



Assessment of Ecosystem Services for Human Wellbeing

Healthy Landscapes Project

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

FINAL REPORT

**Assignment 02: Conduct a study on the assessment of
ecosystem services for human wellbeing**

Submitted to

**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

**Prof. Keminda Herath
Department of Agribusiness Management
Faculty of Agriculture and Plantation Management
Wayamba University of Sri Lank**



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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. The task of this study is to conduct study on assessment of ecosystem services for human wellbeing leading to the deliverable 6 stipulated in the TOR.

We carried out a qualitative assessment to estimate current status of provision of ecosystem services by VTCS, current status of wellbeing of the cascade community, linkages between ecosystem services and constituents of wellbeing and how socioeconomic status of the community moderates these linkages. Data were collected through participatory assessments done with the community, subject experts and various stakeholder engaged with cascade community. The sample size was 154 which was selected by a snowball sampling method. We used the standard frame work developed by Millenium Ecosystem Assessment 2005 (MA 2005) to assess the linkages between ecosystem services and community wellbeing.

It was found that the capacity of key landscapes in Village Tank Cascade Systems (VTCS) to provide ecosystem services ranged from no relevant capacity to relevant capacity. When fully operational, the VTCS should have a high or very high relevant capacity to provide ecosystem services. This suggests that VTCS are currently unable to fully provide ecosystem services. This study further reveal that the community is not efficiently utilizing VTCSs' landscapes for ecosystem services and thus reported moderately relevant demand for ecosystem services.

Provisional services arising from VTCS are strongly linked with the wellbeing of the cascade community which is similar to the global context except for one dimension of wellbeing, good social relations. The strength of the connection between regulatory services and the well-being of the VTCS community is also in line with the global situation. Although support services are strongly linked to all components of well-being in the global scenario, it is not strongly linked with the security and good social relation of the Cascade community. In VTCSs, cultural services are more tightly linked with all aspect of community's wellbeing compared to that of the Global scenario. It can be further concluded that socio economic status of the cascade community moderates the linkage between ecosystem services and wellbeing significantly than that of the global scenario. This concludes that VTCS is a unique ecosystem compared to average global ecosystems.

In conclusion, ecosystem services arising from VTCS has significant linkage to the wellbeing of the community. The welfare of the community can be raised by improving the supply of ecosystem services of VTCSs. However, currently the potential of VTCSs to provide ecosystem services expectedly has reduced substantially. This provide significant insight how important ecological restoration of VTCS is.

INTRODUCTION

The initial result of the HLP will be demonstrated through the work completed in Component 01: Implementation of biodiversity-based options that improve sustainable land management in socio-ecological sensitive areas. These approaches to sustainable landscape management would support improved ecosystem services and ecohealth outcomes adopted in notable socio-ecological sensitive areas of Village Tank Cascade Systems (VTCS). There are four outputs from component 01, namely; 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. As decided upon at the HLP MTR completed in July 2022, the output 1.2, which is related to this assignment, is accomplished through eight major activities. This assignment directly addresses the resulting Activity 1.2.8 and generates deliverable 5 stipulated in the TOR of the consultant. Further, it supports significantly achieving the output 1.4 which is goods, services and functions of VTCS ecosystems identified and mainstreamed.

VTCS is evidence of the symbiotic relationship between nature and human communities. These ancient water management systems, carefully designed and maintained over centuries, not only secure water for agriculture but also result in a variety of ecosystem services that are critical to environmental and human well-being. Currently, for various reasons, VTCS are obsolete and operate with significant deviations from their original capacity. Consequently, the ecosystem services of VTCS are not fully taken into account, which undermines the well-being of the community living in VTCS. Although abundant literature is available on research and studies on historical facts of VTCS and its functionality, ecological perspective, role in climate change, structural and irrigation technology, ecosystem services and socio-economic functionality, hardly any studies are available to examine the effects of VTCS Ecosystem services resulting from VTCS on human health and well-being. Consequently, this assignment aims to fill this gap by assessing how ecosystem services support human wellbeing.

Millennium Ecosystem Assessment, 2005, has comprehensively examined and identified the relationship between ecosystem services and human well-being within the framework of the health synthesis, coherently presenting the conceptual framework that illustrates how ecosystem services are related to the welfare factors of a community living in a particular ecosystem. This can be used as an appropriate framework that explains how ecosystem services resulting from VTCSs impact community well-being. This would underscore the importance of restoring VTCS to improve long-term community well-being.

We have identified major ecosystem services falling under four classes viz. Provisional services, regulatory services, support services and cultural services arising from VTCSs in Assignment 01 and are used in this assignment. We will first develop the assessment procedure which will be used for identifying current status of ecosystem services, wellbeing of the community and how ecosystem services are linked with the wellbeing of cascade community. We present the methodology used in this study in the next chapter comprehensively. Results and discussion is presented in the following chapter while conclusion and recommendations are presented in the last chapter of this report.

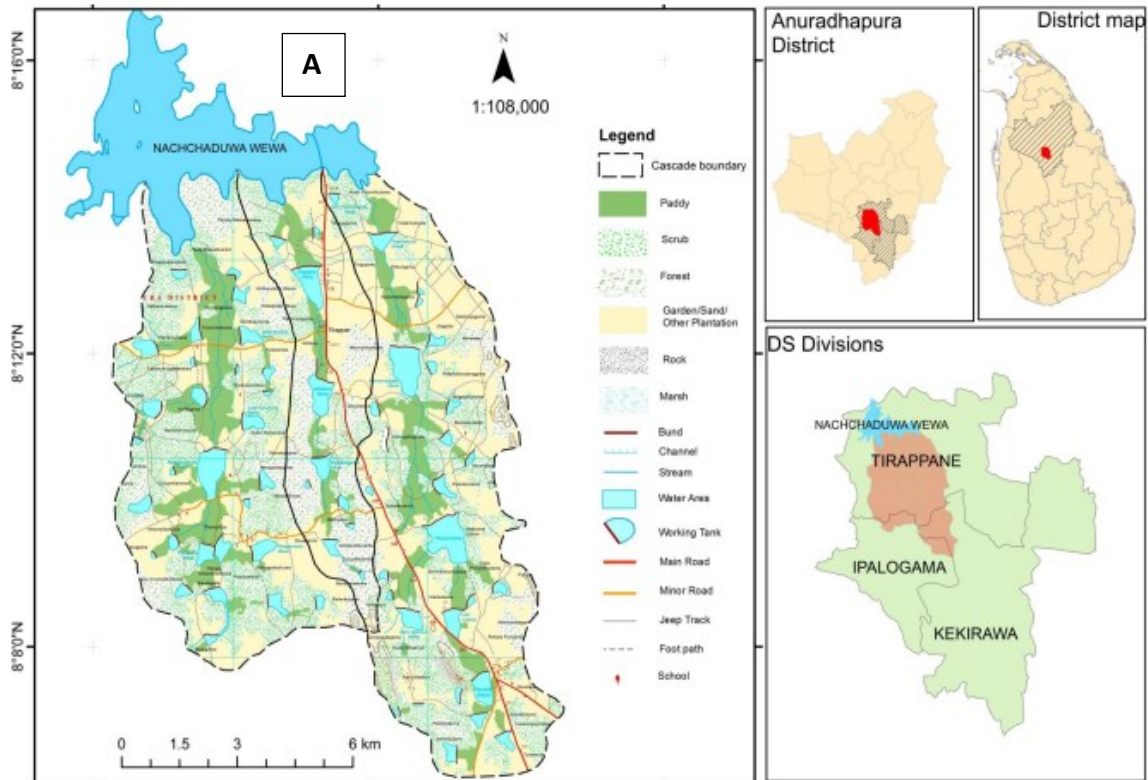
METHODOLOGY

Study area

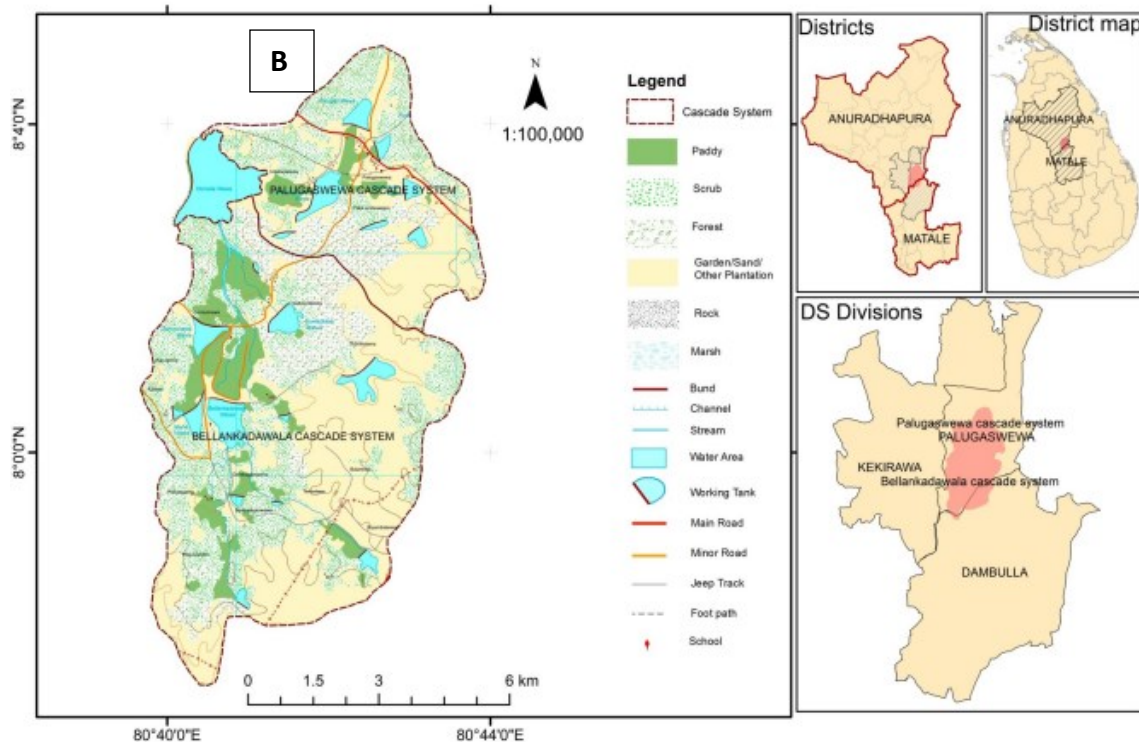
This study covers the total project implementing area depicted in Figure 01 which a brief description detailed in Table 01.

Table 01. A brief description of the study site

Major Reservoir	Village Tank Cascade System (VTCS)	DS Divisions	No. of tanks	Extent (ha)	Extent (km ²)
Nachchaduwa	Mahakanumulla	Ipalogama, Thirappane	29	4,717	47.17
	Thirappane	Thirappane, Ipalogama, Kekirawa	10	2,206	22.06
	Ulagalle	Thirappane, Kekirawa	28	5,127	51.27
Horivila	Palugaswewa	Palugaswewa	14	2,022	20.22
	Bellankadawala	Palugaswewa, Dambulla	28	4,995	49.95
TOTAL			109	19,067	190.67



Source: HLP Project documents



Source: HLP documents

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

Approach

Review of available assessment frame works:

We did a comprehensive literature survey to identify a suitable framework to establish the association between ecosystem services and community wellbeing. Based on the review of studies in international context, we summaries different frameworks that have been developed to assess and understand the relationship between ecosystem services and human well-being. These frameworks help integrate ecological, social, and economic considerations to inform decision-making and sustainable development.

1. **Millennium Ecosystem Assessment (MA)¹:** The Millennium Ecosystem Assessment, conducted between 2001 and 2005, was a comprehensive international effort to assess the state of the world's ecosystems. It provided a conceptual framework that categorizes ecosystem services into four broad categories: provisioning, regulating, supporting, and cultural services to understand and asses contribution of ecosystem service on human wellbeing. This framework has been influential in shaping subsequent work on ecosystem services and human wellbeing done by worldwide scientists and researches application of resource planning, conservation and management with policy and decision-making perspectives.
2. **Common International Classification of Ecosystem Services (CICES)²:** CICES is a standardized classification system for identifying and classifying ecosystem services. Developed by the European Environment Agency (EEA), CICES aims to provide a

¹ Source: <https://www.millenniumassessment.org/>

² Source: <https://cices.eu/>

common language for reporting and assessing ecosystem services across different contexts. It includes three main components: provisioning services, regulating and maintenance services, and cultural services. However, CICES itself does not explicitly articulate the connection between ecosystem services and well-being, its classification system provides a structured way to identify and categorize ecosystem services, which in turn supports the analysis of their contributions to the different constituents of human well-being. Researchers and practitioners often use CICES as a tool to frame their investigations and assessments of the links between ecosystems and human well-being.

3. **The Economics of Ecosystems and Biodiversity (TEEB)³:** TEEB is a global initiative that focuses on the economic aspects of biodiversity and ecosystem services. It seeks to make the values of ecosystems and biodiversity more visible to policymakers and the wider public. TEEB provides guidance on incorporating the values of ecosystems into decision-making processes, emphasizing the economic importance of biodiversity for human well-being. TEEB framework plays a crucial role in relating ecosystem services to human well-being by emphasizing the economic aspects of biodiversity. It focuses on making the values of ecosystems and biodiversity more visible and integrating them into decision-making processes. The framework provides a comprehensive approach to understanding the economic benefits derived from ecosystems and their direct and indirect impacts on human well-being.
4. **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)⁴:** IPBES is often considered the "IPCC for biodiversity." It assesses the state of biodiversity, ecosystem services, and their contribution to people. The assessments produced by IPBES aim to inform policymakers about the impacts of biodiversity loss on human well-being and suggest options for addressing these challenges. IPBES framework supports and relates the contributions of ecosystem services to human well-being by conducting assessments, embracing a multidimensional approach, focusing on specific themes, using scenario analysis, providing policy support, integrating local knowledge, and promoting capacity building.
5. **Wellbeing in Developing Countries (WeD) Approach⁵:** This approach focuses on understanding well-being in the context of developing countries. It emphasizes the multidimensional nature of well-being, incorporating social, economic, and environmental dimensions. The framework acknowledges the role of ecosystems in supporting livelihoods and well-being.
6. **Social-Ecological Systems Framework⁶:** This framework, often associated with resilience thinking, recognizes the interconnectedness of social and ecological systems. SES Framework provides a conceptual foundation for understanding the intricate relationships between ecosystem services and human well-being. While it doesn't prescribe specific methods for assessment, it encourages a holistic and integrated approach that considers the social, ecological, and institutional dimensions of human-environment interactions. Researchers and practitioners often use this framework to guide assessments

³ Source: <https://teebweb.org/>

⁴ Source: <https://www.ipbes.net/>

⁵ Source: <https://www.welldev.org.uk/>

⁶ Source: <https://doi.org/10.5751/ES-10594-230436>

and interventions aimed at sustaining the health of ecosystems and the well-being of human societies

7. **The Natural Capital Project (NatCap)**⁷: NatCap is a partnership between academic institutions and conservation organizations that develops practical tools and approaches for integrating the value of nature into decision-making. Their framework assesses how changes in ecosystems affect the flow of ecosystem services and, subsequently, human well-being.

We found that the most common frame work is the framework of Millenium Assessment (MA), that has developed in 2005. Thus, we chose it to apply to context of VTCSs in Sri Lanka to explain how ecosystem services relate to human wellbeing which is depicted in Figure 02. Based on the literature, mostly they have taken a qualitative approach to assess the linkage between ecosystem services and human wellbeing. Hardly, any examples are found for quantitative approaches in this regard. Thus, we will take a mixed approach; both qualitative and quantitative where major emphasis is given to the qualitative approach. Quantification is done based on a psychometric scale which in the ordinal scale. Ecosystem services arising from village tank cascade system are identified through literature survey and are validated through a participatory study where different stakeholder have participated. The same approach is taken to understand different constituents of well-being of the community associates with VTCSs.

Ecosystem services: Worldwide, ecosystem services are essential to people's well-being (SDG 3). Food, natural fibers, a consistent supply of clean water, control over certain pests and diseases, medicinal materials, entertainment, and defense against natural disasters like storms and floods are just a few of the advantages that ecosystems provide. According to Figure 02, the MA divides ecosystem services into four categories: provisioning, regulating, cultural, and supporting. Each of these categories has multiple subcategories. Patterns of population growth, development, and consumption affect the state of the environment and ecosystems and can either temporarily increase or decrease the supply of ecosystem services.

Human wellbeing: Security, health, good social relationships, and basic necessities for a good life are the components of wellbeing, as shown in Figure 02, and they all work together to guarantee people's freedom of choice and action. The basic and unchangeable needs of the human organism are food, water, clean air, shelter, and a relatively constant climate. In other words, ecosystems play a critical role in maintaining human well-being, particularly in relation to health, which the World Health Organization defines as a state of total physical, mental, and social well-being. People who live in affluent, urban areas frequently take the health-promoting benefits of ecosystems for granted. They assume that access to high-quality healthcare services and wise consumer decisions and behaviors are the keys to good health. However, this fails to acknowledge the importance of the natural environment, including the variety of ecosystems that support human health, social structure, economic endeavors, the built environment, and life itself.

⁷ Source: <https://naturalcapitalproject.stanford.edu/>

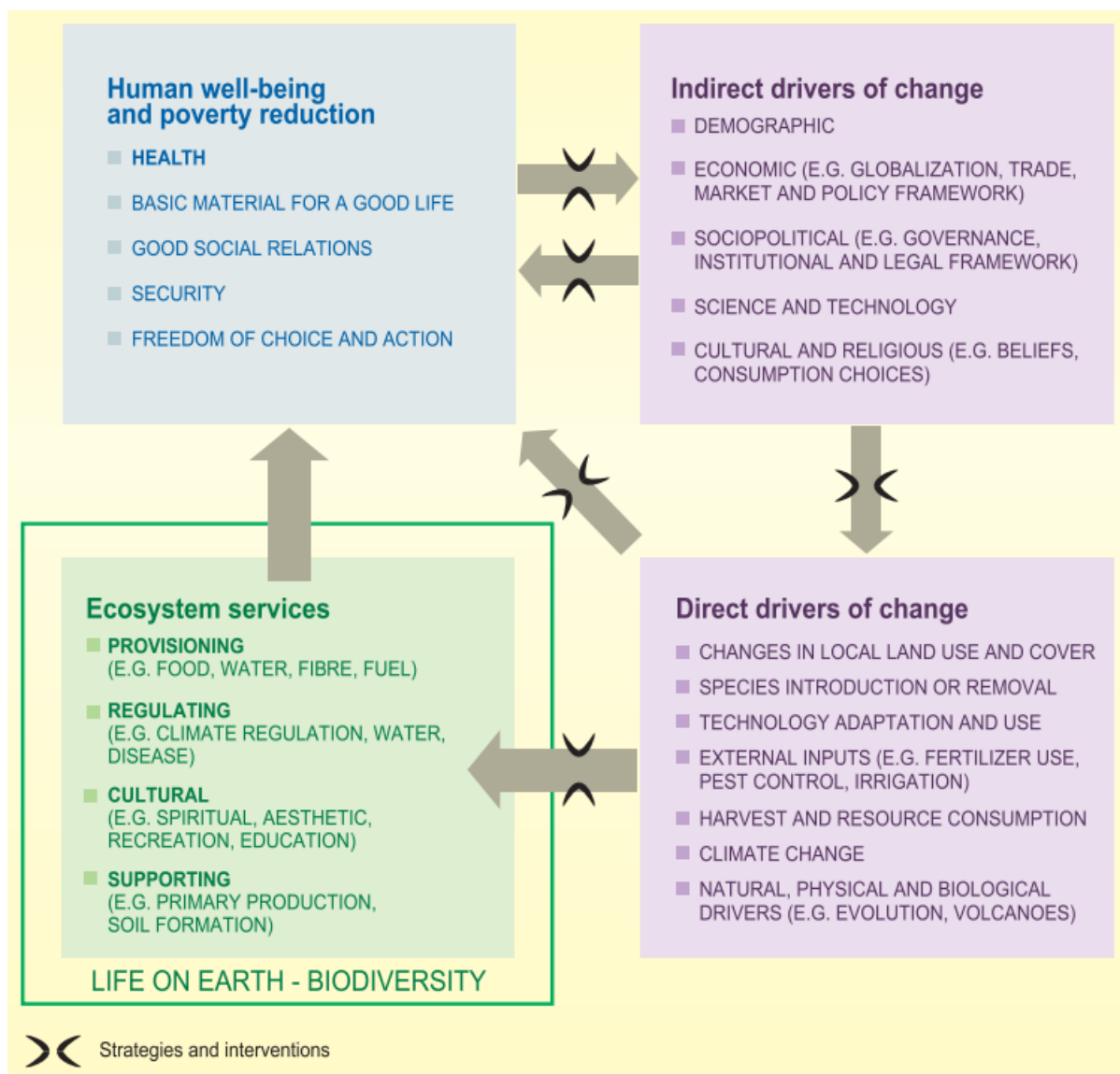


Figure 02. Conceptual framework to explain how ecosystem services relate to human wellbeing (Source: MA, 2005; <https://www.millenniumassessment.org>)

The Assessment procedure

Assessments of this study are more qualitative based on the community’s perception. During this study, we assessed current status of ecosystem services arising from VTCSs, current status of wellbeing of cascade community and linkages of ecosystem services to wellbeing of the cascade community.

Assessment of current status of ecosystem services: This was done by evaluating supply, demand and budgets of ecosystem services arising from VTCSs for which baseline assessment of the status of ecosystem services arising from Palugaswewa VTCSs⁸ was taken as the basis. However, we revised the priority list of ecosystem services before the assessment. The baseline status of Palugaswewa is provided in the Annexure for further reference. We reassessed demand, supply and budgets for the fleet of ecosystem services used in this study where the reference levels were taken from the baseline assessment of HLP.

⁸ Refer Chapter 04 in the Baseline report of HLP

Ecosystem service demand: It is the quantity of all ecosystem goods and services currently consumed or used in a given area over a given period of time. Typically, needs assessment does not take into account where ecosystem service is actually provided (Burkhard et al., 2012). However, ES demand is related to land use and land cover (CULC), which would of course be taken into account when quantifying ecosystem service demand. Various approaches to estimating demand for ESs can be found in the literature, of which a LULC-based participatory approach (Burkhard et al., 2012; Palomo et al., 2013 and Casado et al., 2013) is used to quantify ecosystem services in this study. The stakeholders involved in the participatory evaluation process include experts, managers and direct users of VTCS. A scale from zero to five is used to quantify demand for ecosystem services, with the higher the value, the higher the demand.

Ecosystem service supply: Ecosystem service supply is the ability of a given area to provide a given set of ecosystem goods and services within a given time period. Capacity here refers to the production of the amount of natural resources and services actually used (Burkhard et al., 2012). A participatory LULC-based evaluation is carried out to estimate the delivery of ES through the VTCS, where the stakeholders involved in the evaluation are expectants, and the community who are the direct users of the VTCS. The assessment was done using a scale of 0 to 5, where the higher the value, the higher the rank.

Ecosystem service budget: This is simply the difference between supply and demand of ecosystem services. We measure it with a scale of -5 to 5. Negative values mean that demand exceeds supply, while positive values indicate that supply exceeds demand.

Assessment of current status of wellbeing: The second assessment was done for identification of current status of the wellbeing of the cascade community. We assessed status of four constituents of wellbeing looking at different dimensions based on the community's perceptions which was measured in a five-point Likert scale. Different dimensions under each constituent were identified during the preliminary data collection of this study which we will discuss later in this chapter.

Assessment of linkages between ecosystem services and human wellbeing: The third assessment was about the current status of the linkages between ecosystem services and constituents of wellbeing and how the community's socio-economic status mediates the linkages between ecosystem services and constituents of wellbeing based on the MA2005 assessment framework. In this regard we used the matrix depicted in Table 02. Linkages were assessed based on three-point scale viz. 1 – weak linkage, 2 – Medium linkage and 3 – Strong linkage. The potential of socioeconomic status in VTCSs to moderate the linkages between ecosystem services and wellbeing of the community was assessed with three-point scale viz. 1 – Low, 2 – Medium and 3 - High

Table 02. Evaluation matrix of the impact of ecosystem service on wellbeing

Ecosystem service	Constitute of wellbeing			
	Security	Basic material for good life	Health	Good social relations
Provisional				
Regulatory				
Cultural				
Supporting				

Data and data collection

We collect both secondary data and primary data that was initially used for designing the study and later for all assessments mentioned above.

Secondary data: This was mostly consisting of information about ecosystem services and constituents of wellbeing done through a desk review. Farther data on established linkages between ecosystem services and human wellbeing were also considered which has been published in standard literature.

Primary data: We collected primary data about all aspects discussed under the assessment procedure above. In addition, socio economic status of the informants also was collected.

Data collection methods: Secondary data were collected through a comprehensive desk rive. We used published materials and records available at all stakeholders during the desk review. We collected primary data through Focus grouped discussions (FGDs) and Key informant interviews (KIIs) which were in the semi structured nature.

Sampling procedure: In this study, a representative sample of the stakeholders of VTCS was drawn by employing a snow ball sampling procedure which has been used in similar studies found in the literature. Because we require informants with a faire knowledge about ecosystem services and constituents of wellbeing and their drivers. They should have some capacity to understand the technical background of the rationale of this study otherwise distortion of information can happen.

We carried out data collection of this study in two phases viz.

- Designing phase
- Assessment phase

Design phase: Based on the MA 2005, an assessment of linkages between ecosystem services and human wellbeing needs to be designed carefully using both secondar and real time data, because relationships between ecosystem services and human wellbeing vary from ecosystem to ecosystem and community to community. Consequently, we came across with a design phase, where we collected primary and secondary data first to identify appropriate fleet of ecosystem services arising from VTCSs and constituents of wellbeing of cascade community. Secondary data was updated and validated through primary data collected. We collected primary data through FGDs and KIIs which required for designing the assessment phase data collection. Some snapshots taken during preliminary collection are depicted in Figure 03.



Figure 03. FDGs and KIIs with the community at preliminary data collection

There is significant amount of work done to establish linkages between ecosystem services and constituents of wellbeing of people in international literature. Sarathchandra *et al.*, 2021⁹, has reviewed 220 articles authored between 1988 – 2021 about ecosystem services arising from different ecosystems in Sri Lanka and report that the contribution of ecosystem services to the human wellbeing has been understudied. During the literature survey, we also found hardly any studies on the assessment of the contribution of ecosystem services to human wellbeing in the Sri Lankan context. This this going to be the first attempt in Sri Lanka context to understand and assess the contribution of ecosystem services to human wellbeing.

Dusing the design phase data collection instruments were developed based on the data collected in the designing phase and preliminary analysis of data. They are included in the Annexure of this report.

Prioritizing of ecosystem services, constituents of wellbeing and identification of linkages were carried out by using the primary data collected in the design phase. Based on the literature review and outcomes of the preliminary field data collection through FDGs and KIIs we assembled the conceptual framework with the linkages between ecosystem services and wellbeing of the community living in VTCSs and depicted in Figure 04. This provides the basis for key questions directed in the FDGs caried out in the assessment phase.

⁹ Sarathchandra, C., Abebe, Y. A., Wijerathne, I. L., Aluthwattha, S. T., Wickramasinghe, S., & Ouyang, Z. (2021). An overview of ecosystem service studies in a tropical biodiversity hotspot, Sri Lanka: Key perspectives for future research. *Forests*, 12(5), 540.

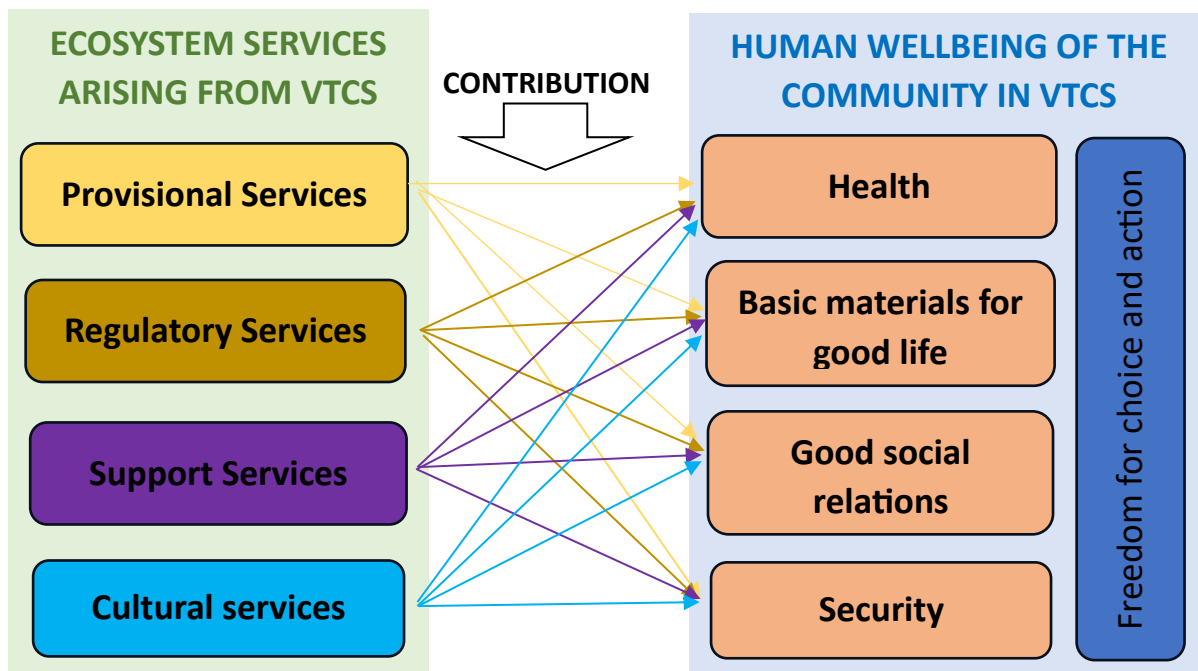


Figure 04. Conceptual framework established and validated based on the literature review and analysis on preliminary data that is used in the assessment of the contribution of ecosystem services arising from VTCSs to wellbeing of its community. *Source: MA, 2005 and Assignment 02 - study on assessment of ecosystem services for human health.*

We pretested all guidelines for FGDs and KIIs used in the assessment phase that were developed before they were finalized. All check lists, guidelines developed in the design phase and used for assessment phase data collection are included in the Annexure in this study

Assessment phase: We assessed current status of ecosystem services arising from VTCSs, current status of wellbeing of the cascaded community and their linkages to ecosystem services using the assessment procedures mentioned above during the assessment phase. All FGDs and KIIs were conducted by the consultant himself. Some occasions of data collection captured during FGDs and KIIs in the assessment phase is depicted in Figure 05. A breakdown of KIIs and FGDs done during design phase and assessment phase is given in Table 03.





Figure 05. Some occasions captured during KIIs and FGDs conducted in the assessment phase

Table 03. Breakdown of FGDs and KIIs conducted during designing phase and assessment phases of data collection

Stakeholder	Tool		No of participants	Phase of data collection
	FGD	KIIs		
HLP project staff	2		6	Design/ Assessment
Community	15		68	Design/ Assessment
Community and community leaders		25	25	Design/ Assessment
Grama Niladhari/ Development offices/ ARPA /AI		11	11	Design/ Assessment
Midwife		2	1	Design/ Assessment
Ayurveda Doctor		2	1	Design/ Assessment
DAD	2	3	11	Design/ Assessment
DS Division - Palugaswewa	1		4	Design/ Assessment
District Secretariate, Anuradhapura		1	1	Assessment
Subject experts		6	6	Design/ Assessment
University Academics and students	2	10	20	Assessment
Total	22	60	154	

Data analysis

We will use a qualitative data analysis framework to analyze the data collected during the design and assessment phases. However, we accommodated exploratory data analysis techniques to analyze both qualitative and quantitative data collected in this study. Most of the primary data that we collect are in the ordinal scale and thus we will use some categorical data analysis method to establish some relationships that address the last key question mentioned in previous section.

RESULTS AND DISCUSSION

As shown in Table 03 we have gathered information qualitatively through 22 FGDs and 60 KIIs from both cascade community and other selected stakeholders with a participation of 154 persons. Selected stakeholders are either government or semi government officials whose education level and exposure to VTCSs and its management was substantially high. Because, VTCSs are managed through a government mechanism where multiple government agencies are involved in. Therefore, in this report we term them as Expert group. The total sample was consisted of 61 experts and 93 persons from the community.

Sample information

The gender distribution of the sample and its breakdown by experts and community is depicted in Figure 06. It can be noticed that there is a faire gender distribution in the sample of informants. We could maintain gender distribution similarly among the informants in expert group and community. Female representation is 44% and the male representation is 56% which assures a faire gender inclusion in this study.

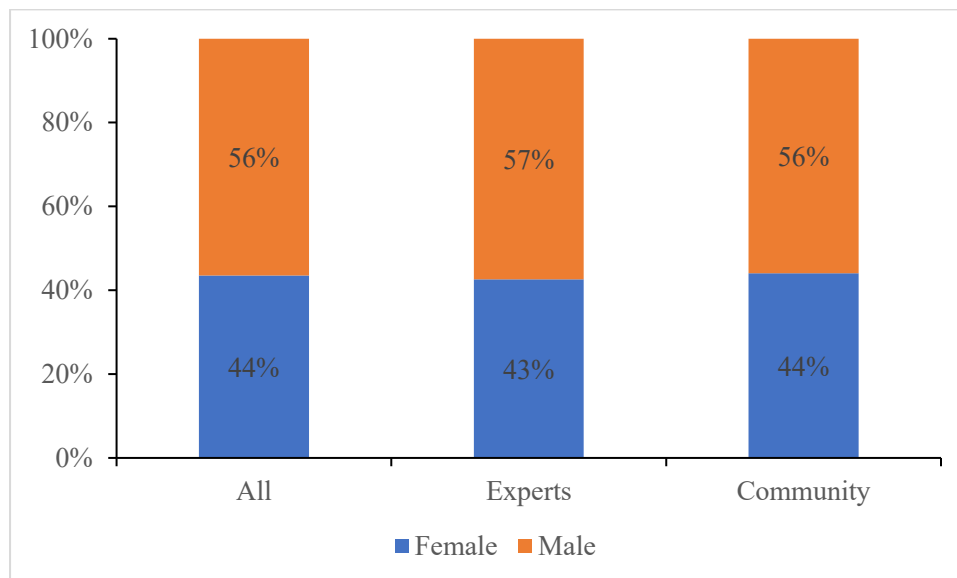


Figure 06. Gender distribution of the sample and its breakdown by experts and community

The age distribution of the sample is depicted in Figure 07. Age distributions of experts and the community are also separately given in it. Summary statistics of the stakeholders by respective group and gender is given in Table 04. Age distribution of the expert group was a right skewed (skewness coefficient = 0.67) with a mean and median age of 39.8 and 38 years respectively. There were significant youths includes in the sample of expert group which assures fair youth inclusion of this study. All these youths were well qualified and had adequate exposure to the cascade environment and its' management. However, most of the subject experts met in KIIs were middle aged or on their retirement who has vast experience working and research with VTCSs. Empirical age distribution of the community in the sample was a left skewed one (skewness coefficient = - 0.16) with a mean and median age of 51.2 and 52 years respectively. This was fairly an elderly group. However, it included a considerable number of youths which assured youth inclusion in this study further. There was no significant difference in the age distribution by the gender.

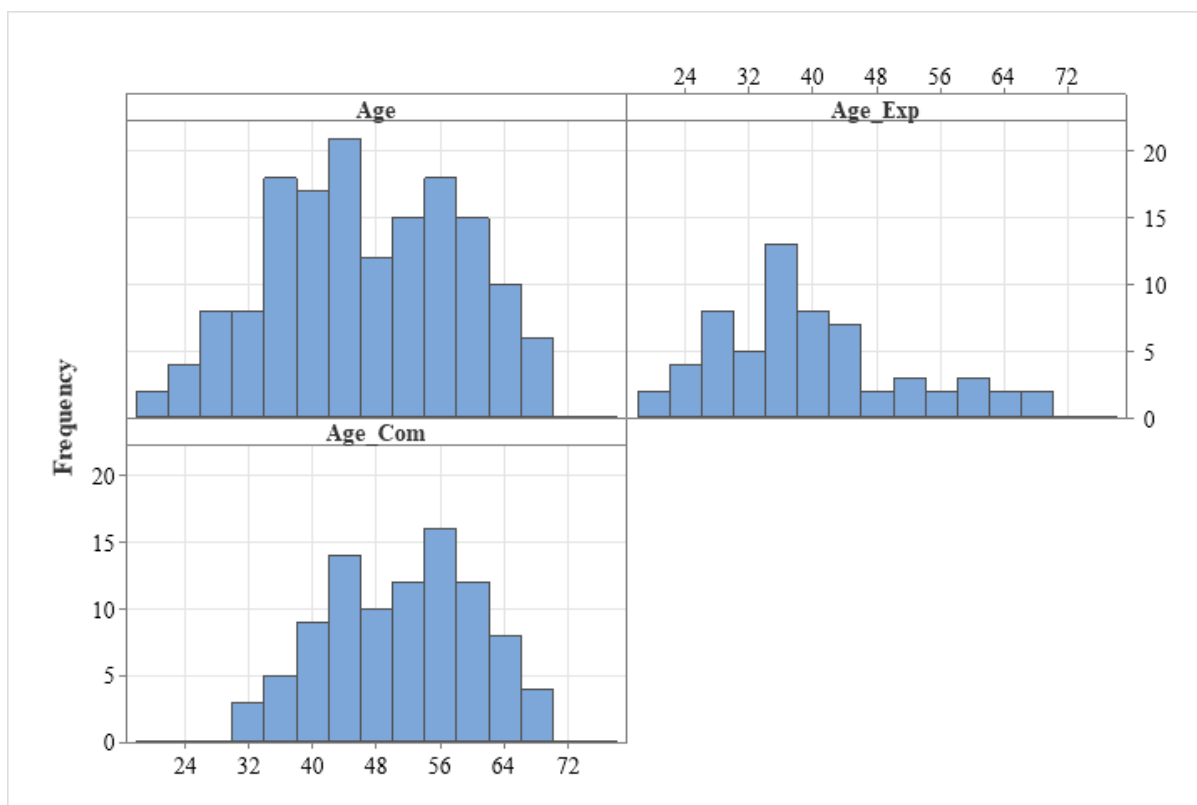


Figure 07. Empirical distribution of the age of the community and the experts participated in FGDs and KIIs; Age – Age of the total sample, Age_Exp – Age of experts and Age_Com – Age of community

Table 04. Summary statistics of all stakeholders participated in FGDs and KIIs

Category	Summary statistic of age						
	Mean	StDev	Minimum	Median	Maximum	Skewness	Kurtosis
All	46.7	11.7	21	46	69	-0.10	-0.82
Experts	39.8	11.7	21	38	69	0.67	-0.10
Community	51.2	9.3	31	52	69	-0.16	-0.75
Female	45.5	12.2	21	46	65	-0.23	-0.96
Male	47.6	11.3	25	47	69	0.06	-0.80

Education status of the informants participated in data collection is given in Table 05. As mentioned before the expert group of participants were with high education backgrounds. The community also were with fairly high education levels who could cooperate effectively with the data collection process.

Table 05. Education status of the informants participated in data collection

Education status	All	Community	Experts
Up to grade 8	3.2%	5.4%	-
Up to GCE (O/L)	7.8%	12.9%	-
UP to GCE (A/L)	15.6%	25.8%	-
Pass GCE (A/L)	32.5%	47.3%	9.8%
Degree	24.0%	8.6%	47.5%
Postgraduate	16.9%	0.0%	42.6%

Present status of ecosystem services arising from VTCSs

The demand, supply and budgets of ecosystem services arising from VTCSs were assessed during this study taking the baseline assessment of HLP as the reference status of ecosystem services. The fleet of ecosystem services (21 under four types ecosystem services) assessed during this study is somewhat different that of the baseline assessment. They were identified and prioritized during the design phase of this assignment and Assignment 01 of the consultancy service undertaken. Supply, demand, and budgets of 21 recognized ecosystem services by different LULC is presented in Table 06, Table 07 and Table 08 respectively.

Table 06. Assessment of current status of the supply of ecosystem services by VTCSs

Ecosystem Services	Tank	Diyagilma	Gas gommama	Kattakaduwa	Godawala	Isvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP
Provisional Services																	
Crop production/ Fisheries/ Livestock	3	2	1	1	1	2	3	1	3	4	0	2	0	3	1	1	0
Supply water for cultivation	4	2	1	1	2	0	2	1	1	1	1	3	1	1	3	1	2
Supply clean water for drinking	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0
Supply water for washing/ bathing/ livestock/ other uses	4	0	0	0	1	2	0	0	0	0	0	0	0	0	2	0	0
Supply nonfood products (Reeds, firewood, medicinal materials etc.)	2	2	3	2	1	3	3	3	3	2	3	1	2	2	2	2	2
Supply food materials (Bee honey, yams, leafy veg. etc.)	1	1	0	1	0	1	1	1	0	1	0	0	1	2	0	0	0
Regulatory services																	
Recharge water table and maintain the flow	3	2	3	2	3	2	1	3	3	3	0	2	2	2	2	2	1
Water purification	2	2	3	2	3	3	1	3	2	2	1	0	1	0	0	2	0
Erosion and flood control	2	2	2	1	2	2	0	3	3	2	0	0	1	3	1	2	2
Regulate climate	3	2	2	2	2	2	1	3	3	2	0	1	2	2	2	2	1
Control human elephant conflict	2	1	1	1	1	1	0	2	1	0	0	0	1	0	1	1	1
Support Services																	
Provide habitats for plants and animals	2	2	1	1	1	1	1	3	1	1	1		2	2	2	2	1
Maintain biodiversity	2	2	1	1	1	1	1	3	1	1	1		2	2	2	2	1
Soil nutrient cycling	2	3	2	1	0	2	2	2	2	2	0	2	2	2	2	2	2
Pollination	2	2	3	2	0	2	2	3	3	3	0	2	2	3	2	1	3
Biological control of pests and diseases	1	1	1	1	1	1	2	3	3	0	0	2	2	1	1	1	1
Cultural Services																	
Recreation	2	0	2	0	0	0	2	1	1	1	1	0	1	1	1	1	1
Aesthetic value and amenity	3	3	3	2	1	2	2	3	3	4	3	2	2	3	3	3	2
Traditional knowledge and education	3	2	2	1	1	1	3	2	1	2	1	2	1	2	3	1	2
Rituals	2	1	2	1	1	1	2	2	0	3	0	1	0	2	3	1	2
Social cohesion, peace, humanity and corporation	2	1	1	1	1	1	2	2	0	3	0	2	0	2	2	1	1

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

0	No relevant capacity	1	Low relevant capacity	2	Medium relevant capacity
3	Relevant capacity	4	High relevant capacity	5	Very high relevant capacity

Source: Study on the assessment of ecosystem services for human wellbeing (Assignment 02)

Supply of ecosystem services

Supply of provisional services: It can be noticed that, home gardens, paddy lands and chena relevant capacity of crop production while tank and open forest have capacities to provide fisheries and livestock production respectively. The community is in the perception that water bodies in VTCSs has relevant capacity to provide water for agriculture, especially for paddy cultivation. However, they mentioned that water bodies have filled with silt and water is insufficient for Maha season mostly. The tank has the relevant capacity to provide water for washing, bathing, livestock and other purposes. Further, forest entities have relevant capacity to provide nonfood materials.

Supply of regulatory services: It can be noticed that based on the community's perception, village tank, some of the tank components and forest components in VTCSs has relevant capacity of regulating the ground water table and its flow. Some of the components still has relevant capacity of purifying water while few of the LULCs in VTCSs are still having relevant capacity of control erosion and floods. Further it can be noticed that currently VTCSs has a low relevant capacity to control human elephant conflict which has not been serious during the era where VTCSs were fully functional. Based on the assessment, none of LULCs in VTCS didn't show high relevant capacity or very high relevant capacity of supplying regulatory services which take place if CVTSS function at their full capacity.

Supply of cultural services: It can be noticed that the capacity to supply recreations services from VTCSs is low. The tank is the only LULC that has medium capacity to supply recreational services. We need to further investigate the underlying reasons for this situation. The probable reasons could be water pollution, land degradation and elephant attacks. However, the supply of aesthetic value and the amenity of VTCS remain at a relevant capacity. Supply of rituals, social cohesion, humanity and corporation by VTCS can be seen at their lower levels.

Supply of support services: Except very few, most of the LULCs in VTCSs have low to moderate relevant capacities to supply support ecosystem services listed in Table 06. However, forest components in VTCSs still show relevant capacities for supplying support services.

Demand for ecosystem services

The demand for ecosystem services is the quantity of ecosystem services expected or used in a given area over a given period of time.

Demand of provisional services: It can be noticed that most of LULCs allowed crop and animal production have medium to relevant demand that indicate these LULCs are being utilized by the community significantly. Except paddy lands, none of the other LULCs showed high to very high relevant demands for crop/fisheries/livestock which is the major provisional service arising from VTCSs. Demand for cultivation water ranged from low relevant demand to high relevant demand. The tank and home gardens are heavily used for water for cultivation. There are agrowells found in many of the home gardens and upland of cascade community. The demand for clean water for drinking from all LULCs considered in this study can be seen very low. Most of the community in VTCSs depends on well water, water schemes or RO purified water for drinking. The community mentioned that mostly the surface water and ground water are contaminated with hardness or agrochemicals. The demand for nonfood products from VTCSs can be found low. However some of LULC in VTCSs are substantially used for food materials such as bee honey, leafy vegetables, yams and other edible materials.

Table 07. Assessment of current status of ecosystem services demand of VTCSs

Ecosystem Services	Tank	Diyagilma	Gas gommama	Katatakaduwa	Godawala	Iyvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP
Provisional Services																	
Crop production/ Fisheries/ Livestock	3	2	1	1	1	3	3	0	0	4	0	2	2	3	2	2	0
Supply water for cultivation	4	2	1	1	2	0	4	1	0	3	0	3	0	3	3	1	2
Supply clean water for drinking	2	0	0	0	2	2	0	0	0	0	0	1	0	0	2	0	0
Supply water for washing/ bathing/ livestock/ other uses	4	0	0	0	2	2	0	0	0	0	0	0	0	0	2	0	0
Supply nonfood products (Reeds, firewood, medicinal materials etc.	1	1	2	2	1	2	2	2	2	2	1	1	2	2	2	2	2
Supply food materials (Bee honey, yams, leafy veg. etc.)	2	1	1	3	2	2	2	3	3	0	0	1	2	2	3	2	1
Regulatory services																	
Recharge water table and maintain the flow	3	2	3	3	3	2	3	3	3	3	0	2	2	2	3	2	1
Water purification	2	2	3	3	3	3	3	3	2	2	1	0	1	1	0	2	0
Erosion and flood control	2	2	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0
Regulate climate	3	2	2	2	2	2	1	3	3	2	0	1	2	2	2	2	1
Control human elephant conflict	4	4	4	2	2	4	0	4	4	0	0	0	4	0	2	4	4
Support Services																	
Provide habitats for plants and animals	3	3	3	3	3	2	1	3	3	1	2	0	3	2	3	3	1
Maintain biodiversity	4	3	4	3	2	2	4	4	3	3	3	2	3	4	3	3	1
Soil nutrient cycling	2	3	2	1	0	2	4	2	2	3	0	3	2	3	2	2	2
Pollination	2	2	3	2	0	2	4	3	3	3	0	2	2	3	2	1	3
Biological control of pests and diseases	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1
Cultural Services																	
Recreation	4	2	0	0	0	0	2	2	2	2	2	0	1	3	2	0	0
Aesthetic value and amenity	4	3	3	2	1	2	4	4	3	4	1	3	2	3	3	2	3
Traditional knowledge and education	3	1	2	1	1	1	2	2	1	2	1	2	1	2	2	1	2
Rituals	2	1	1	1	1	1	2	2	0	2	0	1	0	2	2	1	2
Social cohesion, peace, humanity and corporation	3	1	1	2	1	2	2	2	0	3	0	2	0	2	2	1	1

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

0	No relevant demand	1	Low relevant demand	2	Medium relevant demand
3	Relevant demand	4	High relevant demand	5	Very high relevant demand

Source: Study on the assessment of ecosystem services for human wellbeing (Assignment 02)

Demand of regulatory services: We found that three major regulatory services were highly concerned by the cascade community which are respectively recharge water table and maintain the water flow, water purification and control human elephant conflict by VTCSs. There is a relevant demand for recharge water table and water purification by water bodies their components and forest entities in VTCS which is comparatively high. The demand for controlling human elephant conflict by all related LULC in VTCSs is currently a high relevant demand which means the community are either using and expected to be used those LULCs for controlling human elephant conflict within VTCSs.

Demand for cultural services: It was found the cascade community significantly utilize the tank and chena for recreation purposes. There is some demand for recreational activities from forest entities. We observed some of the community effectively used chena for homestay which is fallen under ecotourism. The community say that they significantly enjoyed aesthetic value and amenity arising from the whole cascade landscape which is reflected by the easement results (Table 07). However, the demand for traditional knowledge, rituals and social cohesion, peace, humanity and corporation from VTCS found to be currently low.

Demand for support services: It can be observed that most LULCs in VTCSs have either a relevant or a high relevant demand for providing habitats for plants and animals and maintaining biodiversity. This may be realistic in large part because the Cascade community has high expectations for the regulation of human-animal conflict; mostly the conflict between human elephants. Furthermore, there is either a relevant or high relevant demand for soil nutrient recycling and pollination by forest landscapes in VTCSs

Ecosystem service budgets of VTCSs

Budget of Provisional services: For crop, fisheries and livestock production the current levels of supply matches with demand in many LULCs in VTCSs. Forest areas in VTCSs are heavily used for livestock where the supply exceeds the demand. However, there are restrictions on the use of some forest areas for livestock farming, which serve to protect the forest and wildlife. Based on the assessment, the cascade community believes that the budget for cultivation water from the tank system in the VTCS is balanced, indicating that supply is in line with demand. However, there are numerous complaints from the community that they do not have enough water for cultivation, especially during the Yala season. They further said that the tank system's drought resilience is currently very low. The demand for clean drinking water in VTCS exceeds its' capacity to supply clean water. Although VTCS's potential for providing non-food products is currently low, the community is less interested in using it. However, there is a significant demand for food materials found in the landscapes of the VTCSs though the potential to supply them is lower.

Budgets of regulatory services: The assessment shows that, with the exception of a few LULCs, the ecosystem services budget is balanced across three regulatory ecosystem services, namely: recharging the groundwater table and maintaining water flow, water purification and climate regulation. For VTCSs' soil erosion and flood protection service, the supply significantly exceeds the demand, indicating that VTCS is still resilient to floods and soil erosion. However, the community says that the capacity of VTCS is substantially low and does not meet their expectations.

Budgets of cultural services: We can see that the cascade community uses many types of landscapes in the VTCS for recreational purposes, although their potential to provide recreational services is lower. Although many landscapes have zero budgets for their aesthetic value and amenity, for some of the landscape such as the tank, home gardens and dense forests the ecosystem demand exceeds its supply. In cultural services such as traditional knowledge and education, rituals and social cohesion, peace, humanity and cooperation, the supply meets the demand although they had low relevant capacities in most of LULCs.

Budgets of support services: It can be observed that the supply of provision of habitats and maintenance of biodiversity exceeds their demand in majority of landscapes in VTCSs. Budgets of rest of the support services indicate that their supply matches except for few LULC in VTCSs.

Table 08. The current status of budget of ecosystem services (supply – demand) of VTCSs

Ecosystem Services	Tank	Diyagilma	Gas gommama	Kattakaduwa	Godawala	Ivetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP
Provisional Services																	
Crop production/ Fisheries/ Livestock	0	0	0	0	0	-1	0	1	3	0	0	0	-2	0	-1	-1	-1
Supply water for cultivation	0	0	0	0	0	0	-2	0	1	0	0	0	1	0	0	0	0
Supply clean water for drinking	-1	0	0	0	-1	-1	0	0	0	0	0	-1	0	0	-1	0	0
Supply water for washing/ bathing/ livestock/ other uses	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0
Supply nonfood products (Reeds, firewood, medicinal prod etc.	1	1	1	0	0	1	1	1	1	0	2	0	0	0	0	0	0
Supply food materials (Bee honey, yams, leafy veg. etc.	-1	0	-1	-2	-2	-1	-1	-2	-3	1	0	-1	-1	0	-3	-2	-1
Regulatory services																	
Recharge water table and maintain the flow	0	0	0	-1	0	0	-2	0	0	0	0	0	0	0	-1	0	0
Water purification	0	0	0	-1	0	0	-2	0	0	0	0	0	0	-1	0	0	0
Erosion and flood control	0	0	2	0	1	2	0	3	3	2	0	0	1	3	1	0	2
Regulate climate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control human elephant conflict	-2	-3	-3	-1	-1	-3	0	-2	-3	0	0	0	-3	0	-1	-3	-3
Support Services																	
Provide habitats for plants and animals	-1	-1	-2	-2	-2	-1	0	0	-2	0	-1	0	-1	0	-1	-1	0
Maintain biodiversity	-2	-1	-3	-2	-1	-1	-3	-1	-2	-2	-2	-2	-1	-2	-1	-1	0
Soil nutrient cycling	0	0	0	0	0	0	-2	0	0	-1	0	-1	0	-1	0	0	0
Pollination	0	0	0	0	0	0	-2	0	0	0	0	0	0	0	0	0	0
Biological control of pests and diseases	0	0	0	0	0	0	2	3	3	0	0	2	1	0	0	0	0
Cultural Services																	
Recreation	-2	-2	2	0	0	0	0	-1	-1	-1	-1	0	0	-2	-1	1	1
Aesthetic value and amenity	-1	0	0	0	0	0	-2	-1	0	0	2	-1	0	0	0	1	-1
Traditional knowledge and education	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
Rituals	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Social cohesion, peace, humanity and corporation	-1	0	0	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

Demand exceed supply					Natural balance	Supply exceeds demand				
-5	-4	-3	-2	-1	0	1	2	3	4	

The overall status of ecosystem services from VTCSs

During the analysis, we upscaled the detailed assessment in Table 06, Table 07, and Table 08 into four main classes of ecosystem services based on the average ranks of different ecosystem services listed in each category. Results are summarized in Table 09, Table 10 and Table 11. This provides us an overall picture about current status of ecosystem services offered by VTCSs. It can be noticed that none of LULCs in VTCSs supply ecosystem services at maximum capacity; high relevant

capacity and very high relevant capacity (Table 09). This may be due to significant degradations that have occurred in the VTCS landscapes over time.

Table 09. Current status of ecosystem services supply by main types of ecosystem services in different LULCs in VTCSs.

Ecosystem Services	Tank	Diyagilma	Gas gommama	Kattakaduwa	Godawala	Isvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP	Overall supply
Provisional services	2.5	1.2	0.8	0.8	1.0	1.5	1.5	1.0	1.2	1.7	0.5	1.0	0.7	1.7	1.5	0.7	0.7	1.2
Regulatory services	2.4	1.8	2.2	1.6	2.2	2.0	0.6	2.8	2.4	1.8	0.2	0.6	1.4	1.4	1.2	1.8	1.0	1.6
Support services	1.8	2.0	1.6	1.2	0.6	1.4	1.6	2.8	2.0	1.4	0.4	2.0	2.0	2.0	1.8	1.6	1.6	1.6
Cultural services	2.4	1.4	2.0	1.0	0.8	1.0	2.2	2.0	1.0	2.6	1.0	1.4	0.8	2.0	2.4	1.4	1.6	1.6

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

0 -0.5	No relevant capacity	.5 -1.5	Low relevant capacity	1.5 -2.5	Medium relevant capacity
2.5 – 3.3	Relevant capacity	3.5 -4.5	High relevant capacity	4.5 - 5	Very high relevant capacity

Current status of ecosystem services demand by main types of ecosystem services in different LULCs in VTCSs is shown in Table 10. It can be noticed that demand for ecosystem services ranges from no relevant capacity to relevant capacity. The frequency of landscapes with relevant capacity is comparatively low. It can be seen that the demand for ecosystem services arising from landscapes in VTCS does not remain at peak levels. This indicates that the Cascade community is currently not efficiently using VTCS landscapes for its ecosystem services.

Table 10. Current status of ecosystem services demand by main types of ecosystem services in different LULCs in VTCSs.

Ecosystem Services	Tank	Diyagilma	Gas gommama	Kattakaduwa	Godawala	Isvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP	Overall demand
Provisional services	2.7	1.0	0.8	1.2	1.7	1.8	1.8	1.0	0.8	1.5	0.2	1.3	1.0	1.7	2.3	1.2	1.0	1.4
Regulatory services	2.8	2.4	2.4	2.2	2.2	2.2	1.4	2.6	2.4	1.4	0.2	0.6	1.8	1.0	1.4	2.4	1.2	1.8
Support services	2.4	2.4	2.6	2.0	1.2	1.8	2.6	2.4	2.2	2.0	1.0	1.4	2.2	2.6	2.2	2.0	1.6	2.0
Cultural services	3.2	1.6	1.4	1.2	0.8	1.2	2.4	2.4	1.2	2.6	0.8	1.6	0.8	2.4	2.2	1.0	1.6	1.7

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

0 -0.5	No relevant demand	.5 -1.5	Low relevant demand	1.5 -2.5	Medium relevant demand
2.5 – 3.3	Relevant demand	3.5 -4.5	High relevant demand	4.5 - 5	Very high relevant demand

Table 11 shoes the current status of ecosystem services budgets by main types of ecosystem services in different LULCs in VTCSs. It indicates that ecosystem service budgets of VTCSs takes a negative value except for few landscapes. This means that the demand for ecosystem services in VTCSs exceeds their supply. From this, we can conclude that the cascade community expects more ecosystem services from VTCSs, which are currently offered at a low level.

Table 09. Current status of ecosystem services budgets by main types of ecosystem services in different LULCs in VTCSs.

Ecosystem Services	Tank	Diyagilma	Gas gonnana	Katakaduwa	Godawala	Isvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP	Overall budget
Provisional services	-0.2	0.2	0.0	-0.3	-0.7	-0.3	-0.3	0.0	0.3	0.2	0.3	-0.3	-0.3	0.0	-0.8	-0.5	-0.3	-0.2
Regulatory services	-0.4	-0.6	-0.2	-0.6	0.0	-0.2	-0.8	0.2	0.0	0.4	0.0	0.0	-0.4	0.4	-0.2	-0.6	-0.2	-0.2
Support services	-0.6	-0.4	-1.0	-0.8	-0.6	-0.4	-1.0	0.4	-0.2	-0.6	-0.6	0.6	-0.2	-0.6	-0.4	-0.4	0.0	-0.4
Cultural services	-0.8	-0.2	0.6	-0.2	0.0	-0.2	-0.2	-0.4	-0.2	0.0	0.2	-0.2	0.0	-0.4	0.2	0.4	0.0	-0.1

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

Demand exceed supply					Natural balance	Supply exceeds demand			
-5	-4	-3	-2	-1	0	1	2	3	4

Perceived status of wellbeing of cascade community at present

Security ststus of cascade community

The security is one of the main constituents of wellbeing of a community. It was measured in this study using six safety dimensions, which were covered by seven perceptual statements (S1 – S7, see Appendix B.). First two questions concerned personal security while the remaining statements addred five other dimentionns respectively, Secure resource acess, Safety from epidemics, Safety from noncommunicable diseases like cronic kidney disease (CKD), Security from natural disasters, Opportunites for componsating for uncertainty. The destrubutions of preceived responses of the community and ecperts (n = 154) for S1 – S7 are dipicted in Figure 08. S1 is about personal security of community from robberies, crimes and other offences while S2 is about personal security from wild animals such as Elephants. Approximately 76% of the Cascade community is at least confident that they are protected from robberies, felonies and other offenses within VTCS, while the rest of the community disagrees. The empirical destrubution of preceived responses of the community to S2 is clearly a right skewed destrubution (Figure 9-S2) which indicate that the maority of the cascade community agree that they have no sufficient protection from wild elephants. S3 is about secure acess to resources of which the empirical destrubution of preceived responses of the community is slightly right skewed. About 44% of the community is on a nutral openion about S3 while 29% of them disagree that they have secure acess to resources.

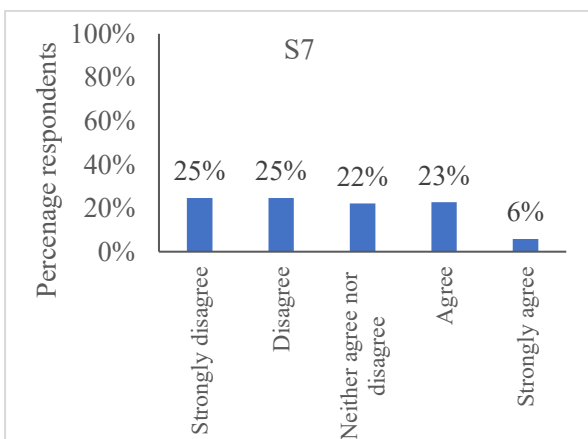
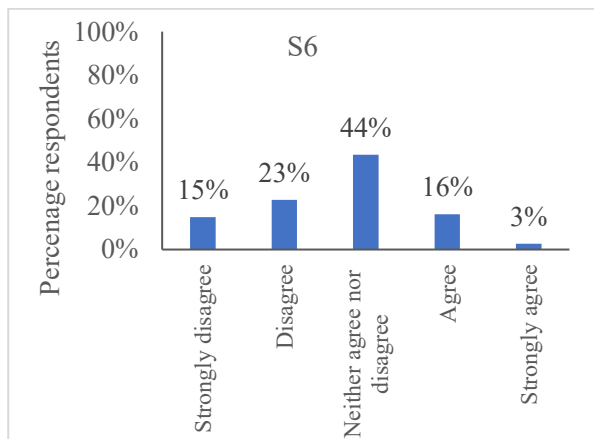
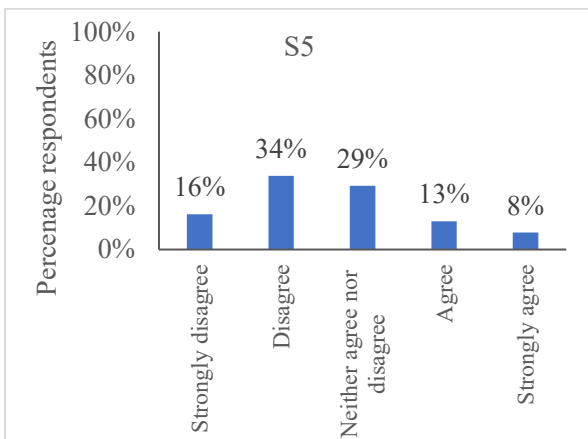
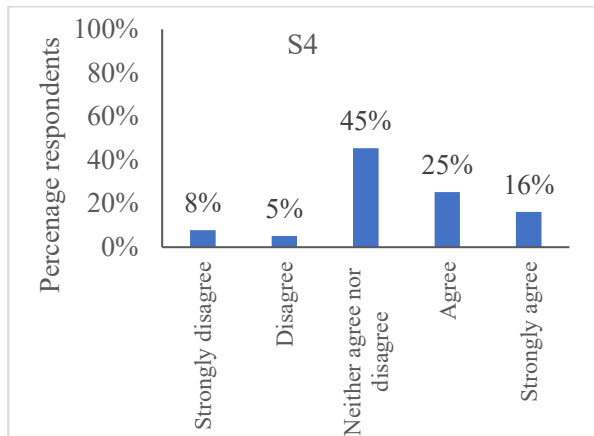
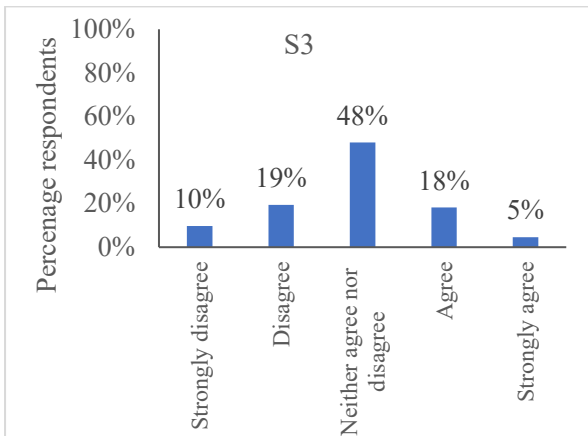
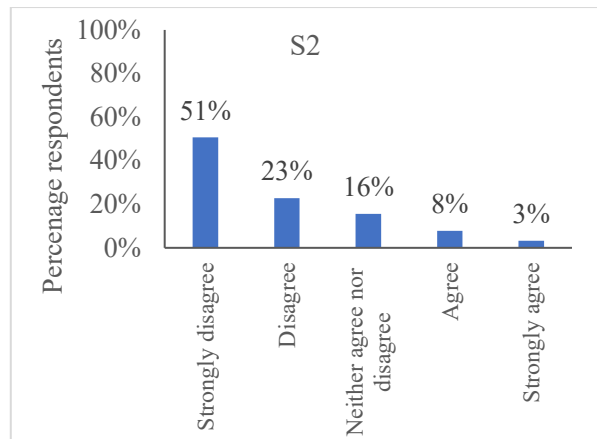
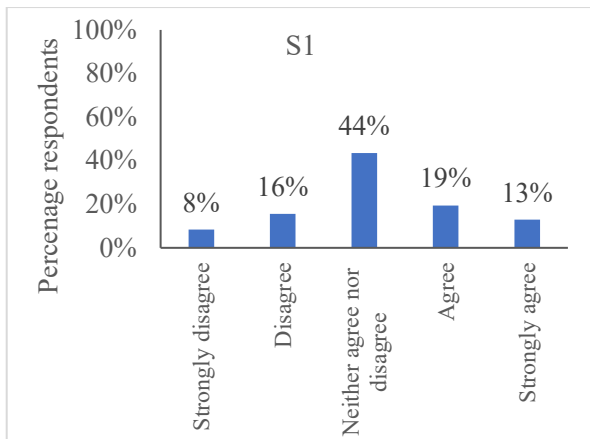


Figure 08. Empirical distributions of perceived response of the cascade community and experts about different dimensions of the security of cascade community: S1 – Cascade community has sufficient security from, robberies, crimes and other kinds of offences, S2 – Cascade community has sufficient security from wild animals such as elephants, S3 – Cascade community has secure access to necessary resources viz. food, water, agric. Inputs, natural resources etc., S4 – Cascade community has sufficient security from epidemics, S5 – Cascade community has sufficient security from noncommunicable diseases such as CKD, S6 – There is sufficient security from natural disasters such as floods and draughts. S7 – There are sufficient opportunities for obtaining compensation for damages from disasters, such as insurance

Empirical distribution perceived responses depicted in Figure 08-S6 follow the same pattern as Figure 08-S3 which shows 28% of the community disagree that they have no sufficient protection from natural disasters. Additionally, they mentioned that while they have significant protection against floods, they do not have sufficient protection against droughts. Empirical distribution depicted in Figure 08-S4 is a left skewed distribution which indicates that most of the community agree that they are protected from epidemics. They further mentioned that they were comparatively protected during the Global COVID 19 pandemic compared to the communities living in other parts of the country. The Distributions shown in Figure 08-S5 and Figure 08-S7 are right skewed distributions which indicate that majority of the cascade community disagree that they are safe from CKD and there are sufficient opportunities for compensating uncertainties, like insurance for disasters. 50% of the community said that they are not protected from noncommunicable diseases such as CKD. Another 50% of the cascade community said that they have no compensation opportunities like insurances for safety risks. Some community members said they had intermittently received government compensations for damages due to floods and droughts which is also did not sufficiently address their issue. Also, they were not sure whether they would get it next time.

Status of basic materials for a good life

Availability sufficient basic materials required for a good life is another constituent of wellbeing of a community which was assessed using six dimensions of it. They are respectively Adequate livelihoods, Sufficient access to nutritious food, Good quality houses, Good education, sufficient access to goods and services, sufficient decent transportation which are available for the community at all times. They were measured based on six perceptual statements; S8 – S13 (See Annexure B).

Figure 09-S8 depicts the empirical distribution of perceived response to the availability of adequate livelihoods for the cascade community within VTCSs which is a right skewed distribution. 65% of the cascade community do not believe that adequate livelihoods are available to them at all times in VTCSs. Figure 09-S9 shows the empirical distribution of perceived responses about adequate access to nutritious food at all times, which also appears to be a right-skewed distribution. 45% of the population say they do not have adequate access to nutritious food, while 29% of the population have a neutral opinion on this. The empirical distribution of informants' perceived responses regarding quality housing for the community is shown in Figure 09-S10. 45% of the community agree that they have good quality shelters while 25% of them are on a neutral opinion on this. Figure 09-S11 shows the empirical distribution of perceived community response to receiving a good education for a better life. It is also a right skewed distribution indicating that majority of the community disagree that they have sufficient opportunities for better education. However, there are about 19% community members who have ability to get better education. Figure 09-S12 is the empirical distribution of communities and experts perceived responses about availability of sufficient access to goods and services for a good life which is slightly a right-skewed one. 37% of the community disagree that they have sufficient access to goods and services for a better life in VTCSs. However there is a significant fraction (32%) of well to do people who have sufficient access to goods and services for a good life. Based on Figure 09-S13, we can infer that majority of the cascade community doesn't have good transport services.

Current health status of the cascade community

This is one of the important constituents of wellbeing of the cascade community which was measured in terms of six dimensions namely, Strength, Feeling well, Feeling happy, Access to clean water

Access to clean air and Access to health care facilities. Perceived responsus of the community about current ststus of these dimintions are dipicted in Figure 10.

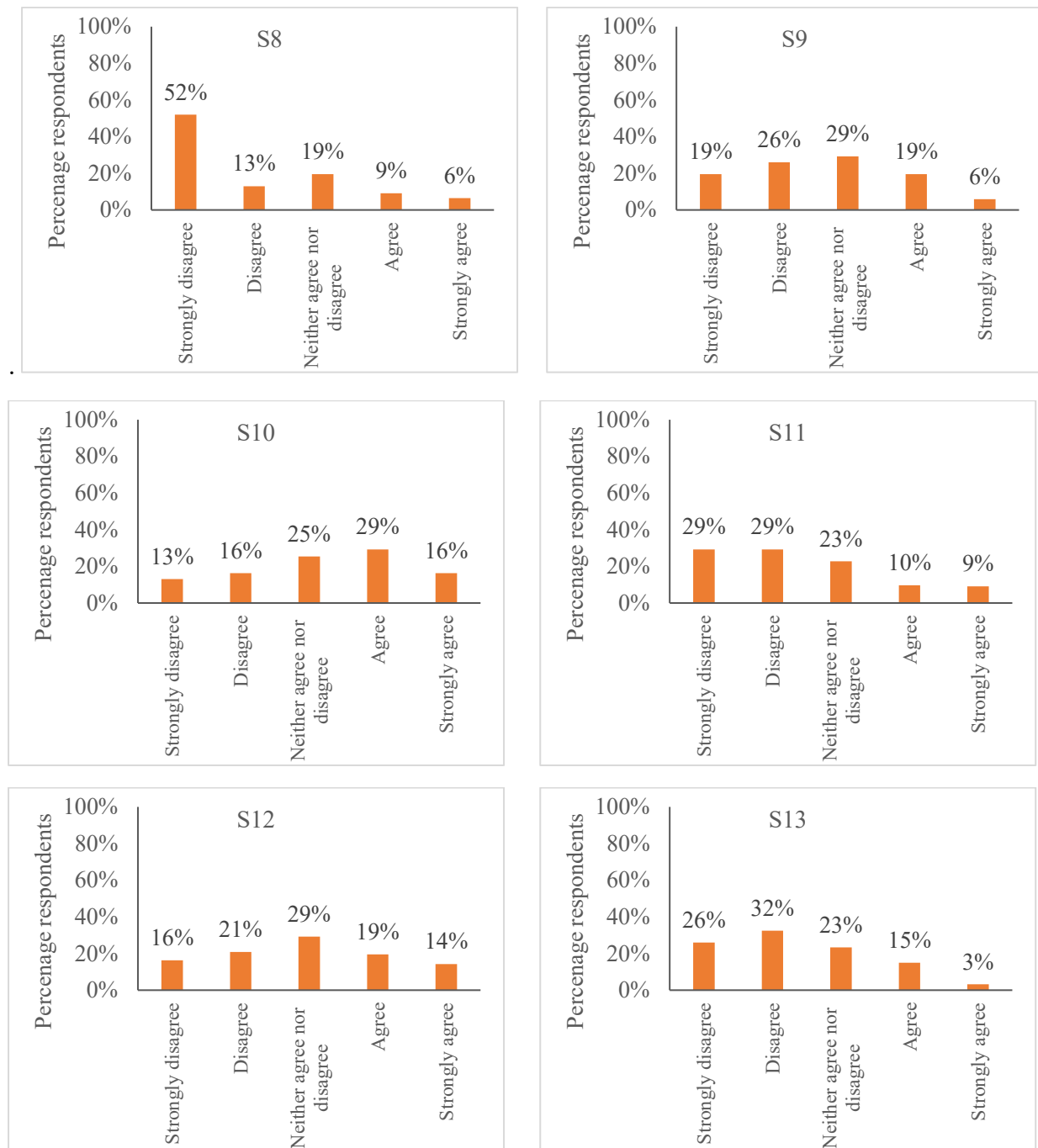


Figure 09. Empirical distributions of perceived response of the cascade community and experts about different dimensions of sufficient availability of basic needs for a good life: *S8 – There are sufficient livelihoods for cascade community for a good life at all time, S9 – Cascade community has sufficient access for nutritious food at all time, S10 – Cascade community has better shelter for a good life at all time, S11 – Cascade community has sufficient opportunities for having good education for a better life at all times, S12 – Cascade community has sufficient access to markets for needs required for a better life, S13 – Cascade community has access to decent transportation at all time*

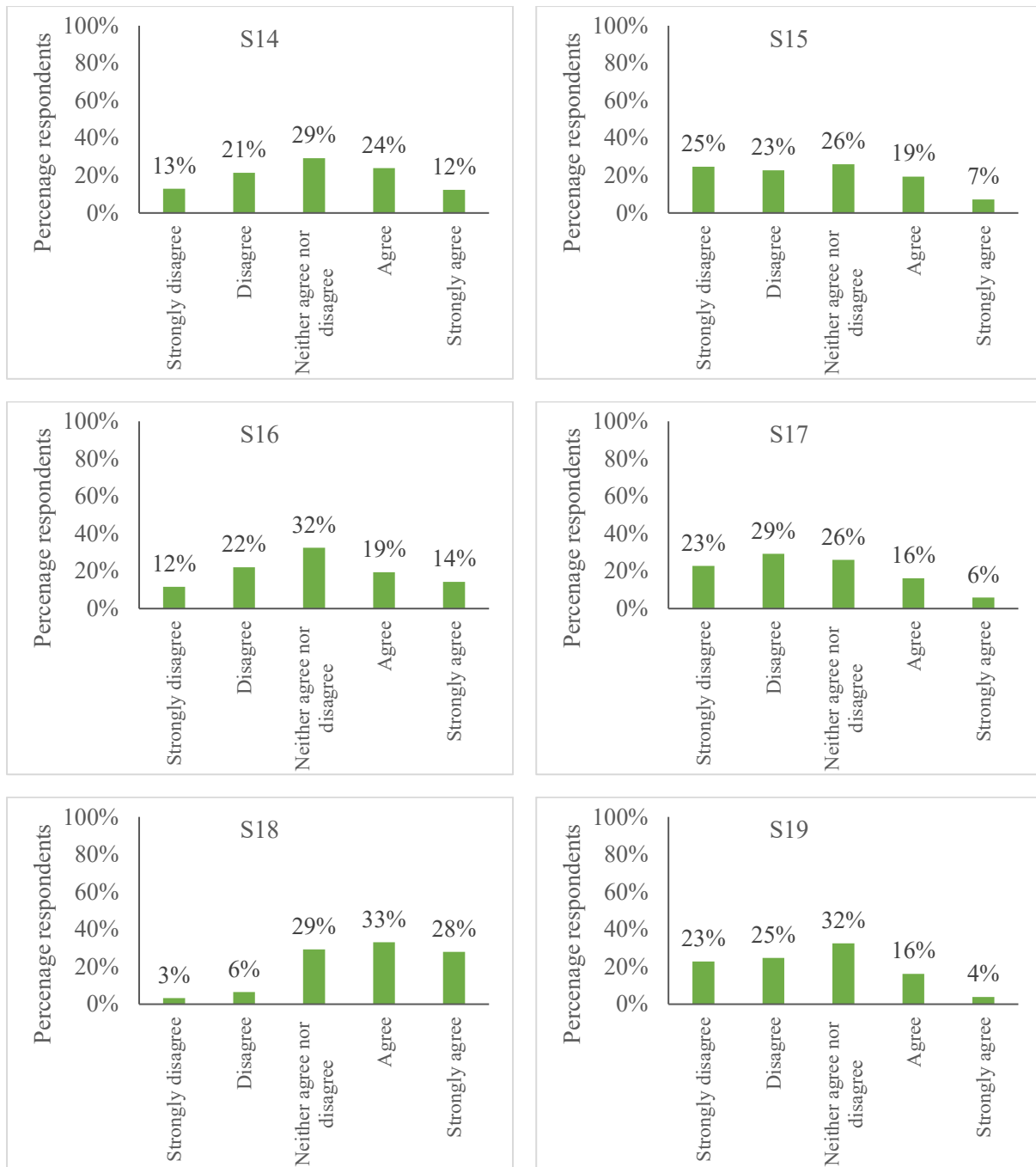


Figure 10. Empirical distributions of perceived response of the cascade community and experts about different dimensions of health status of the cascade community: *S14 – community feels strong at all time, S15 – Cascade community feels well all time, S16 – Cascade community is generally feeling happy at all time, S17 – Cascade community has access to clean water at all time, S18 – Cascade community has access to clean air at all time, S19 – Cascade community has access for sufficient health care at all time*

The dimensions of health status were measured using six perception statements, S14 – S19 as depicted in Figure 10. Figure 10 – S14 depicts the empirical distribution of perceived response of the informant about strength of the cascade community which is slightly left skewed. 32% of them agree that community feels strong al all time while another 24% of them disagree with it. This means that some of the community of VTCSs do not always feel strong and therefore have low

well-being. The empirical distribution of informants' perceived response to the cascade community feels well at all time shown in Figure 10-S15 which is a right skewed distribution. 48% of the community disagree that cascade community feels well at all time. However, 27% of the community agree that cascade community feels well at all time. There are some wealthy who can manage their living in VTCS with good health and feeling well at all time. However, significant fraction doesn't feel well at all time. Figure 10-S16 shows that 63% of the informants disagree on a neutral opinion that cascade community generally feeling happy at all time. This suggest that health status of the cascade community may not be as high as that of a community with good wellbeing. As depicted in Figure 10-S17, 52% of the community doesn't agree that they have access to sufficient clean water. However as per Figure 10 – S18, cascade community has plenty of access to clean air. However very few of them complain that they have no sufficient access to clean air in VTCS. Figure 10-S19 indicate that majority of the informants confirm that there are no access for sufficient health care at all time to the cascade community. However it further reflect the those wealthy people has capacity to access good health care even outside the CTVS.

Status of good social relation in VTCSs

Current status of good social relations of the cascade community was measured taking their social cohesion, corporation, mutual respect and ability to help other into granted. The perceived response of the community and experts were taken using four key perception questions respectively, S20 – There is a social cohesion sufficiently among the cascade community, S21 – Cascade community works very cooperatively, S22 – Cascade community show sufficient mutual respect, S23 – Cascade community has an ability to help others sufficiently. Empirical distribution of their perceived responses on these statements are depicted in Figure 11.

Figure 11 – S20 shows the empirical distribution of perceived response of the community and experts about the status of social cohesion in the cascade community which is rather a symmetric distribution. 39% of them don't agree that social cohesion in the VTCS is sufficient. However, 28% of the informants suggest that the social cohesion remains at a satisfactory level within the cascade community. The empirical distribution of perceived community and expert responses to collaboration within the Cascade community is shown in Figure 11-21 which is rather left skewed. 40% of study participants agree that the cascade community still works cooperatively, while another 31% disagree. 29% of respondents had a neutral opinion.

The empirical distribution of perceived responses of study participants to the status of mutual respect of the cascade community is shown in Figure 11-22 which appears approximately symmetric. 32% of them agree that mutual respect of cascade community is good enough while 36% of them disagree. As shown in Figure 11-23, the cascade community usually has the ability to help other. However, there are a significant number of people whose ability to help others is not sufficient. Overall, we can suggest the all dimensions of good social relations don't remain at their sufficient levels within the cascade community at present. There is evidence that some of the dimensions of good social relations with the community are insufficient.

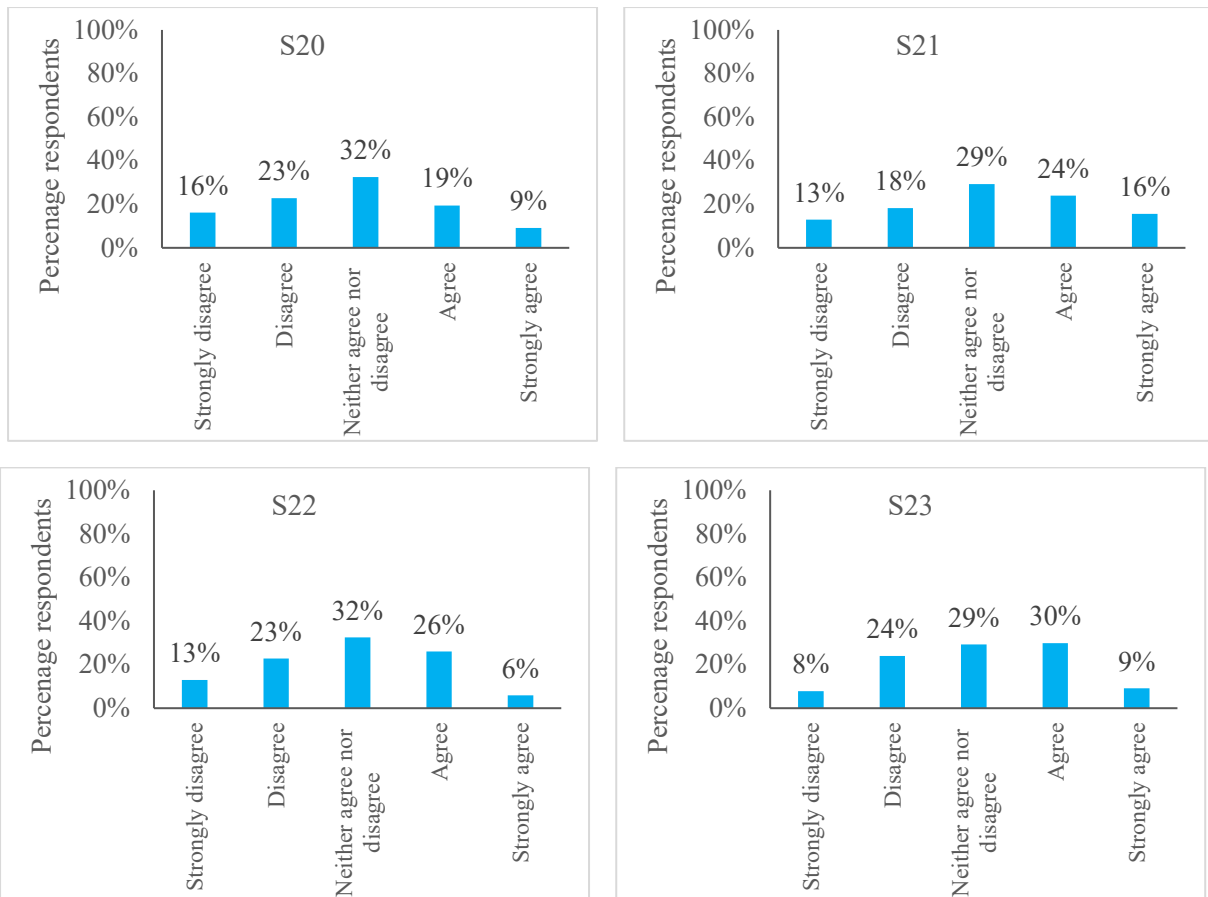


Figure 11. Empirical distributions of perceived response of the cascade community and experts about different dimensions of good social relations of the cascade community: *S20 – There is a social cohesion sufficiently among the cascade community, S21 – Cascade community works very cooperatively, S22 – Cascade community show sufficient mutual respect, S23 – Cascade community has an ability to help others sufficiently*

Linkages between ecosystem services and wellbeing of cascade community

Assessment of the nature of the linkages

The human being is a component of the environment which is the life on earth. Ecology, the scientific study of the interactions between organisms and their environment, is inextricably linked to humans. Ecosystems provides many services for a better life of the human on the earth. As part of the biosphere, humans have a significant influence on ecosystems and are influenced by them. Their actions have profoundly impacted ecological systems in numerous ways. These impacts can be broadly categorized into deforestation, pollution, climate change, and biodiversity loss. This in turn threatens the existence of humans on earth. Understanding the relationship between ecosystem services and human welfare is very important before people on the environment. Understanding this interconnectedness is critical to promoting sustainable practices that ensure the health of both the planet and its inhabitants.

Although VTCS is defined as a man-made system that harbor and transport water form one place to another to be used by the mankind, its real functions are more complex and thus become a multifaceted ecological system which provides numerous ecosystem services for the planet and

its inhabitants including human. VTCS and its ecosystem services impacts the welfare of the community which the inter relations are not well understood which we studied in this assignment.

Some of the ecosystem services are directly linked with different aspects of community wellbeing which strength could be variable from community to community and ecosystem to ecosystem. The direct and indirect relationship between the ecosystem services of the VTCS and the well-being of its community were identified in this study and summarized in Table 10. Supply of clean water and nonfood materials such as fiber, firewood, medicinal materials have indirect linkages with the security of cascade community. Provision of nonfood material has indirect relations with health of the community. In addition, all other provisional services have direct linkages with all four constituents of welfare of the cascade community. Some of the participants identified that provisional services have some times indirect linkages to good social relations. Provisional services are directly related to livelihoods of the community which decides the capacity of cascade community to access to needs for good life.

Table 10. The direct and indirect nature of the relationship between various ecosystem services and key constituents of community wellbeing

Ecosystem services	Constituents of wellbeing			
	Security	Basic materials for good life	Health	Good social relations
Provisional Services				
Crop production/ Fisheries/ Livestock	D	D	D	D/I
Supply water for cultivation	D	D	D	D/I
Supply clean water for drinking	I	D	D	D/I
Supply water for washing/ bathing/ livestock/ other uses	D	D	D	D/I
Supply nonfood products (Reeds, firewood, medicinal prod etc.	I	D	I	D/I
Supply food materials (Bee honey, yams, leafy veg. etc.	D	D	D	D/I
Regulatory services				
Recharge water table and maintain the flow	D	I	D	I
Water purification	D	D	D	I
Erosion and flood control	D	D	D	I
Regulate climate	D	I	D	I
Control human elephant conflict	D	D	D	I
Support Services				
Provide habitats for plants and animals	I	I	I	I
Maintain biodiversity	I	I	I	I
Soil nutrient cycling	I	I	I	I
Pollination	I	I	I	I
Biological control of pests and diseases	I	I	I	I
Cultural Services				
Recreation	I	I	D	D
Aesthetic value and amenity	I	I	D	D
Traditional knowledge and education	I	I	I	D
Rituals	I	I	I	D
Social cohesion, peace, humanity and corporation	D	D	I	D

All major regulatory services (Table 10) directly related to the security and health status of the community as perceived by the study participants. Regulatory services such as water purification, erosion and flood control and control of human elephant control has direct links to sufficient access to basic materials for good line in VTCSs. All regulatory services of VTCS have indirect linkages to maintain good social relation among cascade community.

All support services indirectly link with all four key components of wellbeing of the cascade community, Furthermore, supporting ecosystem services are the backbone of all other ecosystem services. Nutrient cycling, soil formation, primary production and habitat provision form the basis for the provisioning, regulatory and cultural services that VTCSs provide. Recognizing and protecting supporting services is critical to the continued delivery of the diverse benefits that VTCS provide to cascade community for their well-being.

All cultural services directly linked with establishment of good social relations sufficiently among the cascade community and thus unsure their wellbeing. Cultural services, provision recreation, amenity and aesthetic value directly linked with the health status of the cascade community while the rest are not. The study revealed that social cohesion, peace, humanity and corporation directly linked with community security and health. Rest of the cultural services indirectly linked with community's security and access to basic materials for good lime of the community.

Assessment of the strength of the linkages

Assessment matrix of the intensity of linkages between ecosystem services and wellbeing of cascade community is given in Table 11. It can be observed that the strength of the linkages between security status of the cascade community and provisional services, agricultural production and supply of water for cultivation were strong. The major livelihood of the cascade community is agricultural production which is supported by provision of irrigation water by VTCS. They said that if the livelihood status is string then they can get sufficient security measures in all aspects and at all time. Although the supply of water for other purposes and supply of nonagricultural food directly related to community's security, their intensities were week. Linkages between all provisional services and access to basic materials for good line were found to be strong.

Provisional services naturally provide materials for the community to have a good life which is true for VTCS as well. The assessment confirmed this showing string linkages between all provisional services and access to basic materials for good life. Except provision of nonfood materials and water for other uses, rest of provisional services are strongly linked with health status of the cascade community. Supply of agricultural production, water for cultivation and other uses (except for drinking) strongly link with maintaining good social relation among the cascade community. Usually, agricultural activities are done with the support of the community which is important since the scale of production is small. Water management and maintenance in VTCS is a community-oriented service. The efficiency of these services is directly influenced by good social relationships and vice versa.

All key regulatory services are strongly linked with the security status of cascade community regardless the nature of the linkage. Water purification and erosion and flood control are strongly linked with sufficient access to basic materials for good life of the cascade community. As a key regulatory service, water purification by VTCS has a strong link to the health status of the cascade

community. All regulatory services are weakly linked with good social relations among the cascade community. Although all support services are indirectly linked with the wellbeing of the cascade community, some support services viz. provision of habitats, maintenance of biodiversity and soil nutrient recycling has strong linkages with security, access to basic materials for good life and health status of cascade community. Thus their impact of the wellbeing of cascade community could be high.

Table 11. Assessment matrix of the intensity of linkages between ecosystem services and wellbeing of cascade community

Ecosystem services	Constituents of wellbeing			
	Security	Basic materials for good life	Health	Good social relations
Provisional Services				
Crop production/ Fisheries/ Livestock	3	3	3	3
Supply water for cultivation	3	3	3	3
Supply clean water for drinking	2	3	3	2
Supply water for washing/ bathing/ livestock/ other uses	1	3	2	3
Supply nonfood products (Reeds, firewood, medicinal prod etc.	2	3	2	2
Supply food materials (Bee honey, yams, leafy veg. etc.	1	3	3	2
Regulatory services				
Recharge water table and maintain the flow	3	2	2	1
Water purification	3	3	3	1
Erosion and flood control	3	3	2	1
Regulate climate	3	2	2	1
Control human elephant conflict	3	3	3	3
Support Services				
Provide habitats for plants and animals	3	3	3	1
Maintain biodiversity	3	3	3	1
Soil nutrient cycling	3	3	3	1
Pollination	1	2	1	1
Biological control of pests and diseases	1	2	2	1
Cultural Services				
Recreation	1	1	2	3
Aesthetic value and amenity	1	1	2	1
Traditional knowledge and education	2	2	1	2
Rituals	2	1	1	3
Social cohesion, peace, humanity and corporation	3	3	1	3
Intensity score	1 - Weak	2 - Medium	3 - Strong	

Provision of social cohesion, rituals and recreational services of VTCSs are strongly linked with good social interactions among the cascade community. Social cohesion, peace, humanity and corporation have strong links with good security status and access to basic materials for good life of the cascade community.

Potential for mediation by socioeconomic factors

Socio-economic status plays a crucial moderating role in the linkages between ecosystem services and human wellbeing. If the socio-economic status are good then the cascade community would have better access to and can derive greater benefits from ecosystem services, enhancing their overall wellbeing. Community with lower socio-economic background often face barriers to accessing these services, leading to disparities in health, economic security, and quality of life. Addressing these inequalities requires targeted policies and interventions that enhance access to ecosystem services for all socio-economic groups, ensuring equitable distribution of the benefits provided by VTCSs which should be seriously considered during ecological restoration efforts. Assessment results of the potential of socio-economic status community to moderated linkages between ecosystem services and wellbeing of cascade community is given in Table 12.

Table 12. Assessment results of the potential of socio-economic status of cascade community to moderated linkages between ecosystem services and wellbeing of cascade community

Ecosystem services	Constituents of wellbeing			
	Security	Basic materials for good life	Health	Good social relations
Provisional Services				
Crop production/ Fisheries/ Livestock	3	3	3	3
Supply water for cultivation	3	3	3	3
Supply clean water for drinking	3	3	3	3
Supply water for washing/ bathing/ livestock/ other uses	2	3	2	3
Supply nonfood products (Reeds, firewood, medicinal prod etc.	3	3	3	3
Supply food materials (Bee honey, yams, leafy veg. etc.	2	3	3	3
Regulatory services				
Recharge water table and maintain the flow	3	2	3	1
Water purification	3	3	3	1
Erosion and flood control	3	3	3	1
Regulate climate	1	2	1	1
Control human elephant conflict	3	3	3	3
Support Services				
Provide habitats for plants and animals	3	2	3	1
Maintain biodiversity	3	2	3	1
Soil nutrient cycling	2	2	2	1
Pollination	1	2	1	1
Biological control of pests and diseases	1	1	2	1
Cultural Services				
Recreation	2	1	2	3
Aesthetic value and amenity	1	1	1	1
Traditional knowledge and education	1	2	1	2
Rituals	3	1	1	3
Social cohesion, peace, humanity and corporation	3	3	1	3
Potential score	1 - Low	2 - Moderate	3 - High	

It can be clearly noticed that linkages between provisional ecosystem services and constituents of wellbeing are highly moderated by the socio-economic status of the cascade community. The poor

the socio-economic status the lower the benefits from provisional services. The rich people get more opportunity for better access to all provisional services offered by the VTCSs. The linkages between regulatory services, recharge water table, water purification and erosion and flood control and some elements of wellbeing, security, basic materials for good life and health can be highly influenced by socio-economic status of the community. If a flood occurs and clean water is not available, the richer people in VTCS could ensure their safety and a good life with outside help because their purchasing power and access to goods and services are higher. Community with low socio-economic backgrounds in VTCSs would be most vulnerable to floods, sparsity of clean water and health issues. The linkage between control of human elephant conflict and all key aspects of well being is highly moderated by the socio-economic factors. The richest in VTCS has the capacity to invest on safety measures, access to materials for good life and health hazards when they are threatened by encroachments of elephants. The poor communities are the most vulnerable groups for this kind of issues.

Local scenario vs Global scenario

The results in Table 10 were upscaled to key ecosystem service categories for the purpose to compare it with the global scenario synthesized by ¹⁰MA 2005. For the provisional services, the intensity of linkages between provisional services and three constituents of wellbeing; security, access to basic materials for good life and health tally with that of the general scenario published by MA 2005. However, the intensity of the linkage between provisional services and good social relations is high among the cascade community in contrast to that of the global scenario. The responsibility of operation and management of provisional services arising from VTCSs is heavily on the cascade community. Most of the operations linked with provisional services are significantly associated are impacted by good social relations among the cascade community. Since the scale of operation is small, they depend on more labor for smooth operations of agricultural production for which good social relations would heavily support.

Table 13. Comparison of the intensity of linkages between ecosystem services and well being of cascade community with the global scenario synthesized by MA 2005

Ecosystem services		Constituents of well-being			
		Security	Basic materials for good life	Health	Good social relations
Provisional	Local scenario	M	H	H	H
	Global scenario	M	H	H	W
Regulatory	Local scenario	H	H	H	M
	Global scenario	H	H	H	W
Cultural	Local scenario	M	M	M	H
	Global scenario	W	W	M	M
Support	Local scenario	M	H	H	W
	Global scenario	H	H	H	H

Intensity score	W - Weak	M- Medium	H - Strong
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¹⁰ Millennium ecosystem assessment, M. E. A. (2005). *Ecosystems and human well-being* (Vol. 5, p. 563). Washington, DC: Island press.

Intensity of linkages between regulatory services and wellbeing of cascade community does not much deviate from the scenario reported by MA 2005. The intensity of linkage between cultural services and wellbeing of the cascade community is rated as medium which in the global context identified as weak for security and access to basic materials to good life. The tertianship between cultural services on the wellbeing of the cascade community is rated as high which is moderate in the global scenario.

In the global context, support services impact highly on all other ecosystem services significantly and highly link with all aspects of human wellbeing. For VTCS this is true only for Health of the community and access to basic materials for good life. Of the VTCS the linkage between support services and good social interactions is rated as weak.

Comparison of how socio-economic status cascade community moderate linkages between ecosystem services and their wellbeing with the global scenario synthesized by MA 2005 is given in Table 14. In VTCS linkages between ecosystem services and wellbeing are highly moderated by the socio-economic status of the community. The main livelihood of cascade community is agriculture. Most of VTCS areas are rural areas where the level of poverty is rather high. Thus, what we have inferred is not unrealistic. However, in the global context the linkages between provisional services are not highly moderated by socio-economic status of the community.

Table 14. Comparison of how socio-economic status cascade community moderate linkages between ecosystem services and their wellbeing with the global scenario synthesized by MA 2005

Ecosystem services		Constituents of well-being			
		Security	Basic materials for good life	Health	Good social relations
Provisional	Local scenario	H	H	H	H
	Global scenario	H	H	M	L
Regulatory	Local scenario	H	H	H	M
	Global scenario	M	M	M	L
Cultural	Local scenario	M	M	L	H
	Global scenario	M	L	L	L
Supporting	Local scenario	M	M	M	L
	Global scenario	M	M	M	M

Potential score	L - Low	M - Moderate	H - High
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In VTCSs, linkage between regulatory services and constituents of wellbeing are comparatively high moderated by socioeconomic status than that of the global scenario.

CONCLUSIONS AND RECOMMENDATIONS

This study reveals that at present, the supply of all ecosystem services by VTCSs ranges from no relevant capacity to relevant capacity. As mentioned in the literature it has been at either a high relevant capacity or very high relevant capacity. Thus, the potential of VTCSs to provide with its ecosystem services has substantially reduced. It can be seen that most of the landscapes are functioning with their lower capacities to provide respective ecosystem services. However, supply of water for cultivation and other uses (except for drinking water) by the tank component of VTCS remains at a high relevant capacity which may not be sustainable during draught seasons since other component of a VTCS do not support much for provision of water, as they did earlier.

The demand for ecosystem services from different landscapes in VTCSs also ranges from no relevant demand to relevant demand. The incidences of low relevant demand and moderate relevant demand are substantially high compared to incidences of relevant demand. This concludes that overall demand for ecosystem services remain at low to moderate level compared at present. This means that the community is not efficiently utilizing respective landscapes for respective ecosystem services. This needs more research to discover underlying issues, solutions and strategies to improve the demand status that would be useful in support of VTCS restoration.

Budgets of ecosystem services show that although both supply and demand are currently less, in most of the cases the demand exceeds the supply of ecosystem services. This means although the community require to utilize different landscapes in VTCSs efficiently the ecosystem has insufficient capacity to meet the demand. Thus, greater attentions must be given on ecological restoration of VTCS with all necessary policy support.

The wellbeing of the cascade community does not generally remain at a high level. It ranges from lower level to moderate levels for majority of the community. However, there is a portion of the Cascade community whose welfare status is significantly high.

It can be concluded that security status of the majority of cascade community remains at a moderate level. The most threatening factors on their security is human elephant conflict and natural disasters which can be further increased with adverse impacts of climate changes. However, they are significantly protected against epidemics, which was also shown during the COVID-19 pandemic. Cascade Community's potential to access basic materials for a good life remains at a medium level. However, they are suffering from lack of satisfactory livelihoods for a good life.

The overall health status of the cascade community ranges from a low level to a moderate level. Compared to cities their capacity to access clean air is high. However, the access to clean drinking water is comparatively low and they are under threat of the chronic kidney disease. This substantially has lower down their wellbeing status. The majority of the community believe that comparatively they have good social relationships within VTCSs.

Although VTCS is defined as a man-made system that harbor and transport water from one place to another to be used by the mankind, its real functions are more complex and thus become a multifaceted ecological system which provides numerous ecosystem services for the planet and its inhabitants including human. VTCS and its ecosystem services impacts the

welfare of the community which the inter relations are not well understood. We have made an effort to fill this gap with a qualitative approach. We recommend more research in this line covering more ecosystem in Sri Lanka.

Provisional services arising from VTCS are strongly linked with the wellbeing of the cascade community which is similar in the global context except for one dimension of wellbeing, good social relations. The strength of the connection between regulatory services and the well-being of the VTCS community is similar to that of the global situation. Although support services are strongly linked to all components of well-being in the global scenario, it is not strongly linked with the security and good social relation of the Cascade community. In VTCSs, cultural services are more tightly linked with all aspect of community's wellbeing compared to that of the Global scenario. It can be further concluded that socio economic status of the cascade community moderates the linkage between ecosystem services and wellbeing than that of the global scenario. This concludes that VTCS is a unique ecosystem compared to an average global ecosystem.

In conclusion, ecosystem services arising from VTCS has significant linkage to the wellbeing of the community. The welfare of the community can be raised by improving the provision of ecosystem services of VTCSs. However, currently the potential of VTCSs to provide ecosystem services as expected has reduced substantially. This provide significant insight how important ecological restoration of VTCS is.

ANNEXTURE

A. Guidelines and formats for collection of information form FGDs and KIIs

Health (Strength, Feeling well, Access to clean air and water)

Is there any relationship between ES and Health status of the community?

Is the impact direct/ Indirect?

What is the strength of relationship?

Is this relationship moderated by the socio-economic status of the community and how?

Ecosystem service	Evaluation			
	1 – Yes/ No	2 – D/I	3 – W/ M/ S	4 – L/ M/ H
Provisional Services				
Crop production/ Fisheries/ Livestock				
Supply water for cultivation				
Supply clean water for drinking				
Supply water for washing/ bathing/ livestock/ other uses				
Supply nonfood products (Reeds, firewood, medicinal prod etc.				
Supply food materials (Bee honey, yams, leafy veg. etc.				
Regulatory services				
Recharge water table and maintain the flow				
Water purification				
Erosion and flood control				
Regulate climate				
Control human elephant conflict				
Support Services				
Provide habitats for plants and animals				
Maintain biodiversity				
Soil nutrient cycling				
Pollination				
Biological control of pests and diseases				
Cultural Services				
Recreation				
Aesthetic value and amenity				
Traditional knowledge and education				
Rituals				
Social cohesion, peace, humanity and corporation				

Basic needs for having a good life (Adequate livelihoods, Sufficient nutritious food, Shelter, Access to goods)

Is there any relationship between ES and Basic needs for having a good life (Adequate livelihoods, Sufficient nutritious food, Shelter, Access to goods) by the community?

Is the impact direct/ Indirect?

What is the strength of relationship?

Is this relationship moderated by the socio-economic status of the community?

Ecosystem service	Evaluation			
	1 – Yes/ No	2 – D/I	3 – W/ M/ S	4 – L/ M/ H
Provisional Services				
Crop production/ Fisheries/ Livestock				
Supply water for cultivation				
Supply clean water for drinking				
Supply water for washing/ bathing/ livestock/ other uses				
Supply nonfood products (Reeds, firewood, medicinal prod etc.				
Supply food materials (Bee honey, yams, leafy veg. etc.				
Regulatory services				
Recharge water table and maintain the flow				
Water purification				
Erosion and flood control				
Regulate climate				
Control human elephant conflict				
Support Services				
Provide habitats for plants and animals				
Maintain biodiversity				
Soil nutrient cycling				
Pollination				
Biological control of pests and diseases				
Cultural Services				
Recreation				
Aesthetic value and amenity				
Traditional knowledge and education				
Rituals				
Social cohesion, peace, humanity and corporation				

Security (Personal safety, Secure resource access, Security from disasters)

Is there any relationship between ES and Security (Personal safety, Secure resource access, Security from disasters) status of the community?

Is the impact direct/ Indirect?

What is the strength of relationship?

Is this relationship moderated by the socio-economic status of the community?

Ecosystem service	Evaluation			
	1 – Yes/ No	2 – D/I	3 – W/ M/ S	4 – L/ M/ H
Provisional Services				
Crop production/ Fisheries/ Livestock				
Supply water for cultivation				
Supply clean water for drinking				
Supply water for washing/ bathing/ livestock/ other uses				
Supply nonfood products (Reeds, firewood, medicinal prod etc.				
Supply food materials (Bee honey, yams, leafy veg. etc.				
Regulatory services				
Recharge water table and maintain the flow				
Water purification				
Erosion and flood control				
Regulate climate				
Control human elephant conflict				
Support Services				
Provide habitats for plants and animals				
Maintain biodiversity				
Soil nutrient cycling				
Pollination				
Biological control of pests and diseases				
Cultural Services				
Recreation				
Aesthetic value and amenity				
Traditional knowledge and education				
Rituals				
Social cohesion, peace, humanity and corporation				

Social Interactions (Social cohesion, mutual respect, ability to help others)

Is there any relationship between ES and Social Interactions (Social cohesion, mutual respect, ability to help others) of the community?

Is the impact direct/ Indirect?

What is the strength of relationship?

Is this relationship moderated by the socio-economic status of the community?

Ecosystem service	Evaluation			
	1 – Yes/ No	2 – D/I	3 – W/ M/ S	4 – L/ M/ H
Provisional Services				
Crop production/ Fisheries/ Livestock				
Supply water for cultivation				
Supply clean water for drinking				
Supply water for washing/ bathing/ livestock/ other uses				
Supply nonfood products (Reeds, firewood, medicinal prod etc.				
Supply food materials (Bee honey, yams, leafy veg. etc.				
Regulatory services				
Recharge water table and maintain the flow				
Water purification				
Erosion and flood control				
Regulate climate				
Control human elephant conflict				
Support Services				
Provide habitats for plants and animals				
Maintain biodiversity				
Soil nutrient cycling				
Pollination				
Biological control of pests and diseases				
Cultural Services				
Recreation				
Aesthetic value and amenity				
Traditional knowledge and education				
Rituals				
Social cohesion, peace, humanity and corporation				

Guidelines for KII and FGD: Conceptual framework and key questions

Describe the background of the study, ecosystem services and wellbeing to the informants who take part in KIIs and FGDs. Use the following information as a guideline. This includes some conceptual information which need to be described in depth among the information who are not usually familiar with. Ambiguities and confusion about the subject matters and evaluation process should be frequently resolved during interviews.

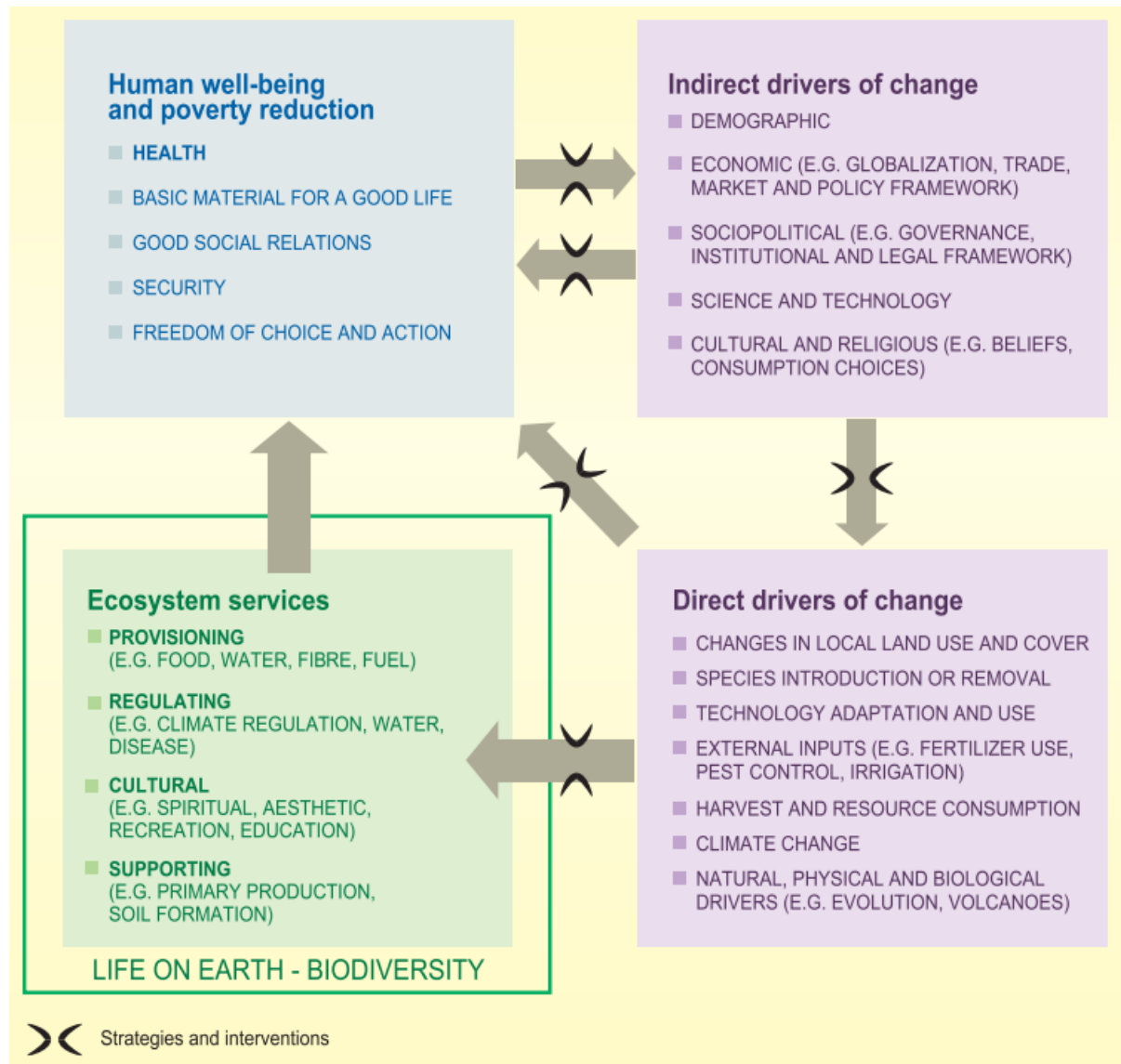


Figure A1. conceptual framework to explain how ecosystem services relate to human wellbeing (Source: MA, 2005; <https://www.millenniumassessment.org>)

1. How well the community aware of the ecosystem services arising from VTCS?
2. What is the current status of the demand and supply of identified ecosystem services by VTCS?
3. How well the community aware of the constituents of human wellbeing?
4. How about current status of the identified constituents of human wellbeing?

5. How about community's perception of the intensity of the linkages between ecosystem services and constituents of wellbeing?
6. Identify the potential for mediation of linkages between ecosystem services and human wellbeing by socio economic factors?

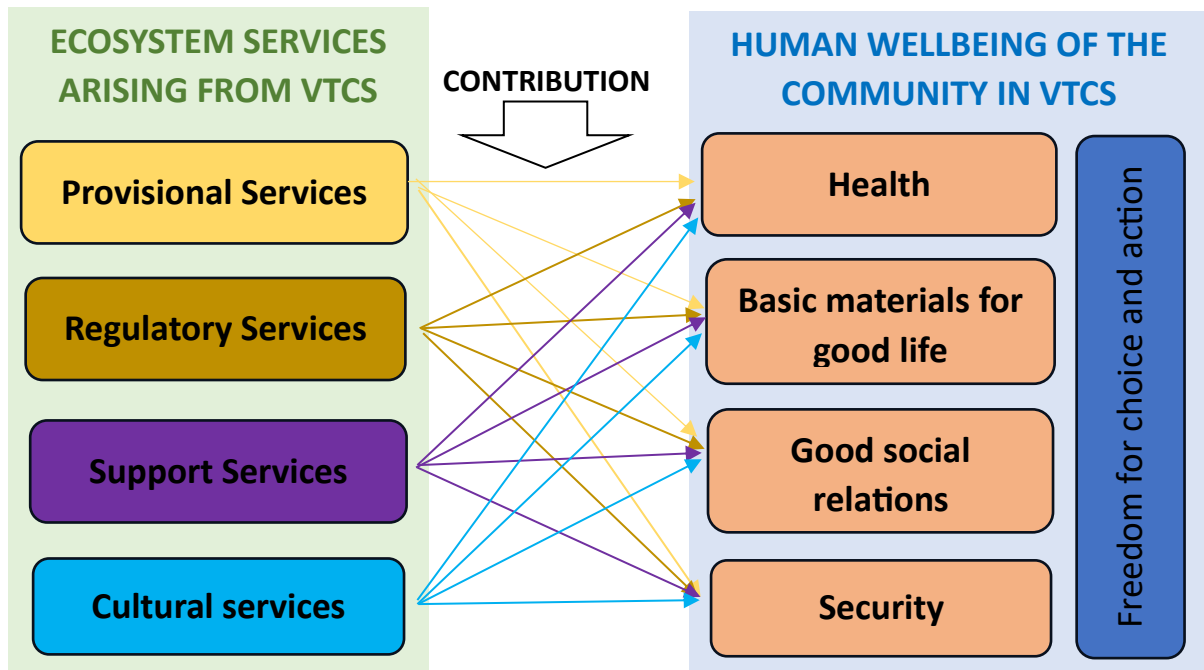


Figure A2. Conceptual framework established and validated based on the literature review and analysis on preliminary data that is used in the assessment of the contribution of ecosystem services arising from VTCSs to wellbeing of its community. *Source: MA, 2005 and Assignment 02 - study on assessment of ecosystem services for human health.*

Potential for mediation by socioeconomic factors	–	L	M	H
Intensity of linkages between ES and human wellbeing	–	L	M	H

B. Guidelines for assessing status of wellbeing of the cascade community during FGDs and KIIs

Key aspects of wellbeing		Statement	Perception
Security			
Personal safety - from human	S1	Cascade community has sufficient security from, thieves, criminals and other kinds of offenders	
Personal safety - from wild animals	S2	Cascade community has security from wild animals such as elephant	
Secure resource access	S3	Cascade community has secure access to necessary resources viz. food, water, agric. Inputs, natural resources etc.	
Safety from epidemics	S4	Cascade community has sufficient security from epidemics	
Safety from CKD	S5	Cascade community has sufficient security from noncommunicable diseases such as CKD	
Security from disasters	S6	There is sufficient security from natural disasters such as floods and draughts	
Opportunity for compensation	S7	There are sufficient opportunities receive compensation for damages from disasters, Like insurance	
Basic materials for good life			
Adequate livelihoods	S8	There are sufficient livelihoods for cascade community for a good life at all time	
Sufficient nutritious food	S9	Cascade community has sufficient access for nutritious food at all time	
Good quality houses	S10	Cascade community has better shelter for a good life at all time	
Good education	S11	Cascade community has sufficient opportunities for having good education	
Access to goods and services	S12	Cascade community has sufficient access to markets for needs required for a better life	
Good transportation	S13	Cascade community has access to decent transportation at all time	
Health			
Strength	S14	Cascade community feels strong at all time	
Feeling well	S15	Cascade community feels well all time	
Feeling happy	S16	Cascade community is generally feeling happy at all time	
Access to clean water	S17	Cascade community has access to clean water at all time	
Access to clean air	S18	Cascade community has access to clean air at all time	
Access to health care facilities	S19	Cascade community has access for sufficient health care at all time	
Good social relations			
Social cohesion	S20	There is a social cohesion sufficiently among the cascade community	
Corporation	S21	Cascade community works very cooperatively	
Mutual respect	S22	Cascade community show sufficient mutual respect	
Ability to help others	S23	Cascade community has an ability to help others sufficiently	

Key: 1 – Strongly disagree, 2 – Disagree, 3 – Neither disagree nor agree, 4 – Agree, 5 – Strongly agree

C. Baseline status of ecosystem service demand, supply and budgets in Palugaswewa VTCS

Table C1. Ecosystem service supply by different land uses in Palugaswewa cascade

ES	Tank	Diyagilma	Gas gommama	Kattakaduwa	Godawala	Isvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP
Provisional Services																	
Paddy and other cereals	0	1	0	1	0	0	2	0	0	4	0	0	0	3	0	0	0
Lentils and other seed crop	0	1	0	0	0	0	2	0	0	2	0	0	0	2	0	0	0
Leafy vegetables, vegetables and tuber crops	1	1	0	1	0	1	1	1	0	1	0	0	1	2	0	0	0
Clean/ fresh water for drinking and domestic use	3	0	0	0	1	2	0	0	0	0	0	0	0	0	2	0	0
Irrigation water	4	2	1	1	2	0	2	1	1	3	0	3	1	3	3	1	2
Inland fisheries	3	1	0	1	0	0	0	0	0	2	0	0	0	0	1	1	0
Livestock	0	2	1	1	1	2	3	1	0	3	0	2	2	2	0	1	2
Fodder and grasses	0	2	1	1	0	1	1	1	1	2	0	1	2	2	0	2	1
Sedges and other alternative plants	1	1	0	1	1	2	0	0	0	2	0	0	1	1	1	2	1
Herbals/ medicinal plants and materials	2	2	3	2	1	3	3	3	3	2	3	1	2	2	2	2	2
Ecotourism	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Regulatory services																	
Control floods/ Flood protection	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0
Ground water recharge and maintain the flow	3	2	3	2	3	2	1	3	3	3	0	2	2	2	2	2	1
Water purification	2	2	3	2	3	3	1	3	2	2	1	0	1	0	0	2	0
Local climate regulation	3	2	2	2	2	2	1	3	3	2	0	1	2	2	2	2	1
Global climate regulation	1	1	2	1	1	2	1	2	2	1	0	1	1	1	1	2	1
Pollination	2	2	3	2	0	2	2	3	3	3	0	2	2	3	2	1	3
Soil Nutrient regulation	2	3	2	1	0	2	2	2	2	2	0	2	2	2	2	2	2
Erosion regulation	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0
Support Services																	
Food security	3	2	2	2	1	2	2	3	3	4	0	2	2	3	3	1	1
Nutrient security	2	2	2	1	1	2	2	3	2	3	0	2	1	3	2	1	1
Conserve and maintain biodiversity	4	3	3	2	2	2	2	3	3	3	3	2	3	3	3	3	1
Cultural Services																	
Recreational and aesthetic value	3	3	3	2	1	2	2	3	3	4	1	2	2	3	3	2	2
Traditional knowledge and values	3	2	2	1	1	1	3	2	1	3	1	2	1	2	3	1	2
Culture, traditions, customs and practices	2	1	2	1	1	1	2	2	0	3	0	1	0	2	3	1	2
peace, harmony and corporation	2	1	1	1	1	1	2	2	0	3	0	2	0	2	2	1	1

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

0	No relevant capacity	1	Low relevant capacity	2	Medium relevant capacity
3	Relevant capacity	4	High relevant capacity	5	Very high relevant capacity

Source: Baseline study of HLP

Table C2. Ecosystem services Demand by different land use in Palugaswewa Cascade

ES	Tank	Diyagilma	Gas gommama	Katakaduwa	Godawala	Isvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP
Provisional services																	
Paddy and other cereals	0	1	0	1	0	0	2	0	0	4	0	0	0	3	0	0	0
Lentils and other seed crop	0	1	0	0	0	0	2	0	0	3	0	0	0	3	0	0	0
Leafy vegetables, vegetables and tuber crops	0	1	0	1	0	1	1	1	0	2	0	0	1	2	0	0	0
Clean/ fresh water for drinking and domestic use	2	0	0	0	2	2	0	0	0	0	0	1	0	0	2	0	0
Irrigation water	4	2	1	1	2	0	4	1	0	3	0	3	0	3	3	1	2
Inland fisheries	3	1	0	1	1	0	0	0	0	2	0	0	0	0	1	1	0
Livestock	0	2	1	1	0	2	3	1	0	3	0	2	2	2	0	1	2
Fodder and grasses	0	2	1	1	0	1	1	1	1	3	0	2	2	2	0	1	1
Sedges and other alternative plants	1	1	1	2	1	1	0	0	0	2	0	0	1	1	2	2	1
Herbals/ medicinal plans and materials	1	1	2	2	1	2	2	2	2	2	1	1	2	2	1	1	2
Ecotourism	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Regulatory services																	
Control floods/ Flood protection	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0
Ground water recharge and maintain the flow	3	2	3	3	3	2	3	3	3	3	0	2	2	2	3	2	1
Water purification	2	2	3	3	3	3	3	3	2	2	1	0	1	1	0	2	0
Local climate regulation	3	2	2	2	2	2	1	3	3	2	0	1	2	2	2	2	1
Global climate regulation	2	1	2	2	1	2	1	2	2	1	0	1	1	1	1	2	1
Pollination	2	2	3	2	0	2	4	3	3	3	0	2	2	3	2	1	3
Soil Nutrient regulation	2	3	2	1	0	2	4	2	2	3	0	3	2	3	2	2	2
Erosion regulation	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0
Support services																	
Food security	3	2	2	2	1	2	4	3	2	4	0	2	2	3	3	1	1
Nutrient security	3	2	3	2	1	2	4	3	1	3	0	2	1	3	2	1	1
Conserve and maintain biodiversity	4	3	4	3	2	2	4	4	3	3	2	3	4	3	3	1	1
Cultural services																	
Recreational and aesthetic value	4	3	3	2	1	2	4	4	3	4	1	3	2	3	3	2	3
Traditional knowledge and values	3	1	2	1	1	1	2	2	1	2	1	2	1	2	2	1	2
Culture, traditions, customs and practices	2	1	1	1	1	1	2	2	0	2	0	1	0	2	2	1	2
peace, harmony and corporation	3	1	1	2	1	2	2	2	0	3	0	2	0	2	2	1	1

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

0	No relevant demand	1	Low relevant demand	2	Medium relevant demand
3	Relevant demand	4	High relevant demand	5	Very high relevant demand

Table 14. Ecosystem services Supply and Demand Balance at different land use in Pallugaswewa Cascade

ES	Tank	Diyagihna	Gas gommama	Kattakaduwa	Godawala	Isvetiya	HG	DF	OF	P	RARE	C	SL	SUCL	LAK	M	FP
Provisional services																	
Paddy and other cereals		0	0			0			0					0			
Lentils and other seed crop		0				0			-1					-1			
Leafy vegetables, vegetables and tuber crops	1	0	0	0	0	0	0	0	-1				0	0			
Clean/ fresh water for drinking and domestic use	1			-1	0							-1			0		
Irrigation water	0	0	0	0	0	-2	0	1	0			0	1	0	0	0	0
Inland fisheries	0	0	0						0						0	0	
Livestock		0	0	1	0	0	0	0	0			0	0	0		0	0
Fodder and grasses		0	0	0	0	0	0	0	-1			-1	0	0		1	0
Sedges and other alternative plants	0	0	-1	-1	0	1			0				0	0	-1	0	0
Herbals/ medicinal plans and materials	1	1	1	0	0	1	1	1	1	0	2	0	0	0	1	1	0
Ecotourism	1	1	1														
Regulatory services																	
Control floods/ Flood protection	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground water recharge and maintain the flow	0	0	0	-1	0	0	-2	0	0	0		0	0	0	-1	0	0
Water purification	0	0	0	-1	0	0	-2	0	0	0		0	-1		0		
Local climate regulation	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0
Global climate regulation	-1	0	0	-1	0	0	0	0	0			0	0	0	0	0	0
Pollination	0	0	0	0	0	-2	0	0	0			0	0	0	0	0	0
Soil Nutrient regulation	0	0	0	0	0	-2	0	0	-1			-1	0	-1	0	0	0
Erosion regulation			0								0						
Support services																	
Food security	0	0	0	0	0	0	-2	0	1	0		0	0	0	0	0	0
Nutrient security	0	0	-1	-1	0	0	-2	0	1	0		0	0	0	0	0	0
Conserve and maintain biodiversity	0	0	-1	-1	0	0	-2	-1	0	0	0	0	0	-1	0	0	0
Cultural services																	
Recreational and aesthetic value	-1	0	0	0	0	0	-2	-1	0	0	0	-1	0	0	0	0	-1
Traditional knowledge and values	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0
Culture, traditions, customs and practices	0	0	1	0	0	0	0	0	0	1		0		0	1	0	0
peace, harmony and corporation	-1	0	0	-1	0	-1	0	0	0	0		0		0	0	0	0

HG – Home gardens, DF – Dense forests, OF – Open forests, P – Paddy, RARE – Rarely used rocks, C – Coconut, SL – Scrublands, SUCL – Sparsely used crop lands (Chena), LAK – Lakes, M – Marshy lands, FP – Forest plantations

Demand exceed supply					Natural balance	Supply exceeds demand			
-5	-4	-3	-2	-1	0	1	2	3	4