling was at GN level where secondary sampling units were households. Sampling was carried out by simple random sampling where the sampling frame was the list of households available at respective GN offices. The sample size was estimated to 287 per choice experiment based on the method adopted by [3]Assele et al., 2023. The nonrespondent rate was considered as 15%.

The sampling method adopted for KIIs and FGDs was snowball sampling techniques which is commonly practiced for such data collection approaches.

Analysis:

The total economic value is estimated as,

$$TEV = UV + NUV \quad (1.1)$$

where TEV – Total economic value, UV – Use value, NUV – Non-use value

We take the market price approach to estimate the DV of cost and benefit which has a distinct market (Equation 1.2)

$$UV = Q * P \quad (1.2)$$

Where Q is quantity and P is unit market price.

Non-market goods are valued using discrete choice modeling. In the context of discrete choice, utility cannot be directly observed. To understand the model, we first consider how the latent utility variable can be estimated. In the general form, the utility (U) for an individual i making a choice j is a function of one or more observed characteristics of the individual (X_i) and one or more observed characteristics of the choice (Z_j), and an error term representing unobserved attributes of decisions and individuals (e_{ij}).

[3] Assele, S. Y., Meulders, M., & Vandebroek, M. (2023). Sample size selection for discrete choice experiments using design features. *Journal of choice modelling*, *49*, 100436.

Thus:

$$U_{ij} = F(X_i, Z_j, e_{ij}) \quad (1.3)$$

In the simplest model, F is assumed to be a linear function (note: this is sometimes called a linear random utility model), so that for a given individual i selecting choice j:

$$U_{ij} = \beta Z_j + \gamma Z_j X_{ij} + e_{ij} \quad (1.4)$$

In order to estimate β and γ ; that is respectively, the utility associated with the choice features and interaction of choice features and individual features, it is assumed the individual considered all choices and selected j, and therefore for all k choices in the choice set where $j! = k, U_{ij} > U_{ik}$. Accordingly, a conditional logit model can be fitted that looks at the probability of actual choice selected in pairwise comparisons as a function of choice and individual characteristics.

We will use both numerical and graphical summary measures to describe the demographics of the sample and other features. Data analysis was carried out by RStudio statistical software which is an opensource software. We used both `support.CEs` and `Rchoice` packages for design and analysis of choice experiment.

Some occasions covered during the data collection carried out in the assessment phase is depicted in Figure 07. This was carried out by the consultant and a well trained group of enumerators.




Figure 07. While data collection in the assessment phase.

RESULTS AND DISSUASION

Estimation of costs and benefits of crop, animal and fisheries production

Crop production

Paddy: We estimated cost of production (COP), yield per Acre and farmgate price using data collected in KIIs and FGDs had with the community during the assessment phase of this study. The summary of estimation is presented in table 09.

Table 09: Cost of Production of Paddy (Kiri Samba), 2023/2024 Maha Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	49 000	00
02	Machinery Cost	44 000	00
03	Input Cost	36 000	00
04	Other Cost	21 060	00
05	Total Cost	150 060	00
06	Total Cost (Without family labor cost)	116 060	00
07	Cost per 1kg with family labor	88	27
08	Cost per 1kg excluding family labor (Family labor =Male-13, Female-1)	68	27
09	Expected yield (Kg/acre)	1 700	
10	Farmgate price (SEM = 21.84)	110.30	

Table 10: Cost of Production of Paddy (Samba), 2023/2024 Maha Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	49 000	00
02	Machinery Cost	44 000	00
03	Input Cost	35 200	00
04	Other Cost	21 180	00
05	Total Cost	149 380	00
06	Total Cost (Without family labor cost)	115 380	00
07	Cost per 1kg with family labor	82	98
08	Cost per 1kg excluding family labor (Family labor =Male-13, Female-1)	64	10
09	Expected yield	1 800kg	
10	Farmgate price (SEM = 13.72)	107.48	

Table 11: Cost of Production of Paddy (Nadu), 2023/2024 Maha Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	49 000	00
02	Machinery Cost	44 000	00
03	Input Cost	33 600	00
04	Other Cost	21 420	00
05	Total Cost	148 020	00
06	Total Cost (Without family labor cost)	114 020	00
07	Cost per 1kg with family labor	74	01
08	Cost per 1kg excluding family labor (Family labor =Male-13, Female-1)	57	01
09	Expected yield	2 000kg	
10	Farmgate price (SEM = 12.38)	101.98	

Maiz: Maiz is manly grown in both Maha and Yala season. We estimated cost of production (COP), yield per Acre and farmgate price using data collected in KIIs and FGDs had with the community during the assessment phase of this study. The summary of estimation is presented in table 12.

Table 12: Cost of Production of Maiz, 2023/2024, Maha and Yala Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	60 000	00
02	Machinery Cost	39 000	00
03	Input Cost	58 000	00
04	Other Cost	20 290	00
05	Total Cost	177 290	00
06	Total cost (Without family labor)	144 290	00
07	Cost per 1kg with family labor	98	49
08	Cost per 1kg excluding family labor (55% family labor cost)	80	16
09	Expected yield	1 800kg	
10	Farmgate price (SEM = 25.78)	135.00	

Big onion: This is one of the very popular condiment crops grown in Thumbikulama area. We estimated cost of production (COP), yield per Acre and farmgate price using data collected in KIIs and FGDs had with the community during the assessment phase of this study. The summary of estimation is presented in table 13.

Table 13: Cost of Production of Big Onion, 2023/2024 Yala Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	252 500	00
02	Machinery Cost	53 000	00
03	Input Cost	204 000	00
04	Other Cost	159 790	00
05	Total Cost	669 290	00

06	Total cost (without family labor)	555 665	00
07	Cost per 1kg with family labor	69	72
08	Cost per 1kg excluding family labor (45% family labor cost)	57	88
09	Expected yield	9 600kg	
10	Farmgate price (SEM = 33.80)	146.30	

Green gram: We estimated costs and benefits of green gram cultivation in the study areas. The summary of estimates in given in Table 14

Table 14. Cost of Production of Green gram, 2023/2024 Yala Season, , cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	114 300	00
02	Machinery Cost	24 000	00
03	Input Cost	33 160	00
04	Other Cost	47 210	00
05	Total Cost	218 670	00
06	Total Cost (without family labor)	150 090	00
07	Cost per 1kg with family labor	420	52
08	Cost per 1kg excluding family labor (60% family labor cost)	288	63
09	Expected yield	520kg	
10	Farmgate price (MSE = 64.65)	325	

Sesame: This is usually grown in the Yala season in VTCSs in Palugaswewa DS division. Estimated costs and benefits per 1 Kg of production is given in Table 15

Table 15. Cost of Production, yield and farmgate price of Sesame, 2023/2024 Yala Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	38 500	00
02	Machinery Cost	15 000	00
03	Input Cost	5 125	00
04	Other Cost	15 100	00
05	Total Cost	73 725	00
06	Total Cost (without family labor)	52 550	00
07	Cost per 1kg with family labor	210	64
08	Cost per 1kg excluding family labor (55% family labor cost)	150	14
09	Expected yield	350kg	
10	Farmgate price (MSE = 69.30)	580.00	

Vegetable production: Number of vegetables are grown in VTCSs in Palugaswewa DS division. Major vegetables that they grow are green chili, brinjal, pumpkin, long beans and tomato which cost of production, average yield and farmgate price is given in Table 16, Table 17, Table 18, Table 19 and Table 20. In addition, they grow sweet potato, bitter gourds, luffa, snake gourds and other vegetables also.

Table 16: Cost of Production, yield and farmgate price of green chili, 2023/2024 Yala and Maha Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	507 000	00
02	Machinery Cost	28 400	00
03	Input Cost	240 265	00
04	Other Cost	172 080	00
05	Total Cost	947 745	00
06	Cost per 1kg with family labor- green chili	75	82
07	Cost per 1kg excluding family labor (45% family labor cost)- Green Chilies	57	57
08	Expected yield	12 500kg	
10	Farmgate price (MSE = 60.70)	150.80	

Table 17: Cost of Production, yield and farmgate price of brinjal, 2023/2024 Yala and Maha Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	377 000	00
02	Machinery Cost	15 000	00
03	Input Cost	265 150	00
04	Other Cost	139 100	00
05	Total Cost	796 250	00
06	Total Cost (without family labor)	645 450	00
07	Cost per 1kg with family labor	54	54
08	Cost per 1kg excluding family labor	44	21
09	Expected yield	14 600kg	
10	Farmgate price (MSE = 15.42)	130.25	

Table 18: Cost of Production, yield and farmgate price of pumpkin, 2023/2024 Yala and Maha Season, , cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	62 000	00
02	Machinery Cost	25 000	00
03	Input Cost	206 500	00
04	Other Cost	34 100	00

05	Total Cost	327 600	00
06	Total cost (without family labor)	293 500	
07	Cost per 1kg with family labor	26	21
08	Cost per 1kg excluding family labor	23	48
09	Expected yield	12 500kg	
10	Farmgate price (MSE = 36.58)	50.00	

Table 19: Cost of Production, yield and farmgate price of long beans, 2023/2024 Yala and Maha Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	108 000	00
02	Machinery Cost	14 000	00
03	Input Cost	58 000	00
04	Other Cost	87 900	00
05	Total Cost	267 900	00
06	Total cost (without family labor)	208 500	00
07	Cost per 1kg with family labor	64	76
08	Cost per 1kg excluding family labor	45	33
09	Expected yield	4 600kg	
10	Farmgate price (MSE = 18,34)	125.00	

Table 20: Cost of Production, yield and farmgate price of tomato, 2023/2024 Yala and Maha Season, cultivated extent = 1 Acre

No.	Description	Cost	
		Rs.	Ce.
01	Labor Cost	180 500	00
02	Machinery Cost	14 000	00
03	Input Cost	149 600	00
04	Other Cost	125 850	00
05	Total Cost	469 950	00
06	Total cost (without family labor)	370 675	00
07	Cost per 1kg with family labor	47	95
08	Cost per 1kg excluding family labor	37	82
09	Expected yield	9 800kg	
10	Farmgate price (MSE = 27.32)	125.00	

Animal production

Under animal production main types are backyard poultry and dairy production. Cost of production, average yield and farmgate price of an egg and a liter of fresh milk are respectively given in Table 21 and Table 22. Cascade community engage in both cattle and buffalo production. There are two heard of free-range buffalo found associated with the Thumbikulama tank.

Table 21: Cost of Production, yield and farmgate price of backyard poultry, 2023/2024, for a flock of 25 hens.

No.	Description		Cost	
			Rs.	Ce
01	Description cost of fixed cost			53
02	Day- old chick cost			76
03	Chick transport cost		0	00
04	Food cost-up to laying		2	67
05	Laying feed cost		8	53
06	Electricity cost		0	07
07	Medicine cost		3	31
08	Labor cost (Male/Female)		1	88
09	Rice husk cost		0	10
10	Litter removing cost		0	33
11	Other cost		0	20
12	Total cost		18	38
13	Income	Organic fertilizer (Chicken manure)		-80
		Sale of chicks	-3	20
14	Net cost of production		14	38
15	Farmgate price (MSE = 4.32)		41	50

Table 21: Cost of Production, yield and farmgate price of fresh cow milk, 2023/2024 for a hear of 5 cows

No.	Description	Cost	
		Rs.	Ce.
01	Fixed cost	38 500	00
02	Cost on 16-month-old cow	15 000	00
03	Transportation	5 125	00
04	Food cost	15 100	00
05	Cost for medicine	73 725	00
06	Labor cost	52 550	00
07	Other costs	210	64
08	Total coat	150	14
09	Income from livestock manure for organic fertilizer	350kg	
10	Net cost of production	393	48
11	Cost of production per linter (average yield per day = 6.6l/cow)	59	62
12	Farmgate price (MSE = 18.5)	145	00

Mr. Premarathna Banda (44 years) is the owner of one buffalo herd in Thimbikulama whose buffalo shed in located in the upper area of Thumbikulama tank. He is a retired army personal whose family size is 3, wife (48), son (11) and daughter (25). There are 25 buffalos in his herd and daily milk yield is 17.5l sold at a rate of LKR 204/liter. His family income is LKR 150,000.00 per month. The cost of production per milk liter is about 48.50 including the family labor.

Fisheries production

We didn't carry out a detailed analysis of costs and benefits of fisheries production associated with tanks in VTCSs. Usually, it is managed by the farmer organization who introduce fingerlings into tanks and lease them annually. We exclude this part from the CBA in this study and recommend future research about inland fisheries in VTCSs.

Estimation of the economic value of ecosystem services of VTCSs

As described in the methodology section, all benefits of ecosystem services that didn't have a market price and intangible were estimated by using a choice experiment. We estimated economic value of provisional services, regulatory services, cultural service and support services separately by using for different choice experiments which actual sample sizes were respectively 251, 250, 250 and 250. The total sample size was 1001 households selected from Bellankadawala VTCS.

Demographic of the community participated in choice experiments

Under the demographics of the study participants, we present their gender, age, marital status, family size, household income, occupation and educational status.

Gender inclusion

The empirical distributions of the gender of participants in for choice experiments are presented in Figure 08. Inclusion of gender in the study sample is nearly 40% which can be considered as faire. The lease female representation was found in the sample used to estimate support services. However, gender inclusion is more than this since most of the time choice questions were answers collectively by the male household and females in the family (Figure 07). Thus, we can conclude that gender inclusion of this study is fair.

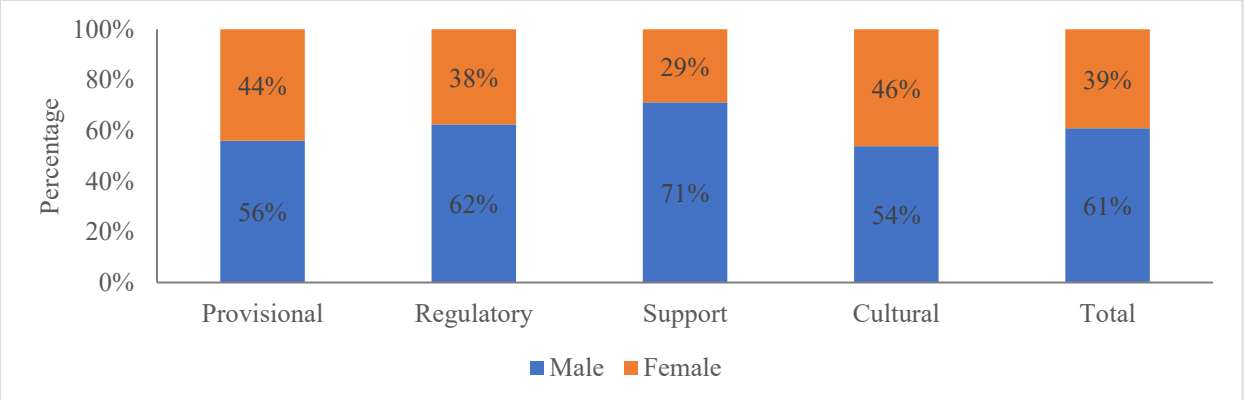


Figure 08. Empirical distribution of the gender in study samples.

Empirical age distribution

Table 22 describes summary measures of participants' age in four choice experiments of which histograms are presented in Figure 09. The average age of informants in the sample is 50 years with a standard deviation of approximately 13.5 years, suggesting that participants have good experiences with the VTCS and its services.

Table 22. Summary measures of participants' age in choice experiments

Ecosystem service	Mean	StDev	Minimum	Q1	Median	Q3	Maximum	Skewness	Kurtosis
Provisional	48.6	14.8	14	36	50	60	83	-0.07	-0.85
Regulatory	49.9	13.0	18	42	48	59	84	0.09	-0.42
Support	50.2	13.6	18	40	50	63	87	0.06	-0.72
Cultural	50.3	13.0	17	42	49	60	87	-0.03	-0.36
Total	**49.8**	**13.4**	**14**	**40**	**49**	**60**	**87**	**-0.01**	**-0.58**

StDev – Sample standard deviation

Figure 09 depicts that the age distributions of participants in all four choice experiments are symmetric around a median of 48 to 50 years which is confirmed by their coefficients of skewness close to zero. Consequently, there is also a faire youth inclusion in the study sample

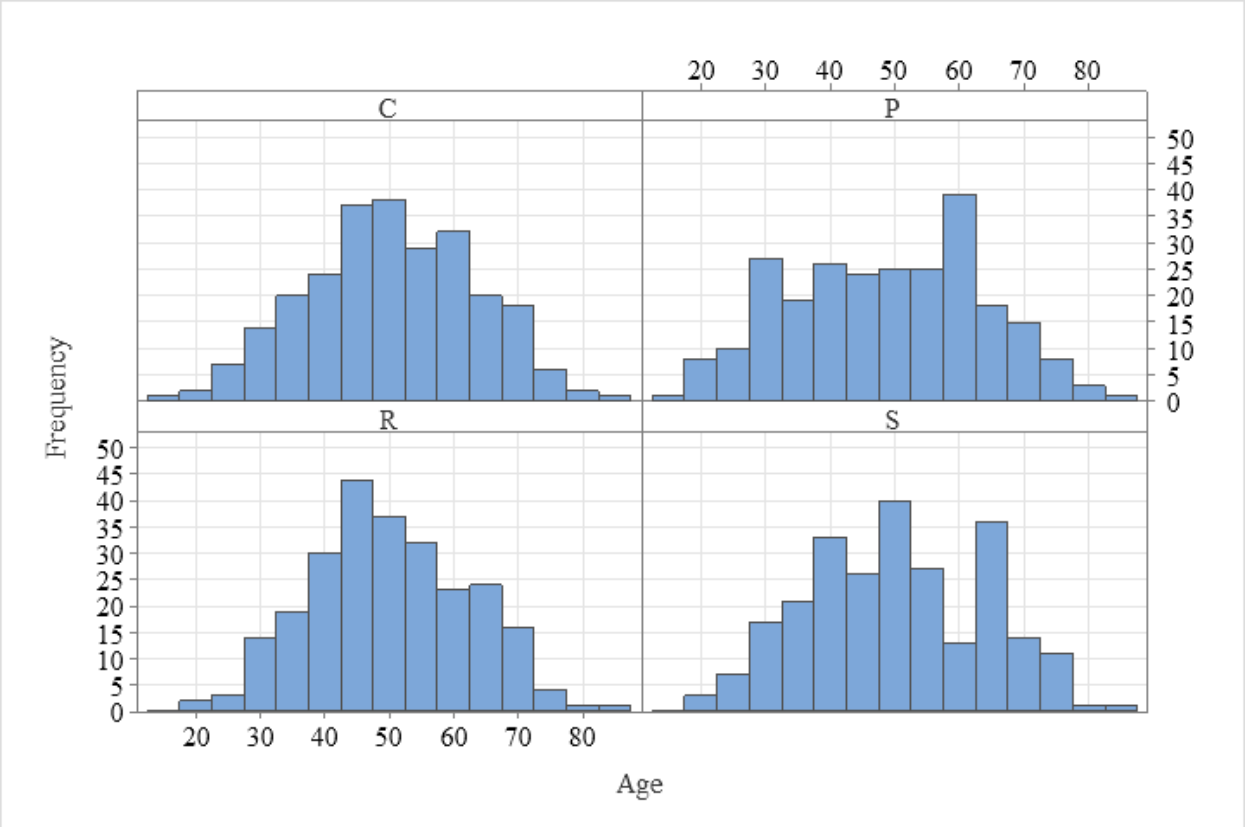


Figure 09. Histograms of age of the participants in four choice experiments; C – Cultural services, P – Provisional services, R – Regulatory services and S – Support services.

Civil status and household size

A 90% of the sample were married persons. The empirical distributions of family sizes of the study samples are given in Figure 10 which are also symmetric. Their skewedness coefficients were also estimated to near zero values. The median family size was 4. Q3 and maximum family size were reported as 5 and 8 respectively. This indicate that about 25% of the community's family sizes are above 5 members.

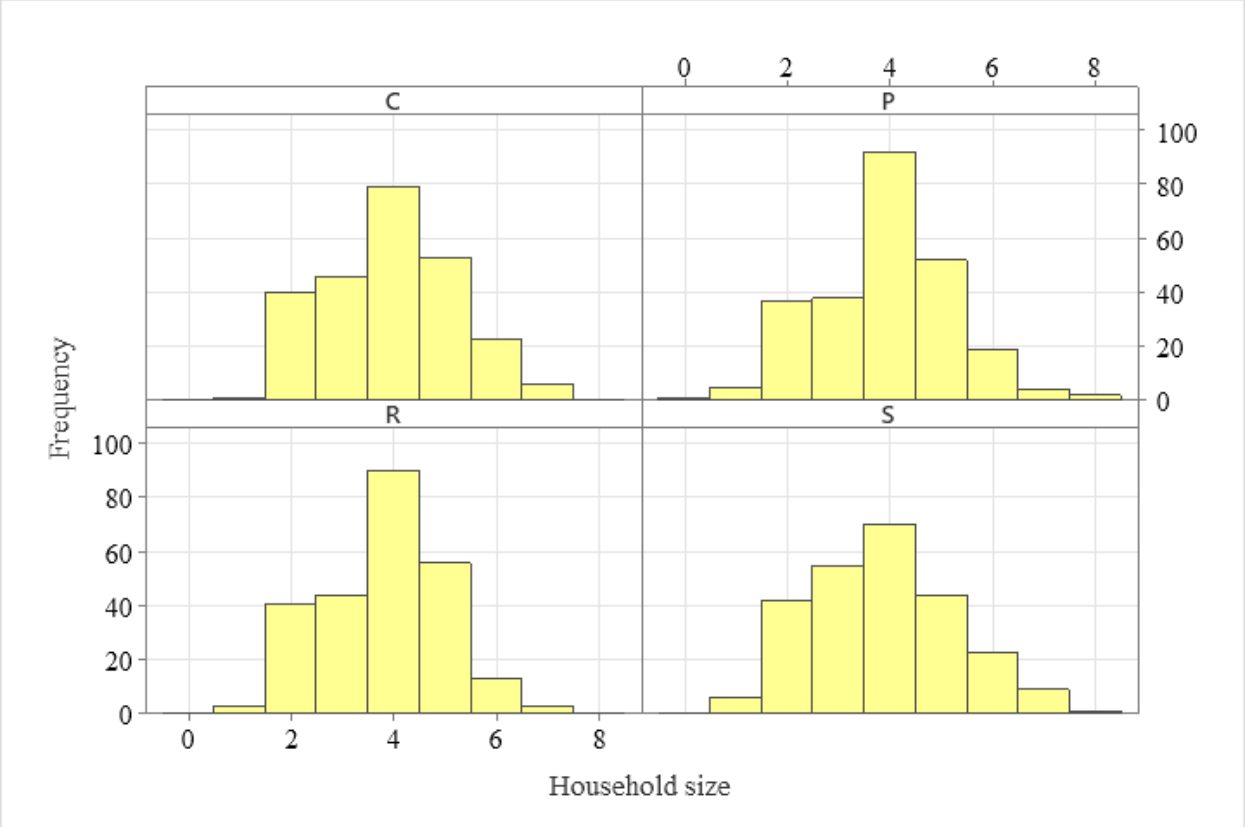


Figure 10. Empirical distributions of family sizes of participants in four choice experiments; C – Cultural services, P – Provisional services, R – Regulatory services and S – Support services.

Education status

Education status of the participants in four choice experiments is summarized in Table 23. It can be noticed that the majority of participants in the study had education up to GCE(O/L). A few participants had education status of GCE(A/L) or above.

Table 23. Education status of participants in four choice experiments

Education level	Provisional	Regulatory	Support	Cultural	Total
up to grade 7	29.5%	28.4%	27.2%	38.4%	30.9%
Up to GCE (O/L)	54.2%	49.6%	58.0%	44.8%	51.6%
Up to GCE (A/L)	13.5%	12.4%	12.8%	13.6%	13.1%
Pass GCE (A/L)	0.8%	6.0%	0.8%	0.4%	2.0%
Graduate	1.2%	1.2%	0.4%	2.4%	1.3%
Postgraduate	0.8%	2.4%	0.8%	0.4%	1.1%

Employment status

Employment status of participants in four choice experiments is shown in Figure 11. The vast majority of the study sample is farmers who highly interact with the VTCS. They must have a fair experience and knowledge about services offered by the VTCS. About 11% to 23% of study samples were employed either in the private sector or in the government sector whose educational status were high compared to that of the farming community. However, all of the community take part in the study were engaged in farming either in full time or pat time. There were some individuals among full time farming community whose education qualifications were high. Some of them were on their retirement.

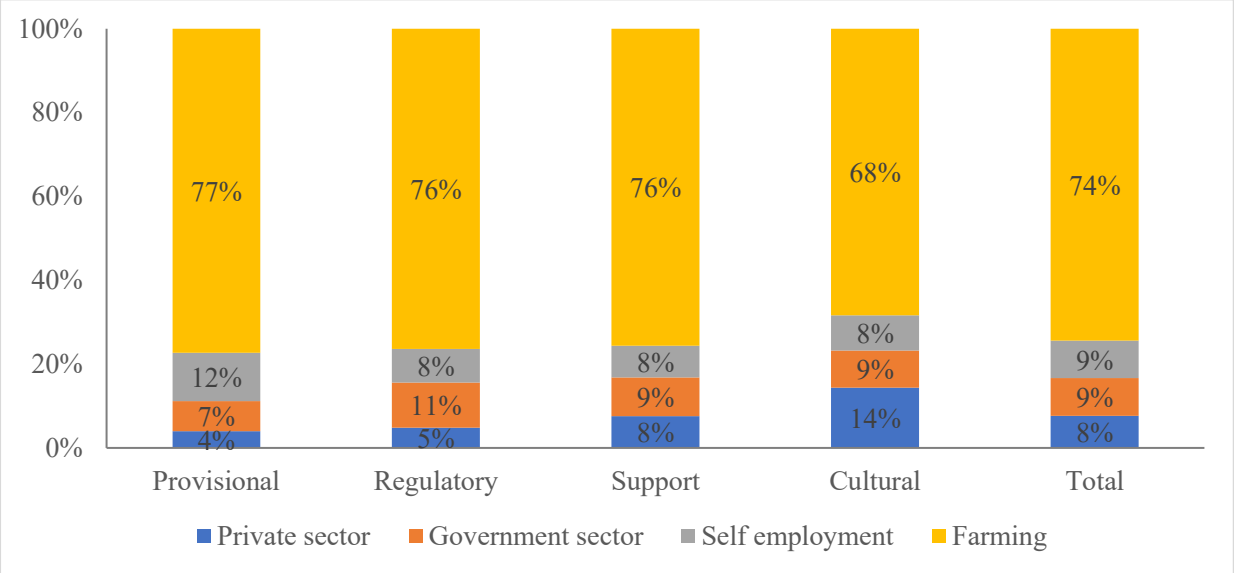


Figure 11. Employment status of participants in four choice experiments

Income status

Household income of the informants taken part in choice experiments is summarized in Table 24. It can be observed that household in come of about 50% of the sample is below LKR 50,000.00 per month. About another 35% of households have income between LKR 50,000 and 100,000 monthly. There were about 15% households whose income exceeded LKR 100,000 limit.

Table 24. Monthly household income of the informants participated in four choice experiments

Income class (LKR)	Provisional	Regulatory	Support	Cultural	Total
< 25,000	23.1%	15.6%	8.0%	5.2%	13.0%
25,000 - 50,000	40.2%	50.0%	24.8%	34.0%	37.3%
50,000 - 100,000	27.9%	26.0%	48.0%	44.0%	36.5%
100,000 - 200,000	7.2%	8.4%	18.4%	16.8%	12.7%
200,000 - 500,00	1.2%	0.0%	0.8%	0.0%	0.5%
>500,000	0.4%	0.0%	0.0%	0.0%	0.1%
Mean income	55,826.69	52,800.00	76,700.00	71,600.00	64,223.28
MSE of income	9,029.75	8,817.31	7,635.44	7,758.22	4,167.35

Economic value of provisional services

We fitted a conditional logit model as the utility function to choice data collected in order to estimate marginal willingness to pay (MWTP) for provisional services listed in Table 08 which the model estimates are given in Table 24. The likelihood ratio test on the model was statistically significate (1415 on 12 DF, p-value: <0.001) which indicate that the model adequately captures the relationship between willingness to pay and all attributes in the model.

ASC is the alternative specific constant which has a negative sign and is not statistically significant at the 5% level. The ASC is omitted for one alternative, which becomes the 'base', again to avoid the 'dummy variable trap'. ASC can be interpreted as representing the net average effect of omitted variables other than the attributes in the model. Including ASCs ensures that, when estimated by maximum likelihood, logit is able to replicate the aggregate choice shares. The negative ASC indicates that cascade community are more inclined to choose scenarios of provisional services in the model than any other scenarios of provisional services.

Table 08. Estimated model parameters of the utility function fitted to choice experiment data for provisional services.

Variable	Coefficient	Exp(coef)	se(coef)	z	p-value
ASC	-0.226	0.797	0.164	-1.377	0.169
ES1_L2	0.477	1.611	0.085	5.592	<0.001
ES1_L3	1.630	5.102	0.099	16.529	<0.001
ES2_L2	0.170	1.186	0.086	1.987	0.047
ES2_L3	0.234	1.264	0.087	2.690	0.007
ES3_L2	0.491	1.634	0.098	5.008	<0.001
ES3_L3	1.009	2.742	0.089	11.331	<0.001
ES4_L2	0.366	1.442	0.083	4.434	<0.001
ES4_L3	0.413	1.511	0.079	5.215	<0.001
ES5_L2	0.066	1.069	0.099	0.671	0.502
ES5_L3	0.550	1.733	0.093	5.901	<0.001
Share_Restoration	0.00003	1.000	0.00001	2.677	0.007

Note: *Likelihood ratio test=1415, df. =12, p-value < 0.001, n= 6750, number of events= 2250*

The monitory attribute in the model is statistically significant with a positive sign which is expected to be in the utility function of a usual choice model. This indicate that having contributed more on the restoration of VTCS by the community increases the utility or wellbeing of them. In this context MWTP should be estimated as β_i/β_m where β_i is the coefficient of i^{th} attribute and β_m the coefficient of the monitory attribute (Atkinson et al., 2018)[4]. All attributes in the model except ES5_L2 are statistically significant at 5% level with positive signs. This shows us if any of the provisional services are increase to the stated levels then the community's utility will increase.

Estimated MVTP values at different levels of provisional services offered by VTCS is given in Table 09. 95% confidence intervals of MWTP were estimated by Krinsky and Robb method. It can be noticed that they are not willing to pay for the status quo levels of provisional services. However, they value more the higher levels of all five provisional services more. The highest value

[4] Organisation for Economic Co-operation and Development. (2018). *Cost-benefit analysis and the environment: further developments and policy use*. OECD publishing. https://www.oecd-ilibrary.org/sites/9789264085169-8-en/index.html?itemId=/content/component/9789264085169-8-en

is placed for the irrigation water if it is sufficiently available for both Maha and Yala seasons even under draughts.

Table 09. MWTP estimates of different levels of provisional ecosystem services

Variable	MWTP	2.5%	97.5%
ASC	(8,513.71)	(28,006.12)	5,947.18
ES1_L2	17,943.68	8,846.15	60,841.46
ES1_L3	61,290.56	35,035.17	202,907.03
ES2_L2	6,405.16	(9.01)	24,513.10
ES2_L3	8,810.57	1,748.77	35,660.05
ES3_L2	18,464.39	8,483.98	63,697.70
ES3_L3	37,935.90	21,360.54	128,075.20
ES4_L2	13,764.73	5,777.65	49,252.48
ES4_L3	15,518.54	7,242.27	52,945.96
ES5_L2	2,499.47	(5,287.99)	17,197.62
ES5_L3	20,686.85	9,697.94	74,519.35

Economic value of regulatory services

Estimates of the conditional logit model fitted to choice data for regulatory services are given in Table 10. The likelihood ratio test of the model was statistically significate (1501 on 12 DF, p-value: <0.001) which indicate that the model adequately captures the relationship between willingness to pay and all attributes in the model. ASC is positive and statistically significant (P-value < 0.001). This indicates that the cascade community would more likely to choose none of the regulatory ecosystem services scenarios which indicate that they care less about VTCS regulatory service scenarios.

Table 10. Estimated model parameters of the utility function fitted to choice experiment data for regulatory services.

Variable	Coefficient	Exp(coef)	se(coef)	z	p-value
ASC	1.076	2.932	0.158	6.794	<0.001
ES6_L2	-0.230	0.795	0.085	-2.707	0.007
ES6_L3	0.017	1.017	0.082	0.203	0.839
ES7_L2	0.550	1.733	0.091	6.013	<0.001
ES7_L3	0.747	2.110	0.094	7.909	<0.001
ES8_L2	0.030	1.030	0.090	0.327	0.744
ES8_L3	0.553	1.738	0.091	6.096	<0.001
ES9_L2	0.172	1.188	0.082	2.106	0.035
ES9_L3	0.506	1.659	0.084	5.998	<0.001
ES10_L2	0.609	1.839	0.091	6.712	<0.001
ES10_L3	1.359	3.892	0.094	14.405	<0.001
Share_Restoration	-0.0001	1.000	0.00001	-5.448	<0.001

Note: *Likelihood ratio test=1501 on 12 df, p=<0.001, n= 6750, number of events= 2250*

Except for ES6_L3 and ES8_L2, model parameters of other attributes were statistically significant at least at 5% level. ES6_L2 was the only level with a negative coefficient and also ES6_L3 is

not statistically significant. This concludes that cascade community is not willing to pay for recharging ground water table and maintenance of water flow by VTCS. However, the cascade community believes that its utility would be high if other regulatory services of a VTCS were higher.

MWTP for maintaining regulatory services at higher levels than their reference levels are given in Table 11. The community place a higher value on control of conflicts between human and animal especially control of the human elephant conflict.

Table 11. MWTP estimates of different levels of regulatory ecosystem services

Variable	MWTP	2.5%	97.5%
ASC	21,190.70	14,652.50	31,943.90
ES6_L2	(4,527.80)	(8,987.70)	(1,297.70)
ES6_L3	326.80	(2,743.00)	4,197.00
ES7_L2	10,834.50	6,954.20	17,192.00
ES7_L3	14,711.30	10,063.80	22,941.00
ES8_L2	581.30	(2,918.40)	4,588.50
ES8_L3	10,882.50	6,518.70	18,761.00
ES9_L2	3,394.60	162.20	7,415.80
ES9_L3	9,971.20	6,183.60	16,284.50
ES10_L2	12,003.00	7,820.30	19,288.50
ES10_L3	26,765.10	19,114.20	41,929.80

Economic value of support services

Estimates of the conditional logit model fitted to choice data for support services are given in Table 12. The likelihood ratio test of the model was statistically significate (1840 on 12 DF, p-value: <0.001) which indicate that the model adequately captures the relationship between willingness to pay and all support service attributes in the model.

Table 12. Estimated model parameters of the utility function fitted to choice experiment data for support services.

Variable	Coefficient	Exp(coef)	se(coef)	z	p-value
ASC	4.797	121.200	0.241	19.934	<0.001
ES11_L2	-0.375	0.688	0.081	-4.643	<0.001
ES11_L3	-0.679	0.507	0.081	-8.378	<0.001
ES12_L2	0.775	2.171	0.092	8.425	<0.001
ES12_L3	0.255	1.290	0.089	2.851	0.004
ES13_L2	-0.120	0.887	0.088	-1.362	0.173
ES13_L3	-0.047	0.954	0.086	-0.548	0.584
ES14_L2	-0.981	0.375	0.083	-11.793	<0.001
ES14_L3	-0.517	0.596	0.083	-6.212	<0.001
ES15_L2	-0.187	0.830	0.087	-2.142	0.032
ES15_L3	-0.445	0.641	0.091	-4.900	<0.001
Share_Restoration	-0.000024	1.000	0.00001	-2.823	0.005

Note: Likelihood ratio test=1840 on 12 df, p=<001, n= 6750, number of events= 2250

ASC of the discrete choice model was positive and statistically highly significant (p-value < 0.001). This indicates that the cascade community is more likely to prefer a different scenario than the underlying scenarios of the support services offered by a VTCS. The Monitory attribute is statistically significant at 1% level and has a negative coefficient, which is normally expected from discrete choice models. This suggests that community's utility for support services would decrease as community contribution to VTCS restoration and maintenance increases. ES13, Nutrient recycling was not statistically significant while rest of the attributes were statistically significant at least at 5% level. Except for maintenance of biodiversity, rest of the attributes have negative model parameters. This shows that the cascade community is willing to pay for ecological restoration of VTCS if biodiversity conservation in VTCS is improved. However, they are not prepared to pay for increased support services, but would rather be paid to ensure that VTCS support services remain at a higher level.

Estimates of part worth (MWTP) of all support service attributes in the model are given in Table 13. Of note, the ASC representing the status quo, with another ecosystem services scenario is very highly valued by the cascade community (LKR 199,291.00/household/year), indicating a broad preference for other ecosystem service scenarios than ecosystem support services setup alone. It can be inferred that the cascade community is willing to forgo a compensation of LKR 23,192.80 on behalf of maintaining biodiversity at a moderate level within the VTCS.

Table 13. MWTP estimates of different levels of support ecosystem services

Variable	MWTP	2.5%	97.5%
ASC	199,291.00	118,971.30	599,389.10
ES11_L2	(15,561.50)	(49,703.30)	(7,210.30)
ES11_L3	(28,208.60)	(82,477.20)	(16,516.30)
ES12_L2	32,192.80	18,462.50	94,150.40
ES12_L3	10,588.90	3,055.90	34,680.00
ES13_L2	(4,986.40)	(17,514.30)	2,923.10
ES13_L3	(1,952.60)	(11,087.30)	7,567.90
ES14_L2	(40,730.60)	(123,078.40)	(23,301.40)
ES14_L3	(21,494.90)	(67,821.50)	(11,075.20)
ES15_L2	(7,749.40)	(30,099.40)	(500.30)
ES15_L3	(18,500.30)	(59,106.60)	(8,584.20)

Economic value of cultural services

Parameter estimates from the discrete choice model fitted to cultural services sample data are presented in Table 14. The likelihood ratio test of the model was statistically significate (1324 on 12 DF, p-value: <0.001) which indicate that the model adequately captures the relationship between willingness to pay and all cultural service attributes in the model. The ASC of this model has a negative coefficient which is highly statistically significant (p-value<0.001). This indicates that the community is more likely to choose cultural services scenarios in VTCS rather than a status quo ecosystem services scenario.

As expected, the Monitory attribute has a statistically significant (p-value < 0.05) negative coefficient. This suggests that the higher the commitment to restoring VTCS, the lower the utility to cultural services arising from VTCS. All coefficients of the other attributes are positive. It can be seen that ES16_L3 is marginally significant (p-value < 0.1) while all the other attributes are

statistically highly significant (p-value ≤ 0.01). It can be inferred that if the cultural services could be increased through restoration of the VTCS, the community's welfare would be significantly high.

Table 14. Estimated model parameters of the utility function fitted to choice experiment data for cultural services.

Variable	Coefficient	Exp(coef)	se(coef)	z	p-value
ASC	-0.959	0.384	0.180	-5.335	<0.001
ES16_L2	0.205	1.227	0.086	2.379	0.017
ES16_L3	0.168	1.183	0.093	1.811	0.070
ES17_L2	0.916	2.499	0.088	10.385	<0.001
ES17_L3	1.255	3.508	0.087	14.486	<0.001
ES18_L2	0.319	1.375	0.097	3.299	0.001
ES18_L3	0.648	1.911	0.088	7.386	<0.001
ES19_L2	0.649	1.913	0.085	7.665	<0.001
ES19_L3	0.973	2.647	0.086	11.360	<0.001
ES20_L2	1.273	3.571	0.104	12.256	<0.001
ES20_L3	1.725	5.610	0.101	17.032	<0.001
Share_Restoration	-0.00002	1.000	0.00001	-2.068	0.039

Note: Likelihood ratio test=1324 on 12 df, p=< 0.001, n= 6777, number of events= 2259

Estimated part worth of cultural services is given in Table 15. Part worth of ASC indicate that cascade community expects to receive a compensation of LKR 47,313.80 per household peer year under the status quo scenario where cultural services remains in their lower levels. In contrast to other cultural services, they are willing to forgo the highest compensation on behalf of the restoration of social cohesion, peace, harmony and humanity prevailed in the VTCS. In addition, they place a higher value on greater aesthetic value and amenity restored withing the VTCS.

Table 15. MWTP estimates of different levels of cultural ecosystem services

Variable	MWTP	2.5%	97.5%
ASC	(47,313.80)	(301,564.40)	(14,414.00)
ES16_L2	10,109.40	(452.20)	65,023.50
ES16_L3	8,300.50	(2,839.40)	58,606.70
ES17_L2	45,213.90	19,193.60	256,455.60
ES17_L3	61,945.30	28,379.50	344,549.40
ES18_L2	15,721.80	2,886.10	93,170.00
ES18_L3	31,975.60	12,564.90	193,321.80
ES19_L2	32,018.80	13,044.60	186,784.70
ES19_L3	48,045.60	20,766.40	281,670.20
ES20_L2	62,831.70	28,187.20	345,931.40
ES20_L3	85,126.10	38,638.20	475,222.90

Current status of VTCSs in terms of providing ecosystem services

During this study, we assessed the current status of all ecosystem services used in choice experiments based on their levels used in choice cards which could provide direction on how far VTCS restoration should be advanced. The assessment was done based on the cascade

community's perceived responses about the current conation of respective ecosystem services which the summary is provided in Table 16.

Current status of provisional services: Majority (54%) farmers are in the perception that they get sufficient irrigation for from their tanks. However, some tanks in Belankadawala cascade have water sufficient for the Maha season. The majority of the cascade community say that cascade water must be purified before drinking. At present, they mostly rely on the purified water. They say that tank water is not sufficient to be used for other purposes such as bathing, washing and livestock etc. Bothe services, supply of nonfood materials and food materials also currently remain at their lower levels.

Table 16. Summary of the assessment of ecosystem services

Ecosystem service	Levels of ecosystem services used in Choice Experiments		
	L1	L2	L3
Provisional services			
ES1 - Supply water for cultivation	8%	38%	54%
ES2 - Supply clean water for drinking	13%	65%	22%
ES3 - Supply water for washing/ bathing/ livestock/ other uses	47%	50%	3%
ES4 - Supply nonfood products (Reeds, firewood, medicinal materials etc.	35%	59%	6%
ES5 - Supply food materials (Bee honey, yams, leafy veg. etc.)	33%	60%	7%
Regulatory services			
ES6 - Recharge water table and maintain the flow	16%	22%	62%
ES7 - Water purification	35%	59%	5%
ES8 - Erosion and flood control	16%	68%	16%
ES9 - Regulate climate	9%	85%	6%
ES10 - Control human animal (elephant) conflict	23%	65%	12%
Support services			
ES11 - Provide habitats for plants and animals	26%	50%	24%
ES12 - Maintain biodiversity	4%	72%	24%
ES13 - Soil nutrient cycling	9%	62%	30%
ES14- Pollination	16%	64%	20%
ES15 - Biological control of pests and diseases	25%	59%	16%
Cultural services			
ES16 - Recreation	67%	24%	9%
ES17 - Aesthetic value and amenity	5%	57%	38%
ES18 - Traditional knowledge and education	19%	50%	31%
ES19 - Rituals	7%	67%	26%
ES20 - Social cohesion, peace, humanity and corporation	6%	40%	54%

Current status of regulatory services: Based on the community's perception, most of the situations grown water table is well recharged and maintain the water flow in VTCS. However, there are situations where well water is sufficient for either 10 months or less than 8 months of the year and tankas do not have their optimal capacity. The other regulatory services are currently largely at a moderate level.

Current status of support services: 50% of the community report that provision of habitats remains at its medium level. However, there are significant number of situations where provision of habitats remains either at its lowest level or highest level. Community witness that maintenance of biodiversity in VTCS is moderate. 24% of them believe that VTCS has higher biodiversity in some cases. They further confirm that nutrient recycling, pollination and biological control of plant pest and diseases are moderate within VTCS.

Current status of cultural services: The majority (67%) believe that recreational opportunities in the VTCS are currently minimal. However, there are cases where the recreational activities in VTCS are mediocre. 51% of the community believe that some in the VTCS still has traditional knowledge and education while 31% of them say that about 50% of the cascade community has traditional knowledge and education. Majority of the cascade community is in a perception that some of them still follow rituals inherent in the VTCSs. The majority of respondents believe that social cohesion in VTCS is still at a moderate or high level.

Benefit cost analysis of VTCS restoration: Thumbikulama case study

The capacity of Thumbikulama tank after renovation 2100 Acre feets which can provide an uninterrupted water supply for its downstream paddy lands of 600 – 700 acres during both Maha and Yala seasons. The community believe that there is a greater opportunity for paddy cultivation in an intermediate season. Moreover, it recharges few tanks dawn in the Bellankadawala VTCS. There is another cultivatable 600 acres of uplands in the immediate downstream of Thumbikulama tank. Our benefit cost analysis is based on this information confirmed by the community, various stakeholders and field observations.

Total expected annual cost incurred in crop and animal production under Thumbikulama tank

We assume that if cropping lands under Thumbikulama are duly released, the community (380 households) would cultivate paddy lands in full during both Maha and Yala season. Further, they would cultivate uplands during two seasons with combinations of few main crops: for Yala, maiz, big onion, sesame and five main vegetables viz. green chili, brinjal, tomato and pumpkin; for Maha, Maiz and five main vegetables viz. green chili, brinjal, tomato and pumpkin. These are the main crops currently cultivated by the community suburb Thumbikulama tank. In addition, they cultivate other crops that we have excluded from this analysis. Details of the total annual cost incurred in crop and animal production under Thumbikulama tank is given in Table 17.

Table 17. Total annual cost incurred on crop and animal production under Thumbikulama tank

Crop	Area (Acre)	Harvest (Kg/Acre)	COP for unit of product (LKR)	Total benefit per year (LKR)
Paddy in Maha season (Nadu)	650	2000	74.01	96,213,000.00
Paddy in Yala season (Nadu)	550	2000	74.01	81,411,000.00
Maiz in Maha season	350	1800	98.49	62,048,700.00
Maiz in Yala season	300	1800	98.49	53,184,600.00
Big onion in Yala season	250	9500	69.72	165,585,000.00
Sesame in Yala season	100	350	210.64	7,372,400.00
Vegetable in Maha				
Green chili	100	12500	75.82	94,775,000.00

Brinjal	50	14600	54.54	39,814,200.00
Tomato	50	9800	26.21	12,842,900.00
Pumpkin	50	12500	47.95	29,968,750.00
Vegetable in Yala				
Green chili	20	12500	75.82	18,955,000.00
Brinjal	10	14600	54.54	7,962,840.00
Tomato	10	9800	26.21	2,568,580.00
Pumpkin	10	12500	47.95	5,993,750.00
Animal	Size	Harvest/ Day		
Backyard poultry by 25% of the total households of 380	25 Birds	14 Eggs	14.38	20,146,175.00
Livestock (buffalo milk) - Two herds	25 cows	17.5 liters	44.10	2,541,840.00
Total cost of crop/ and animal production				**701,383,735.00**

Total expected annual benefits arising from crop and animal production under Thumbikulama tank

Total estimated annual benefit arising from crop and animal production by the community under Thumbikulama tank is provided in Table 18. Estimates were done on the basis of total production and farm gate price estimated for year 2023/2024 during this study. Land allocation for different crops is detailed in Table 18. In Yala season people tend to cultivate maize in lowlands and thus 100 Acres of lowlands were additionally allocated of maize instead of 200 Acre allocation of uplands. The crop diversity in Yala season found to be high which is a step taken by the community to reduce the risk of production due more draughts incidences in Yala. Further it was presumed that all crops hold same production levels in both seasons since the tank is capable of providing an un interrupted water supply. It efficiently recharges all agro-wells in uplands which assure a continuous water supply for upland crops. Farmgate price of crop and animal products very by the season which were counted in the analysis.

Table 18. Estimation of total annual benefits arising from crop and vegetable production under Thumbikulama tank.

Crop	Area (Acre)	Harvest (Kg/Acre)	Farmgate Price (LKR/Kg)	Total benefit per year
Paddy in Maha season (Nadu)	650	2000	101.98	132,574,000.00
Paddy in Yala season (Nadu)	550	2000	101.98	112,178,000.00
Maiz in Maha season	350	1800	111.98	70,547,400.00
Maiz in Yala season	300	1800	135.00	72,900,000.00
Big onion in Yala season	250	9500	146.30	347,462,500.00
Sesame in Yala season	100	350	580.00	20,300,000.00
Vegetable in Maha				
Green chili	100	12500	78.5	98,125,000.00
Brinjal	50	14600	130.25	95,082,500.00
Tomato	50	9800	81.70	40,033,000.00
Pumpkin	50	12500	26.70	16,687,500.00

Vegetable in Yala				
Green chili	20	12500	150.8	37,700,000.00
Brinjal	10	14600	130.25	19,016,500.00
Tomato	10	9800	125.00	12,250,000.00
Pumpkin	10	12500	50.00	6,250,000.00
Animal production	Farm Size	Harvest/ Day		
Backyard poultry by 25% of the total households of 380	25 Birds	14 Eggs	41.50	20,146,175.00
Livestock (buffalo milk) - Two herds	25 cows	17.5 liters	204.00	2,541,840.00
Total benefit from crop/livestock/ fisheries production)				**1,103,794,415.00**

Economic benefit of ecosystem services upon restoration of Thumbikulama tank

Thumbikulama tank was a completely dilapidated tank before its' 50% restoration in 2023. Downstream development has not yet taken place for various reasons, which is expected to happen in the future with the concurrence of relevant authorities. After the restoration activities taken place in the tank and the upstream, it takes naturally a significant time period tank components to get its original condition. Because this happens through a man induced natural succession.

Thumbikulama tank is the ideal tank in Bellankadawala VTCS to be developed as a pilot model to demonstrate how effective ecological restoration of the VTCS due to following reason.

- It is located in the upper cascade of the Belankadawala VTCS and is the third biggest tank in the cascade. Thus, it has the greatest potential for recharging tanks in the cascade system among the other tanks in the cascade.
- Since the tank has been abandoned and ignored over a long period time, all components in the Thumbikulama tank system remain undisturbed. There is a greater potential to develop it into as similar situation of an original VTCS in ancient time. This situation is not met with any of the other tanks in Bellankadawala cascade.
- Compared to the other tank systems in Bellankadawala VTCS, illegal encroachments and other anthropogenic activities are minimum in Thumbilulama tank system. This would facilitate the ecological restoration process with minimum social and political issues.
- Being the Thumbikulam an Olagam tank in a VTCS, the restoration process would be rather easy since activities for development of the hamlet (Gangoda) becomes minimum.

In this context we estimate the economic benefit of ecosystem services arising from Thumbikulama tank assuming 50% ecological restoration. Therefore, it is assumed that all ecosystem services should be currently operating at a moderate level (Table 08). Based on the findings presented in Table 16, about 48% of a VTCS provides ecosystem services at their intermediate level while 20% of cases overall ecosystem services are provided at their lowest level. Consequently, bringing all ecosystem services operational into their moderate level implies that the capacity CVTS to offer its ecosystem services has been improved by 20%. It can be concluded that we have achieved this situation through a 50% restoration of the Thumbikulama tank system.

Table 19. Total estimated economic value of ecosystem services offered by Thumbikulama tank system after it's partial restoration.

Ecosystem service	Value per household per year	Total value per year
Provisional services		
ES1_L2	17,943.68	6,818,598.40
ES2_L2	6,405.16	2,433,960.80
ES3_L2	18,464.39	7,016,468.20
ES4_L2	13,764.73	5,230,597.40
ES5_L2	2,499.47	949,798.60
Total value per year		*22,449,423.40*
Regulatory services		
ES6_L2	4,527.80	1,720,564.00
ES7_L2	10,834.50	4,117,110.00
ES8_L2	581.30	220,894.00
ES9_L2	3,394.60	1,289,948.00
ES10_L2	12,003.00	4,561,140.00
Total value per year		*11,909,656.00*
Support services		
ES11_L2		5,913,370.00
ES12_L2	32,192.80	12,233,264.00
ES13_L2	4,986.40	1,894,832.00
ES14_L2	40,730.60	15,477,628.00
ES15_L2	7,749.40	2,944,772.00
Total value per year		*38,463,866.00*
Cultural services		
ES16_L2	10,109.40	3,841,572.00
ES17_L2	45,213.90	17,181,282.00
ES18_L2	15,721.80	5,974,284.00
ES19_L2	32,018.80	12,167,144.00
ES20_L2	62,831.70	23,876,046.00
Total value per year		*63,040,328.00*
Annual grand total		**135,863,273.40**

The cost of restoration and maintenance of Thumbikulama tank system

The cost of 50 percent restoration of Thumbikulama tank is LKR 52 million funded by the Healthy Landscape Project (HLP) implemented by SACEP and Ministry of Environment, Sri Lanka. The restoration work was completely carried out by the Department of Agrarian Development (DAD), Anuradhapura. The maintenance of the system is looked after jointly by the community and DAD which the cost is not very straight forward. Further, other stakeholders such as Irrigation Department, Department of Agriculture, District Secretariate, Divisional Secretariate and many other organizations are intervening to the maintenances and sustainable development of this system in the long run which the cost is difficult to be counted.

In this assessment, the some restoration costs and maintenance costs was estimated for a five year period since 2024, based on the approximate expenses borne by both the community and DAD. The total annual allocation of DAD, Anuradhapura is approximately LKR 250 million in 2024

which is basically to maintain 3417 tanks distributed among 469 VTSCs under the preview of DAD. For Thumbikulama, it is assumed that DADs' contribution would take place only through the KICKSTART program form which LKR 500,000.00 is expected annually for necessary maintenance and development of the tank system. Restoration investment of downstream development is approximately estimated to LKR 65 million which is expected form future funding opportunities. If we broadly, part of capital and recurrent expenses stakeholders directly and indirectly contribute to restoration, management and maintenance of Thumbikulama tank system.

Community contribution: Thumbukulama community have newly established a farmer organization which current designated job role is water management and minor maintenance of the tank system. Their contribution take place through provision of community labor for management, security and minor repair of the tank and components. Approximately they contribute 20 labor units per month which the value is estimated at the rate of LKR 2,000.00 per day. The estimated investment of restoration and annual estimated expenditure of maintenance ang management is summarized in Table 20.

Table 20. estimated investment of restoration and annual estimated expenditure of maintenance ang management

Item	Initial investment	Labor units	Rate	Annual allocation
Restoration of the tank and upstream (Actual)	52,000,000.00			
Restoration of the downstream of the tank (Estimated)	65,000,000.00			
DADs' contribution – KICKSTART program				500,000.00
Community contribution - in terms of labor per year		240	2,000.00	480,000.00
Total				980,000.00

The cost and benefit streams by different components over five-year period are provided in Table 21 which was used for benefit cost analysis. This includes both tangible and intangible costs and benefits. The costs, prices can vary annually with the inflation of the country which we didn't consider in this analysis. It could lead to some misspecification of the cost benefit analysis which will not pointedly harm the general picture of the outcome the analysis and the significance of ecological restoration of VTCSs. This could be considered in future analysis with more research and information. The economic discount rate used in the analysis is 8%.[5]

Table 21. Costs and Benefits streams used in the benefit cost analysis on VTCS restoration

Item	Investment	Year 1 (2024)	Year 2 (2025)	Year 3 (2026)	Year 4 (2027)	Year 5 (2028)
Cost						
Investment on upstream development (Actual)	52,000,000.00					
Investment on downstream development (Estimated)	65,000,000.00					
DADs' contribution		500000	500000	500000	500000	500000

[5] Vidanage, S. P. (2018). *Economic value of an ancient small tank cascade system in Sri Lanka* (Doctoral dissertation). http://archive.cmb.ac.lk:8080/research/bitstream/70130/6526/1/D%20162.pdf

Community contribution		480000	480000	480000	480000	480000
Crop and animal production		701,383,735.00	701,383,735.00	701,383,735.00	701,383,735.00	701,383,735.00
Total cost	**117,000,000.00**	**702,363,735.00**	**702,363,735.00**	**702,363,735.00**	**702,363,735.00**	**702,363,735.00**
Benefits						
Crop and animal production		1,103,794,415.00	1,103,794,415.00	1,103,794,415.00	1,103,794,415.00	1,103,794,415.00
Provisional services		22,449,423.40	22,449,423.40	22,449,423.40	22,449,423.40	22,449,423.40
Regulatory services		11,909,656.00	11,909,656.00	11,909,656.00	11,909,656.00	11,909,656.00
Support services		38,463,866.00	38,463,866.00	38,463,866.00	38,463,866.00	38,463,866.00
Cultural services		63,040,328.00	63,040,328.00	63,040,328.00	63,040,328.00	63,040,328.00
Total benefit		**1,239,657,688.40**	**1,239,657,688.40**	**1,239,657,688.40**	**1,239,657,688.40**	**1,239,657,688.40**

Estimates of benefit-cost analysis conducted for three scenarios of Thumbikulama tank restoration are presented in Table 22. No crop production is taking place under the current scenario of the tank restoration because the downstream of the tank still need to be restored. However, as a result of partial restoration it is offering numerus ecosystem services which the economic value was estimated in this study and make available for future use. At the moment the cost of maintenance and the management of the tanks is less. We can see with the result of BCA (Scenario A) the benefits of restoration are extremely over the investment and other costs. IRR indicates that the investment is highly worth. The impact of ecosystem services is clearly visible onsite. For examples;

- ✓ The elephant human conflict in Thumbikulama and adjacent villages has substantially controlled since the system has provided elephants with sufficient water, food and habitats.
- ✓ In addition, it has provided habitat for number other plants and animals viz. Crocodiles, indigenous fishes (Thambalaya), many bird species which were not observed before the tank was restored.
- ✓ Well water level in surrounding villages remained significantly high even during the prolonged drought in 2023 -2024 which didn't happen before.
- ✓ Even though tanks in the downstream were successfully recharged during last draught periods, there were plenty of water observed in the tank providing its ecosystem services unchanged.

Table 22. Estimates of benefit-cost analysis conducted for three scenarios of Thumbikulama tank restoration

Scenario	NPV (LKR)	BCR	IRR
A. Investment on 50% restoration + Ecosystem service + maintenance (current scenario)	486,549,799.54	9.70	176.8%
B. Investment on complete restoration + Only crop and animal production + maintenance (Conventional BCA)	1,489,709,161.06	1.51	262.1%
C. Investment on full restoration + Ecosystem services + Crop animal production + maintenance (EBCA)	2,028,258,960.60	1.69	318.0%

Duration: Five (05) years; Discount rate: 8%

With the benefits from ecosystem are significantly higher, the breakeven point of tank restoration falls withing the first year after restoration. The scenario B is a conventional benefit cost analysis where the fanatical value of tangible benefits and costs of crop production and animal production has been considered. If the total area was cultivated then the benefits would be substantially over the costs in terms of their discounted values. Hight IRR indicate the higher worth of this

investment. Scenario C is about the value of a fully restored tank system, which is also very worthwhile to continue.

CONCLUSIONS AND RECOMMENDATIONS

Ecosystem services arising from VTCS: The cascade community aware about the ecosystem services arising from VTCS. Apart from crop, animal and fisheries production, the key provisional service of VTCS, they recognize provision of irrigation water, provision of water for drinking, provision of water for other purposes viz. use for livestock production, bathing, washing etc., provision of nonfood products viz. fire wood, fiber, herbal medicine, flowers etc. and provision of nonagricultural food products viz. wild honey bee, yams, leafy vegetables etc. as main provisional ecosystem services arising from VTCSs.

Among regulatory ecosystem services of VTCS, they prioritize soil erosion and flood control, regulating ground table and water flow, regulating human animal conflict, regulating the climate and water purification as the most important regulatory services. Recreation, aesthetic value and amenity, traditional knowledge and education, rituals, social cohesion and ecotourism were recognized as key cultural services arising from VTCS. Main support services recognized by the cascade community are respectively, nutrient recycling, provision of habitats, maintenance of biodiversity, pollination and biological control of peat and diseases.

Current status of the provision of ecosystem services by VTCSs: During the assessment we considered three scenarios of the level of ecosystem provision, low level, medium level and high levels. Medium values are expected when VTCS is partially functioning, while high values are expected when VTCS is fully functioning. Half of the instances water is sufficiently provided for cultivation within the VTCS. Rest of the cases water is either insufficient of partially sufficient for cultivation. Mostly tank water in the cascade system is unable to readily drink. However, it can be consumed with purification. Supply of water for other purposes viz. washing, bathing and use for animals doesn't seem good as mentioned by the community. Supply of nonfood items and other food items are not in their full capacity. Overall, supply of nonmarket provisional services from VTCS remain at a moderately sufficient level.

Out of the regulatory services of VTCS, recharging water table water flow remains at a significant level as the majority of the community pointed out. However, rest of the key regulatory services are offering at either an insufficient level of moderately sufficient level. The community is not happy with the level of water purification and the control of human elephant conflict by the cascade system.

All key cultural services that arise in the VTCS are either insufficiently or moderately sufficiently offered in the current context. Majority of the cascade community believe that recreational services offered by VTCS are currently a very few. However, according to the community, we can conclude that the social cohesion remains substantially withing the cascade system.

Similarly, as regulatory services all key support services are mostly offered moderately sufficiently by the system. There are significant incidences that provisions of habitats and biological control are insufficient. However, for some instances mainstreaming biodiversity and soil nutrient recycling are taking place very efficiently.

In conclusion it can be inferred that overall provision of ecosystem services by VTCSs is mostly insufficient of moderately sufficient as a consequent of degraded nature of VTCS at present. Necessary actions are need to improve current status of VTCSs.

Economic value of provisional services: It can be concluded that the cascade community is more inclined to choose key provisional services scenarios than the status quo situation. They will be more willing to contribute to the restoration of the VTCS if key provisional services are increased. They would like to receive compensation of LKR 8,513 per household per year if the VTCS status quo status of provisional services continues. They are willing to forgo significant amount of money on behalf of restoration of provisional services offered by the VTCS. The gives an assurance for community's support for restoration processes of VTCSs. The highly values provisional services is provision of irrigation water which is the man function of VTCS. They are even to forgo a benefit worth LKR 61,290.56 per household per year on behalf of assuring sufficient water for both cultivation seasons. They are willing to pay substantial amounts on behalf of assuring high-levels of water for other purposes and sufficient amounts nonagricultural food commodities available in VTCSs.

Economic value of regulatory services: It can be inferred that cascade community is less likely to choose any of regulatory ecosystem scenarios presented in the study. However, they are willing to forgo some contribution maximum annually on behalf of restoring regulatory service at a significantly sufficient level withing the VTCS. They most value regulation of the human elephant conflict willing to forgo LKR 26,765.10 per household per year if this conflict is resolute sufficiently.

Economic value of cultural services: The Cascade Community supports the presented cultural service scenarios in contrast to the status quo of VTCS in this study. They are willing to contribute for CTVS restoration looking for higher levels of cultural services. They attach great importance to aesthetic value and amenity as well as social cohesion, equality, peace and harmony and are willing to pay even LKR 85,126.10 if they are restored to a high standard.

Economic value of support services: It is concluded that the cascade community is more likely prefer a different scenario than underlying scenarios of the support services offered by VTCSs. The have a broader preference on other ecosystem services scenarios and willing to pay for it at most LKR 199,291 per household annually which should further identify.

We finally conclude that cascade community are interested in receiving higher benefits of ecosystem services and willing to contribute substantially to the restoration process. We draw this to the attention of decision makers and recommend to take necessary steps to support VTCS restoration.

Benefit cost of VTCS restoration: It can be concluded that all benefits of restoration extremely exceeds the investment of restoration and all other associated costs. Benefit cost analysis exclusively revealed that the investment on restoration of Thumbikulama tank is highly worth. The impact of ecosystem services were clearly visible onsite. For examples;

- ✓ The elephant human conflict in Thumbikulama and adjacent villages has substantially controlled since the system has provided elephants with sufficient water, food and habitats.
- ✓ In addition, it has provided habitat for number other plants and animals viz. Crocodiles, indigenous fishes (Thambalaya), many bird species which were not observed before the tank was restored.
- ✓ Well water level in surrounding villages remained significantly high even during the prolonged drought in 2023 -2024 which didn't happen before.

- ✓ Even though tanks in the downstream were successfully recharged during last draught periods, there were plenty of water observed in the tank providing its ecosystem services unchanged.

We recommend taking the necessary measures to continue the full restoration process of the Thumbikulama Village Tank.

ANNEXTURE

A. Semi structured questionnaire used for data collection of the choice experiment

Ecosystem service valuation survey jointly done by HLP and WUSL – 2024

QUESTIONNAIRE

Questionnaire No:	Enumerator:

A. ජනවිකාස තොරතුරු

පුද්ගලික /පවුලේ තොරතුරු :

පුද්ගයාගේ නම				දිස්ත්‍රික්කය		ප්‍රා .ලේ .කොා					
ගම් ප්‍රදේශය		එල්ලංගාවේ නම			වැවේ නම						
වයස		ස්ත්‍රී/පුරුෂ භාවය		විවාහක/අවිවාහක බව		පවුලේ ප්‍රමාණය					
පවුලේ සාමජිකයන්	දරුවන්		යෞවනයින්		වැඩිහිටියන්		මහල්ලන්		රැකියාව		
GPS				Telephone:							

රැකියාව: 1. –පෞද්ගලික අංශයේ, 2. – රාජ්‍ය අංශයේ, 3. – ස්වයං රැකියා, 4. – ගොවිතැන්; ස්ත්‍රී/පුරුෂ භාවය: 1 – පිරිමි, 2 – ගැහැණු; විවාහක/අවිවාහක බව: 1 – විවාහකයි, 2 – අවිවාහකයි, 3 - වෙනත්

Notes: Explain the nature of the job

පවුලේ මාසික දළ අදායම

<25,000		25,000-50,000		50,000 – 100,000		100,000 – 200,000		200,000 – 500,000		>500,000	

අධ්‍යාපනය

7 වසර දක්වා		සා.පෙළ දක්වා		උ.පෙළ දක්වා		උ.පෙළ සමත්		උපාධිදාරී	
පශ්චාත් උපාධිදාරී		වෙනත් (විශේෂිත):							

B. දැනුම කොටස: මෙම කොටසින් එල්ලංගා පද්ධතියේ තොරතුරු, කායර්යන් සහ පරිසර පද්ධති සේවා පිළිබඳ දැනුම පරීක්ෂා කරන්නෙමු. මේ සඳහා "ඔව් ", "නැත " ප්‍රශ්න මාලාවක් භාවිතා කරයි

වගන්ති	ඔව්	නැත	විශ්වාස නැත
1. එල්ලංගා පද්ධතිය යනු වියළි කාලයේදී කෘෂිකර්මාන්තය සඳහා ජලය සපයා ගැනීමට මිනිසා විසින් සාදන ලද වාරි පද්ධතියකි.			
2. එල්ලංග පද්ධති සියවස් ගණනාවක් පුරා පවතින අතර ස්වභාවික පරිසර පද්ධතියකට බොහෝදුරට සමාන වේ			
3. එල්ලංගා පද්ධතිය මගින් දේශගුණික විපර්යාසවල අහිතකර බලපෑම් අවම කරන අතර ඒවාට ඔරොත්තු දීමේ හැකියාව ගොඩනඟයි.			
4. එල්ලංගා පද්ධතිය යනු දේශගුණික සුකුරු වාරිමාගර් පද්ධතියකි			
5. එල්ලංගා පද්ධතිය භූගත ජල මට්ටම පවත්වා ගැනීමට සහ ජල ප්‍රවාහය නියාමනය කරයි.			

6. එල්ලංගා පද්ධතිය ශ්‍රී ලංකාවට පමණක් ආවේණික දෙයක් නොවේ			
7. වතර්මානයේදී එල්ලංගා පද්ධතිය සහ එහි ක්‍රියාකාරීත්වය පිරිහී ගොස් ඇත			
8. එල්ලංගා පද්ධතිය සතුන්ට හා ශාක වලට වාසභූමි සපයන අතර පරාගණය සඳහා දායක වේ			
9. එල්ලංගා පද්ධතිය තුළ පාරිසරික සංචාරක ව්‍යාපාරය සඳහා ඉහළ විභවයක් පවතී.			
10. චාරිත්‍ර සහ චාරිත්‍ර, දෘශ්‍යමාන සුන්දරත්වය සහ විනෝදාස්වාදය එල්ලංග පද්ධතිය විසින් සපයනු ලබන සංස්කෘතික සේවාවන් කිහිපයකි.			

ප්‍රධාන වචන පදනම් කරගත් දැනුම පරීක්ෂා කිරීම: (ඔබ පහත සඳහන් දෑ ගැන අසා තිබේ ද)

පදය / ප්‍රධාන වචනය	ඔබ කවදා හෝ මෙම අයිතමය ගැන අසා තිබේ ද? (ඔව් නෑ)	ඔබ මෙම යෙදුම ඇසුවේ කොහෙන්ද? (යතුර 1 භාවිතා කරන්න)	ඔබට මෙම යෙදුම කොපමණ වාරයක් අසන්නට ලැබේ ද? (යතුර 2 භාවිතා කරන්න)	මෙම යෙදුම පිළිබඳ ඔබේ සමස්ත දැනුම කුමක් ද? (යතුර 3 භාවිතා කරන්න)
1. එල්ලංගා පරිසර විද්‍යාව				
2. ජෛව විවිධත්වය				
3. පරිසර පද්ධති ප්‍රතිස්ථාපනය				
4. පරිසර සංරක්ෂණය				
5. දේශගුණික විපර්යාස, ඔරොත්තු දීමේ හැකියාව සහ අවම කිරීම				
6. පරිසර පද්ධති සේවා				
7. තිරසාර බව				
8. පැවතීමේ වටිනාකම /භාවිත නොකරන දෙවල්හි අගය				
9. ජලය කළමනාකරණය				
10. එල්ලංගා වැව් පද්ධතිය				

යතුර 1: 1 – TV/ ගුවන් විදුලිය, 2 – පත්තර/ සඟරා/ පොත්, 3 – අන්තජර්ාලය/ සමාජ මාධ්‍ය, 4 – මිතුරන්/ ඥාතීන්/ විෂය ප්‍රවීණයන්, 5 – අධ්‍යාපනය හරහා, 6 – වෙනත්(නිශ්චිත)

යතුර 2: 1 – බොහෝ විට, 2 – ඉඳහිට, 3 – එක් වරක් හෝ දෙවරක් පමණි

යතුර 3: 1 – ඉතා අඩුයි/ දන්නේ නැහැ, 2 – අඩුයි, 3 – අඩුවෙන් හෝ වැඩියෙන් හෝ නොදනී , 4 – සාමාන්‍යයි, 5 –ඉහළයි

C. එල්ලංගා පද්ධතිය සහ එහි ප්‍රතිස්ථාපනය පිළිබඳ කොරතුරු සපයන්නන්ගේ අවබෝධය (යතුර 4 භාවිතා කරන්න)

වගන්තිය	අවබෝධය
1. එල්ලංගා පද්ධතිය පරිසර විද්‍යාත්මකව ප්‍රතිස්ථාපනය කළ යුතුයි	
2. එල්ලංගා පද්ධතියක වැව ඇතුළු අනිකුත් සියළු කොටස් නඩත්තු කොට පෙර සේ පවත්වාගෙන යාහැකිය	
3. දියගිල්ම සහ ජල පෝෂක ප්‍රදේශය අතර භූමි අනුපාතය පෙරදවස මෙන් වතර්තමානයේදීද පවත්වාගෙන යෑමට හැකියාව ඇත	
4. වැව සහ එයට අයත් ප්‍රදේශයන්හි නීති විරෝධී අත්පත් කරගනීම්, අනවසර පදිංචිවීම් සහ පරිහරණයන් ආපසු හැරවිය හැකියි (නැවැත්විය හැකිය)	
5. එල්ලංගා පද්ධතිය ප්‍රතිස්ථාපනය සහ නඩත්තුකොට පවත්වාගෙන යාම සඳහා ගාස්තුවක් /බද්දක් එහි ප්‍රජාවෙන් අය කල යුතුයි	
6. එල්ලංගා පද්ධතියේ වතර්මාන තත්ත්වය සහ පැවැත්ම සතුටුදායකය	

7. එල්ලංගා පද්ධතිය තුළ පරිසර සංචාරක ව්‍යාපාරය ප්‍රවර්ධනය කළ යුතුයි	
8. එල්ලංගා වැවු පද්ධතිය අනාගත පරපුර සඳහා සංරක්ෂණය කොට ආරක්ෂා කරගත යුතුය	
9. එල්ලංග පද්ධතිය නිසි ලෙස ප්‍රතිස්ථාපනය කොට පවත්වාගෙන යාම සඳහා නිසි අණ පනත් නොමැත	
10. එල්ලංගා පද්ධතිය නිසි ලෙස ප්‍රතිස්ථාපනය කිරීම තුලින් එහි පරිසරපද්ධති සේවාවන් නිසි පරිදි සපයා ගත හැකි අතර ප්‍රදේශයේ සමාජ ආර් ථික තත්ත්වය සැලකිය යුතු ලෙස ඉහල දැමිය හැක. එනයින් රටේ ආර්ථික සංවර්ධනය ඉහළ දැමිය හැකිය.	

යතුර 04: 1 – දැඩි ලෙස එකඟ නොවේ, 2 – එකඟ නොවේ, 3 – එකඟ නොවන්නේ හෝ එකඟ වන්නේ නැත, 4 – එකඟයි, 5 – දැඩි ලෙස එකඟයි

D. එල්ලංගා පද්ධතිය වෙතින් ලබා දෙන පරිසර පද්ධති සේවාවන් හි වත්මන් තත්ත්වය ඇගයීම

පරිසර පද්ධති සේවා	ඇගයීම		
ප්‍රතිපාදන සේවා			
වගාව සඳහා ජලය සැපයීම	මහට නොසෑහෙ	මහට පමණක් සෑහේ	මහට සහ යලට සෑහේ
වෙනත් භාවිතයන් සඳහා ජලය සැපයීම *(සේදීම / නෑම / සතුන් සඳහා)*	මාස *8* හෝ අඩු කලකට සෑහේ	මාස *10* කට පමණ සෑහේ	වසර පුරා පවතී
වැවෙන් පානීය ජලය සැපයීම	කිසි සේ බීමට නොහැක	පිරිසිදුකොට බීමට ගතහැක	කෙලින්ම බීමට ගතහැක
ආහාරමය නොවන ද්‍රව්‍ය සැපයීම*(දර, පන්, ඕලු , නෙළුම් ,මානෙල් වැනි මල් වගර්)*	ඉතා සුළු වශයෙන් පවතී	පවතී, ඉල්ලුම සපුරාලිය නොහැක	පවතී, ඉල්ලුම සපුරාලිය හැක
ආහාරයට ගත හැකි ද්‍රව්‍ය සැපයීම.*(මීපැණි ,පලතුරු,අලවගර් ,ඖෂධ පැළෑටි)*	ඉතා සුළු වශයෙන් පවතී	පවතී, ඉල්ලුම සපුරාලිය නොහැක	පවතී, ඉල්ලුම සපුරාලිය හැක
නියාමන සේවා			
පාංශු ජල මට්ටම සහ ජල ප්‍රවාහය පවත්වාගෙන යාම	ලිං වල ජලය මස *8*ක් පමණ පවතී	ලිං වල ජලය මස *10*ක් පමණ පවතී	ලිං ජලය වසර පුරා පවතී
ජල පිරිසිදු කිරීම	වෙල්පහු ජලය හා වැවට එන ජලය අපිරිසුදුය	වෙල්පහු ජලය හා වැවට එන ජලය තරමක් පිරිසුදුය	වෙල්පහු ජලය හා වැවට එන ජලයඉතා පිරිසිදුය
පාංශු බාදනය සහ ගංවතුර පාලනය	සිදුනොවේ	යම් පමණකට සිදුවේ	ඉතා හොඳින් සිදුවේ
දේශගුණය නියාමනය කිරීම	සිදුනොවේ	යම් පමණකට සිදුවේ	ඉතා හොඳින් සිදුවේ
අලි මිනිස් ගැටුම පාලනය කිරීම	සිදුනොවේ	යම් පමණකට සිදුවේ	ඉතා හොඳින් සිදුවේ
උපකාරක සේවා			
ශාක සහ සතුනට වාසභූමි සැපයීම	වර් ගයකට හෝ අඩුවෙන්	වර් ග *2-3* කට	බොහෝ වරග වලට
ජෛව විවිධත්වය පවත්වා ගෙන යාම	ඉතා අඩුයි *(කුරුළු වරග <4)*	සාමාන්‍ය වශයෙන් *(කුරුළු වරග 8 පමණ)*	බහුලය *(කුරුළු වරග >12)*
පාංශු පෝෂක චක්‍රය පවත්වා ගෙන යාම	ඉතා අවම මට්ටමින් පවතී	යම් පමණකින් සිදුවේ	ඉතා හොඳින් සිදුවේ
පරාගණය	මිමැස්සන් වගාබිම් තුල දුලර්භය	මිමැස්සන් ටිකදෙනෙක් වගාබිම් තුල දැකිය හැකිය	මිමැස්සන් වගාබිම තුල බහුලව දැකිය හැකිය
ශාක හා සත්ව ලෙඩ රෝග ජෛව පාලනය	ඉතා අවම මට්ටමින් පවතී *(රසායනික පාලනය අතවශ්‍ය වේ)*	යම් පමණකින් සිදුවේ *(රසායනික පාලනය යම් දුරකට අවශ්‍ය වේ)*	ඉතා හොඳින් සිදුවේ *(රසායනික පාලනය අවශ්‍ය නොවේ)*

සංස්කෘතික සේවා			
විනෝද ක්‍රියාකාරකම් සැපයීම	ඉතා සුළු වශයෙන් පවතී	ක්‍රියාකාරකම් කිහිපයක් *(<5)* පවතී	ඉතා බහුලව පවතී
දෘශ්‍යමය සුන්දරත්වය සහ ඒ සඳහා වූ පහසුකම් සැපයීම	අවමය	මධ්‍යස්තව පවතී	ඉතා අලංකාරය
අධ්‍යාපනික/ සාම්ප්‍රදායික දැනුම	ඉතා සුළු පිරිසක්	යම් පිරිසක් *(<25%)*	බහුතර පිරිසක් *(>50%)*
චාරිත්‍ර චාරිත්‍ර	ඉතා සුළු පිරිසක්	යම් පිරිසක් *(<25%)*	බහුතර පිරිසක් *(>50%)*
සාමය, මනුෂ්‍යත්වය සහ අන්තර් සම්බන්ධතා ඇතිකිරීම	අවමය	මධ්‍යස්ථව පවතී	ඉතා හොඳින් පවතී

E. CE **ප්‍රශ්නවලට පිළිතුරු: තොරතුරු සපයන්නන් එක් එක් තේරීම් කාඩ්පත් (තේරීම ප්‍රශ්නය) සමඟ ලබා දී ඇති විකල්පයන්ට ඔවුන්ගේ තේරීම ලබා දිය යුතුය.**

කාණ්ඩය/ Block	1	2	3	4	5

ප්‍රශ්නය	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
තේරීම									

යතුර E: 1 - තේරීම 1, 2 - තේරීම 2; 3- මින් එකක්වත් නොවේ

Notes/ Observations

F. මහ සහ යල කන්නයන්හි වගා කරන භෝග සහ සත්ව පාලනය පිළිබඳ තොරතුරු

භෝගය	**ගොඩ/ මඩ**	**කන්නය**	**අරමුණ**	**වගා කල ප්‍රමාණය (Ac)**		**අස්වැන්න (Yield/ Ac)**		**විකුණුම් මිල**		**දළ වියදම**	
				යල	**මහ**	**යල**	**මහ**	**යල**	**මහ**	**යල**	**මහ**

යතුර 05: 1 - ගොඩ; 2 - මඩ **යතුර 06:** 1 - මහ; 2 - යල **යතුර 07:** 1 - ගෙදර කෑමට; 2 - විකිනීමට

පශුසම්පත්			කුකුළු පාලනය		මිරිදිය මත්ස්‍යයන්
ගවපාලනය	එළුවන්	වෙනත්	බිත්තර	මස්	

Notes/ Observations

B. Sample choice cards used for estimation of economic value of ecosystem services

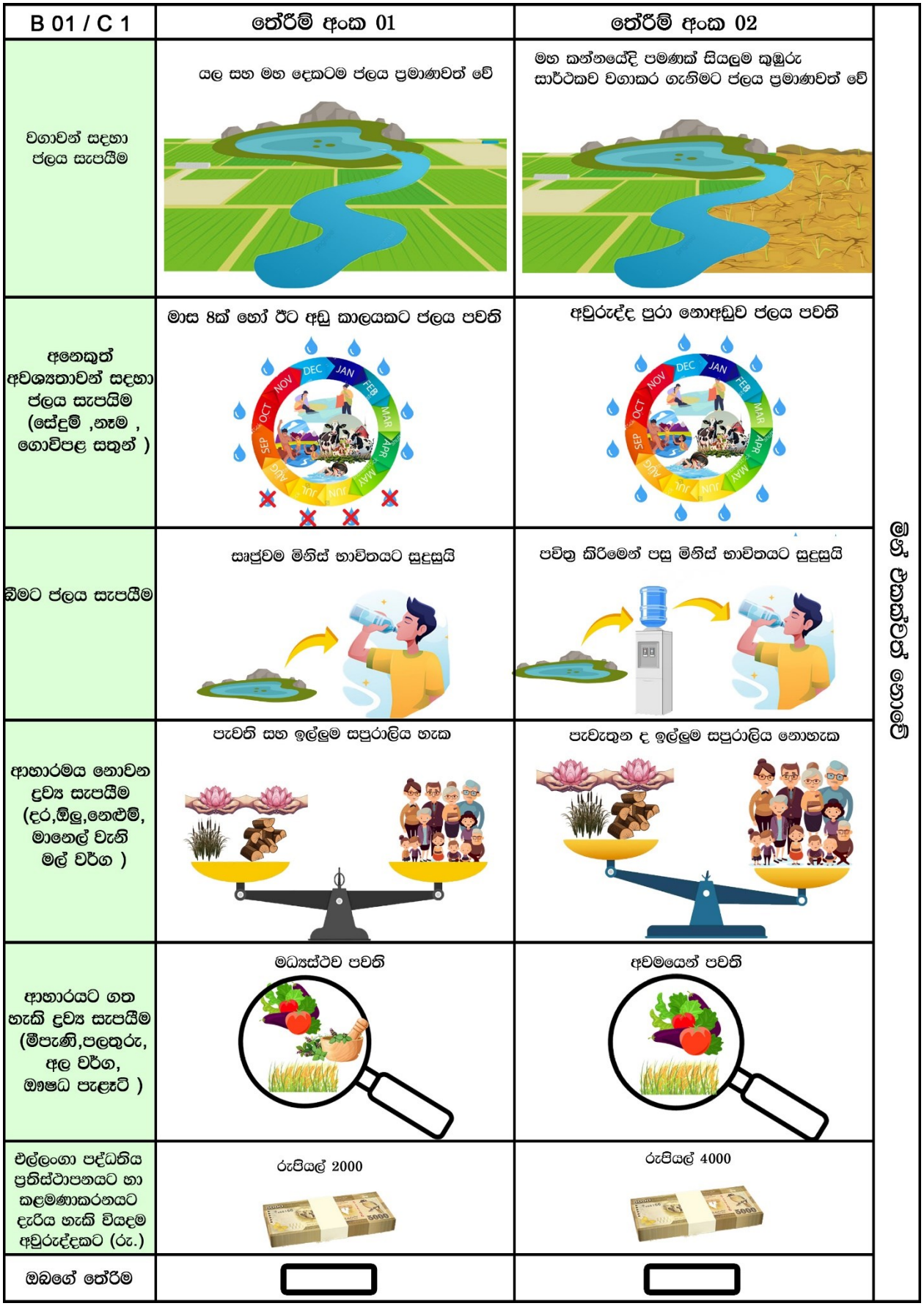


Figure B1. Choice card 01 in block 01 used in the choice experiment to estimate economic value of provisional services

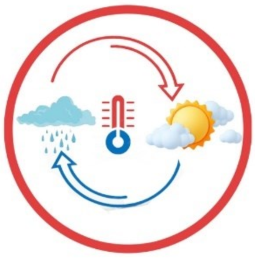
B 04 / C 9	තේරීම් අංක 01	තේරීම් අංක 02	මින් එකක්වත් නොවේ
පාංශු ජල මට්ටම සහ ජල ප්‍රවාහය පවත්වා ගෙන යාම	ලිං වල ජලය මාස 8ක් පමණ පවති 	ලිං වල ජලය මාස 8ක් පමණ පවති 	
ජල පිරිසිදු කිරීම	වෙල්පහු ජලය හා වැවට එන ජලය තරමක් පිරිසිදුය 	වෙල්පහු ජලය හා වැවට එන ජලය ඉතා පිරිසිදුය 	
පාංශු ඛාදනය සහ ගංවතුර පාලනය	යම් පමණකට සිදුවේ 	යම් පමණකට සිදුවේ 	
දේශගුණය නියාමනය කිරීම	ඉතා හොඳින් සිදුවේ 	සිදුනොවේ 	
අලි මිනිස් ගැටුම පාලනය කිරීම	ඉතා හොඳින් සිදුවේ 	යම් පමණකට සිදුවේ 	
එල්ලංගා පද්ධතිය ප්‍රතිස්ථාපනයට හා කළමණාකරනයට දැරිය හැකි වියදම අවුරුද්දකට/පවුලකට (රු.)	රුපියල් 6000 	රුපියල් 6000 	

Figure B2. Choice card 09 in block 04 used in the choice experiment to estimate economic value of regulatory services

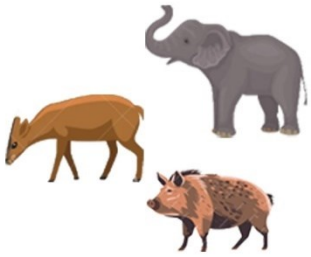
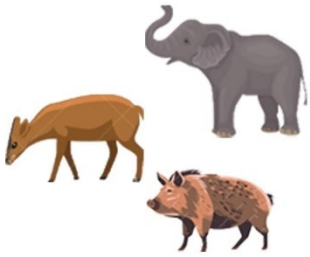
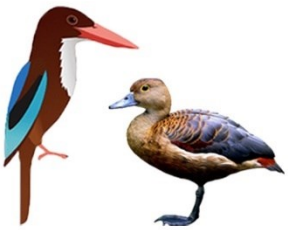
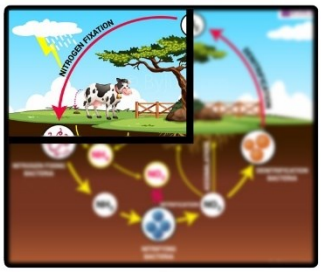
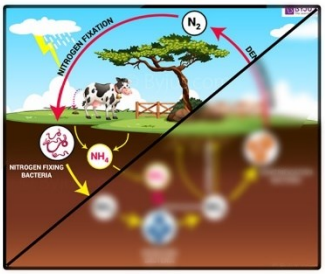
B 02 / C 5	තේරීම් අංක 01	තේරීම් අංක 02
ශාක සහ සතුන් සඳහා වාසස්ථාන සැපයීම	වර්ග 2-3 කට වාසස්ථාන සපයයි 	වර්ග 2-3 කට වාසස්ථාන සපයයි 
ජෛව විවිධත්වය පවත්වා ගෙන යාම	ඉතා අඩුයි (කුරුළු වර්ග< 4 / සුළු සංඛ්‍යාවක්) 	සාමාන්‍ය වශයෙන් (කුරුළු වර්ග 8 පමණ) 
පරාගණය	මී මැස්සන් ටික දෙනෙක් වගාබිම් තුල දැකිය හැකිය 	මී මැස්සන් ටික දෙනෙක් වගාබිම් තුල දැකිය හැකිය 
පාංශු පෝෂක චක්‍රය පවත්වා ගෙන යාම	ඉතා අවම මට්ටමින් පවති 	යම් පමණකින් සිදුවේ 
ජීව විද්‍යාත්මකව පළිබෝධකයින් හා රෝග පාලනය	යම් පමණකින් සිදුවේ (රසායනික පාලනය දුරකට අතවශ්‍ය වේ) 	යම් පමණකින් සිදුවේ (රසායනික පාලනය දුරකට අතවශ්‍ය වේ) 
එල්ලංගා පද්ධතිය ප්‍රතිස්ථාපනයට හා කළමණාකරණයට දැරිය හැකි වියදම අවුරුද්දකට/පවුලකට (රු.)	රුපියල් 2000 	රුපියල් 4000 

Figure B3. Choice card 05 in block 02 used in the choice experiment to estimate economic value of support services

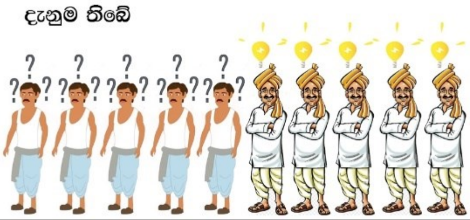
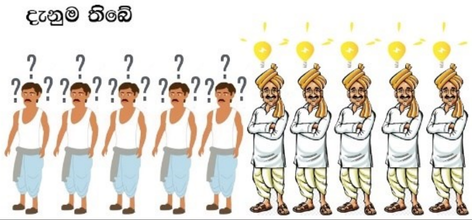
B 05 / C 1	තේරීම් අංක 01	තේරීම් අංක 02	මින් එකක්වත් නොවේ
විනෝද ක්‍රියාකාරකම් සහ මානසික හා ශාරීරික සෞඛ්‍යය	ක්‍රියාකාරකම් පහක් පමණක් ඇත 	ක්‍රියාකාරකම් පහක්ට වඩා වැඩි ප්‍රමාණයක් ඇත 	
සොබා දහමේ සුන්දරත්වය සහ ප්‍රසන්නත්වය	මධ්‍යස්ථයි 	අවමයි 	
සම්ප්‍රදායික දැනුම හා ඒ පිළිබඳ අධ්‍යාපනය	සමස්ථ ප්‍රජාවෙන් 50% පමණ පිරිසකට සම්ප්‍රදායික දැනුම තිබේ 	සමස්ථ ප්‍රජාවෙන් 50% පමණ පිරිසකට සම්ප්‍රදායික දැනුම තිබේ 	
පාරම්පරික චාරිත්‍ර වාරිත්‍ර	සුළු පිරිසක් චාරිත්‍ර අනුගමනය කරයි 	බහුතරයක්(50% පමණ පිරිසක්) චාරිත්‍ර අනුගමනය කරයි 	
සමාජ සහයෝගීතාව සහ අන්තර් සම්බන්ධතා	මධ්‍යස්ථයි 	මධ්‍යස්ථයි 	
එල්ලංගා පද්ධතිය ප්‍රතිස්ථාපනයට හා කළමණාකරනයට දැරිය හැකි වියදම අවුරුද්දකට (රු.)	රුපියල් 9000 	රුපියල් 4000 	
ඔබගේ තේරීම			

Figure B4. Choice card 01 in block 05 used in the choice experiment to estimate economic value of cultural services

C. Abandoned downstream of Thumbikulama Tank

Abandoned paddy fields

An abandoned sluice gate

Abandoned channel system