Ecosystem services assessment in selected agricultural lands in Kandy, Badulla and Nuwara Eliya districts of Sri Lanka

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Acronyms and abbreviations

BDS	Biodiversity Secretariat
ES	Ecosystem Services
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
GHGs	Green House Gases
IAS	Invasive Alien Species
IFMs	Innovative Financing Mechanisms
IUCN	International Union for Conservation of Nature
MEA	Millennium Ecosystem Assessment
MMD&E	Ministry of Mahaweli Development and Environment
SLM	Sustainable Land Management
TEEB	The Economics of Ecosystems and Biodiversity
VES	Visual Encounter Survey

Executive summary

Agricultural lands or Agroecosystems use ecosystem services provided by nature and can generate ecosystem services, as well as disservices (negative impacts), for biodiversity and human wellbeing. It is therefore important to understand the kinds of services provided by different types of lands and at various scales so that the flow and availability of such ecosystem services can be properly managed (Garbach et al 2014). The adoption of sustainable land management (SLM) practices and the preservation of natural ecosystems in agricultural landscapes may reduce the disservices and enhance ecosystem benefits.

One of the overall objectives of the Rehabilitation of Degraded Agricultural Lands (RDAL) project by the Food and Agriculture Organisation of the UN (FAO) and the Global Environment Facility (GEF), in partnership with the Ministry of Mahaweli Development and Environment (MMDE), is to promote the use of sustainable land management practices among farmers in the central highlands of Sri Lanka. In order to do so, this assessment seeks to identify the ecosystem services generated and current land management practices utilised in different agricultural lands of Badulla, Nuwara Eliya and Kandy Districts. The findings of this study will thereafter enable the development of appropriate innovative financing mechanisms to encourage SLM practices. This section provides a summary of the four-step approach undertaken for the assessment and the findings.

The first stage consisted of understanding agricultural land use types present in the project area. Workshops with various experts resulted in the identification of four main agricultural land use types: Vegetable lands, Paddy lands, Tea cultivations and Home gardens, and a total of 64 Sustainable Land Management (SLM) practices under behavioural, physical and biological categories, within those land use types.

The next stage involved developing a structured questionnaire to understand which of the sustainable land management practices are being used by farmers, the reasons for not using such practices, and details about the plots of land including topography, land tenure and other information. In general, the study found that there were 53.17 percent of instances where relevant practices are not being used. From the four reasons provided for not using a relevant SLM practice, the lack of awareness was the most cited reason at 45 percent of total instances. Affordability is quoted the least as a reason for not adopting a relevant SLM practice (at less than 5 percent), however, this may be largely underestimated, for there may be farmers who are unaware of the costs involved with a particular SLM practice. The report describes in further detail the findings from each type of agricultural land.

The third step was a rapid assessment of Ecosystem Services (ES) of the four agricultural land use types (paddy, vegetable, home gardens and tea lands), utilising visual observations, biodiversity assessments and interviews with farmers. The structure of the ES assessment allowed both qualitative and quantitative information to be gathered on the flow, scale, importance and the stakeholders involved of each ecosystem service as well as insight into how different SLM practices may affect the delivery of these ESs on 40 field sites (10 of each agricultural land type).

In general, it was found that of the cultural ecosystem services, the recreational value was largely not observed (81-100 percent of lands), mainly due to the location of the agricultural lands which were away from the main road and not easily approachable. When considering the aesthetic value of the different agricultural lands, it can be seen that Paddy lands (81-100%) and Tea lands (61-80%) are more visually pleasing. Although the educational value was observed to some extent in all of the land types, there were more observations in paddy lands (61-80%) including the use of some paddy lands for workshops and training for the community. Cultural or heritage/historical value was also largely not observed (100 percent of lands) in any of the lands and this is mainly because the culture was captured under the religious/spiritual significance of the agricultural land.

With regard to the provisioning services, it was found that the ESs fibre and fodder were not identified in any agricultural land type. Freshwater storage is observed on most vegetable lands (61-80%) and as expected, fuelwood collection occurs more in home gardens and tea lands (at 61-80% of sites) due to the types of plants/crops grown.

In general, the regulating ecosystem services listed were observed in all of the agricultural land types. Where there were no observations, it can be interpreted as an ecosystem *disservice* from the agricultural land. There was no water purification observed because of the use of chemical fertiliser and pesticides which contributed to water pollution (disservice). It can be seen that soil retention and water flow regulation efforts are less evident in home gardens than in the other three agricultural land types. A higher percentage of pollinators is observed in home gardens than the other types of agricultural land. For habitat provision, the species richness of flora and fauna were considered. Paddy lands have the highest average faunal species richness; however, this isn't significantly greater than the other types of lands. The flora species richness does vary, indicating that home gardens have the highest average species richness (24%) and therefore a stronger habitat provision, compared to vegetable lands which have the lowest flora species richness (14.98%).

These findings are drawn from a rapid ES assessment and the importance of a full assessment considering temporal and spatial variations is well understood and recommended.

The final stage of the assessment consisted of valuing and comparing the ecosystem services of well-managed agricultural lands and poorly managed agricultural lands. In general, the comparison indicates that for most ecosystem services, a good site (with a large number of SLM practices), shows a relatively higher amount of ecosystem service provision. However, given that the SLM practices and the ecosystem outcomes vary by type of land use, comparisons were done within agricultural land use type and this showed that some ESs (e.g. habitat provision and species richness) are prevalent in poorly managed lands.

Given the short timeframe and the data limitation of the study, the 'benefits transfer method' was used with generalised values for selected ecosystem services in well-managed sites. Applying these values would indicate that on average and in general, a farmer with a 1-acre site, would generate approximately Rs 25 000 worth of water quality and purification benefits, about Rs 6 000 worth of air quality benefits, Rs 10 000 worth of climate regulation benefits and about Rs 17 000 worth of soil fertility benefits per year. Alternatively, the total economic value (TEV) can be calculated at about Rs 79 000 per year. It was also noted that a 1-acre home garden (under the assumption that it represents an Analog Forest with benefits similar to an agroforestry system) would generate approximately Rs 4 000 worth of pollination benefits and about Rs 177 000 worth of carbon sequestration benefits per year.

The comparative study of well-managed lands and poorly managed lands highlight the resulting ecosystem services that can be generated with good agricultural practices. A generalized valuation highlights that these ecosystem services have significant value for both society and farmers and landowners. Therefore, identifying and implementing mechanisms to encourage farmers to adopt sustainable land management practices on their farmlands can generate both private and public values.

Introduction

It is well known that ecosystems provide benefits to society (or ecosystem services) which in turn contribute to our wellbeing and wealth (Costanza *et al.* 1997; de Groot *et al.* 2002; MEA 2005; TEEB 2010; Crossman *et al.* 2013). The ecosystem services concept came about as a means to communicate society's dependence on ecological systems for their wellbeing (Daily 1997, De-Groot *et al.* 2002; Gomez-Baggethun *et al.* 2010; Luck *et al*. 2012). It is therefore important to understand the kinds of services provided by different types of lands and at various scales so that the flow and availability of such ecosystem services can be properly managed (Garbach *et al.* 2014). The millennium ecosystem assessment (MEA 2005) and the economics of ecosystems and biodiversity (TEEB 2010), are the two key frameworks which allow for the understanding, identification and valuation of ecosystem services so that it can be incorporated into management decisions and national policy.

Ecosystem: An ecosystem is the dynamic complex webs of plant, animal and micro-organism communities and their non-living environments that interact together as a function unit.

Ecosystem Services: The benefits that people derive from ecosystems. Examples include food, freshwater, timber, climate regulation, protection from natural hazards, erosion control, pharmaceutical ingredients and recreation.

Source: MEA, 2005 and Dissanayake, 2018.

The very nature of agricultural lands or agroecosystems is to create provisioning ecosystem services such as food, fibre, fuelwood, etc. The availability of these tangible benefits (for example tea) is entirely dependent on the regulating services (such as water flow) and supporting services (such as soil fertility) of that type of land (Figure 1.1). There are intangible benefits also generated by agricultural lands such as aesthetic or spiritual value and these fall under the category of cultural ecosystem services. Agricultural lands or Agroecosystems use ecosystem services provided by nature and can generate ecosystem services, as well as disservices (negative impacts), to biodiversity and human wellbeing (Dale and Polasky 2007) (Figure 1.1 and Figure 1.2).

ES type	ES from agriculture	ES used as inputs	ED from agriculture
Regulating services	Soil retention	Soil retention	Soil erosion
	Pollination	Pollination	Competition for pollination
	Pest control	Pest Control	Pest outbreaks
	Water purification		Nutrient run-off Pesticide run-off
	Habitat provision		Habitat loss
	Atmospheric regulation		Greenhouse gas emissions
	Flood control		Flooding
	Seed dispersal		Loss of seed dispersal
Supporting services	Soil structure	Soil structure	Soil compaction
	Soil fertility	Soil fertility	Soil fertility loss
	Biodiversity	Genetic biodiversity	Biodiversity loss
	Water cycling	Soil moisture	Soil moisture loss Competition for water from other ecosystems
	Nutrient cycling	Soil nutrients	Eutrophication of rivers, estuaries, and lakes
Cultural services	Esthetic landscape		Loss of esthetic value
	Recreation		Loss of recreation value
	Spiritual well-being		Loss of well-being
	Rural lifestyles		Loss of rural culture and lifestyles
Production services	Food		
	Fuel		
	Fiber		

Figure 1.1. Mapped Ecosystem Services (ES) and Disservices (ED) from agriculture
Source: Stallman, 2011.

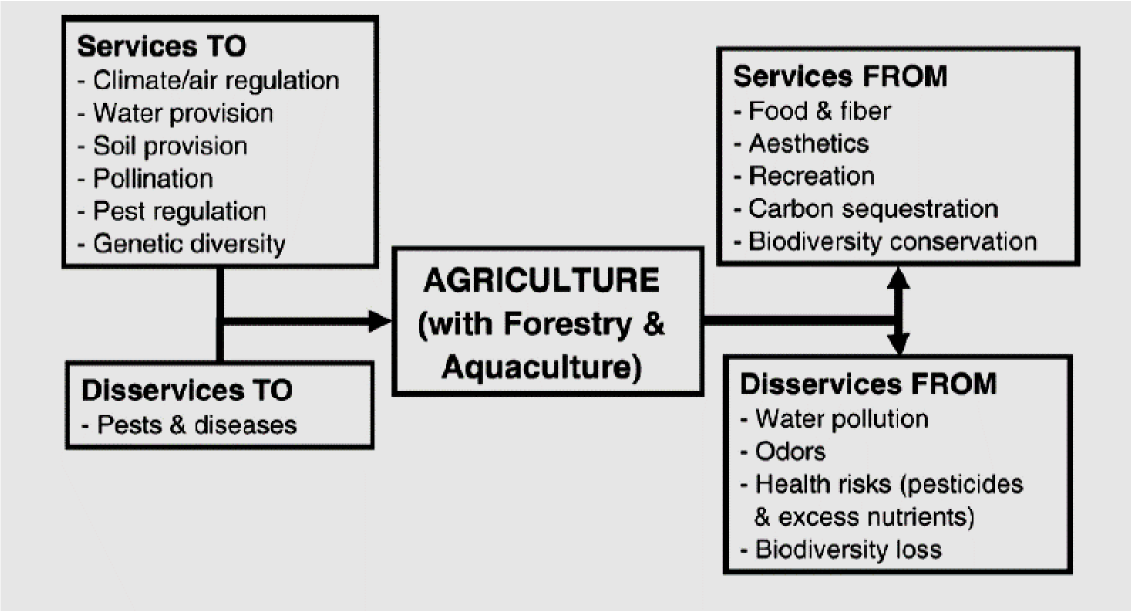


Figure 1.2. Mapping of ecosystem services to and from agriculture
Source: Swinton *et al.,* 2007.

Since agroecosystems can generate both benefits and negative impacts (Disservices, Figure 1.2) the type of land management practices undertaken plays a key role in the stock and flow of ecosystem services. Conversion of natural ecosystems to agriculture does significantly alter and/or diminish the ecosystem services generated by that land, and creates 'disservices'. For example, loss of habitat for conserving biodiversity. Unmanaged agricultural lands can also affect the flow of ecosystem services, such as nutrient runoff, soil erosion, sedimentation of waterways and emission of GHGs (Zhang *et al.* 2007, Power 2010) (Figure 1.1 and Figure 1.2). However, the disservices produced from agricultural lands are a lot less when compared to natural land that is converted to urban development, and assessments should be viewed and conducted in this context (Swinton *et al.* 2007, Power 2010).

Sustainable Land Management is "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions"

Source: FAO, 2019.

The adoption of sustainable land management (SLM) practices and the preservation of natural ecosystems in agricultural landscapes can reduce the disservices and enhance ecosystem benefits (Swinton *et al*. 2007). The farmers engaging in sustainable practices benefit from enhanced ecosystem services, and this has a positive effect on adjacent households and communities. Moreover, depending on the type of ecosystem service, it can result in benefits at the watershed, national or global scale. SLM in agriculture involves measures to conserve, protect and sustainably use resources (FAO 2019) to improve the volume of production and enhance the wellbeing of the natural environment and humans that are part of that environment. One or two SLM practices can affect the flow of several ecosystem services where for example, "conservation tillage and the maintenance of plant cover year-round can reduce runoff and associated soil, nutrient and pesticide loss, and the reduction of runoff also serves to increase infiltration, which increases the water available to plants and can improve groundwater recharge" (Swinton *et al*. 2007, p.251).

The Rehabilitation of Degraded Agricultural Lands (RDAL) project by the Food and Agriculture Organisation of the UN (FAO) and the Global Environment Facility (GEF), in partnership with the Government of Sri Lanka through the Ministry of Mahaweli Development and Environment (MMDE), aims to encourage the use of sustainable land management practices in agricultural lands in the central highlands of Sri Lanka. The project components include (i) strengthening institutional, policy and regulatory frameworks for SLM, (ii) implementation of land restoration technologies, (iii) the development and implementation of innovative funding for SLM and (iv) awareness-raising and knowledge management. IUCN's role in this project involves part of component 3, where innovative financing mechanisms to promote SLM will be developed. In order to achieve this, IUCN has formulated an approach which is laid out in this report the *Ecosystem Services Assessment of Agricultural Lands* as well as the report on *Innovative Financing Mechanisms for SLM.*

The objective of this report is to assess the ecosystem services of agricultural landscapes in the three districts (project area) Kandy, Badulla and Nuwara Eliya. By identifying the ecosystem services generated and assessing current land management practices, the broader objectives of valuing these ecosystem services and developing appropriate innovative financing mechanisms to encourage SLM practices and enhance the delivery of ES can be achieved.

To assess the ecosystem services of agricultural lands in the project area, a four-step approach was undertaken as follows:

1. Understanding agricultural land use types present in the project area and the relevant Sustainable Land Management (SLM) practices for these lands;
2. Assessing the use of SLM practices in each of the land use types;
3. Identifying ecosystem services in each of the agricultural land use types and understanding how practices affect the delivery of these ecosystem services; and
4. Valuing and comparing the ecosystem services of well-managed agricultural lands vs poorly managed agricultural lands

The report is organised into sections according to these four steps and each section includes the proposed methodology, the findings and main conclusions, with an overall key finding at the end of the report. The follow-up to this report will involve the identification of five innovative finance mechanisms (out of which three will be developed into detailed proposals) and the development of general guidelines for IFMs, in order to promote the use of SLM practices. This will contribute as part of the third component in the larger FAO/GEF project where the main objective is to rehabilitate degraded agricultural lands in the central highlands of Sri Lanka.

1. Understanding agricultural land use types and identifying sustainable land management practices in the project area

An initial workshop held on the 25 March 2019 in Peradeniya with participants from different fields of expertise allowed for open discussion on the different agricultural land use types in the central highlands of Sri Lanka, the SLM practices currently used by farmers and their links to agricultural ecosystem services. The discussion at this workshop and further review of existing literature led to identifying four main agricultural land use types in the project area, namely:

- Vegetable lands
- Paddy lands
- Tea based systems
- Home gardens

The subsequent work plan and analysis were structured around this selection of agricultural land use types. In addition, there were a total of 64 SLM practices under behavioural, physical and biological categories, identified and validated at the workshop (See Annex 1). The workshop also provided an opportunity for IUCN to present how innovative finance mechanisms could incentivise individual farmers to engage in SLM practices on their lands.

Figure 1.3. Session of the consultative workshop held on 25 March 2019 on evaluation of ES and development of IFMs to promote sustainable land management in Central Highlands

2. Assessing sustainable land management practices in the project area

Approach

Based on the information provided by the participants of the workshop held on the 25 of March, a structured questionnaire was developed to understand which of the 64 sustainable land management practices are being used by farmers, the reasons for not using such practices, and details about the plots of land including topography, land tenure and other information (see Annex 2).

The existing institutional infrastructure and the human resources used by the RDAL (FAO/GEF) project were used to conduct the survey. Nine extension officers from the Divisional Secretariat offices of Dholuwa, Hali Ela, Welimada, Nuwaraeliya and Uva Paranagama, Land Use Policy Planning Department in Kandy and Deltota, and the Agrarian Services Department Bandarawela collected information through the use of the questionnaire. Each of these nine officers was instructed to collect information about a maximum of 10 agricultural lands from each of the 4 land-use types (Vegetable, Paddy, Tea, Home-Gardens). A total of 264 farmers (of the targeted sample of 360) were interviewed and their farmlands examined by these officers across 8 watersheds of the central highlands.

For each SLM practice, the survey elicited information on whether or not an SLM practice was adopted, and if it was not, further questions were asked to clarify the reason (see also Annex 2):

- Is the SLM practice relevant for the specific agricultural land (e.g. maintaining a plucking table will not be relevant for paddy)
- If the SLM practice is relevant but not implemented by the farmer, relevant questions were asked to identify pertinent barriers for adoption:
    - The respondent wasn't aware of the SLM practice.
    - The respondent didn't know how to implement the SLM practice.
    - The respondent couldn't afford to conduct the SLM practice.
    - The respondent is planning to conduct the SLM practice in the future.

It's important to note that if a respondent was not aware of a particular SLM practice, they are likely to also not know how to implement or have information about the cost but they would only choose the first option.

General observations of sustainable land management practices on agricultural lands

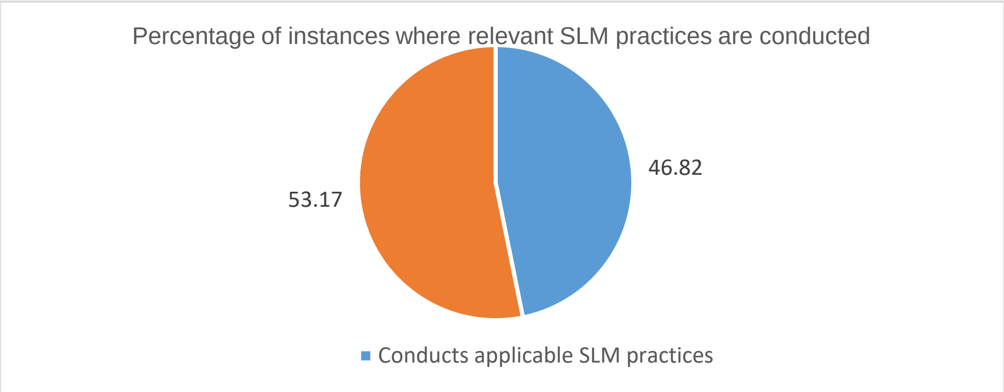


Figure 2.1. Percentage of instances where the farmer uses relevant SLM practices

Out of the possible usage of 6 546 relevant SLM practices on agricultural lands, the study found that there were 3 065 (46.82%) instances where relevant practices have been used and 3 481 (53.17%) instances where relevant practices are not being used (Figure 2.1).

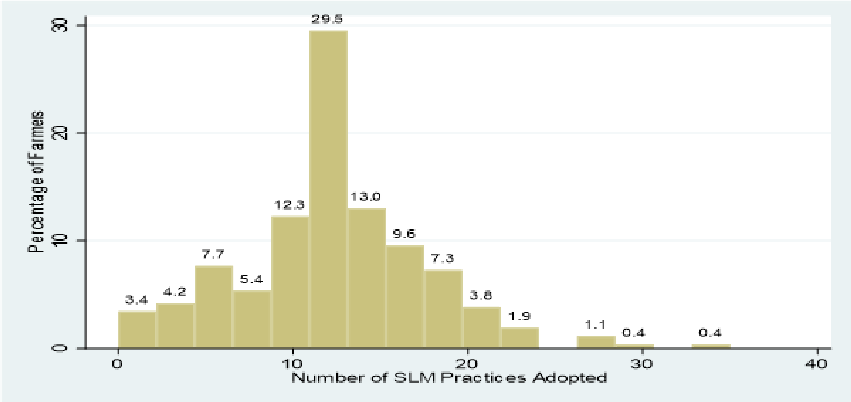


Figure 2.2. The percentage of farmers adopting SLM practices on their lands

Figure 2.2 depicts the percentage of farmers who have adopted a particular number of relevant SLM practices on their lands. While there appear to be a few farmers who conducted over 20 SLM practices each, the percentage of farmers who conducted 12 relevant SLM practices is the largest, representing 30 percent of the sampled farmers.

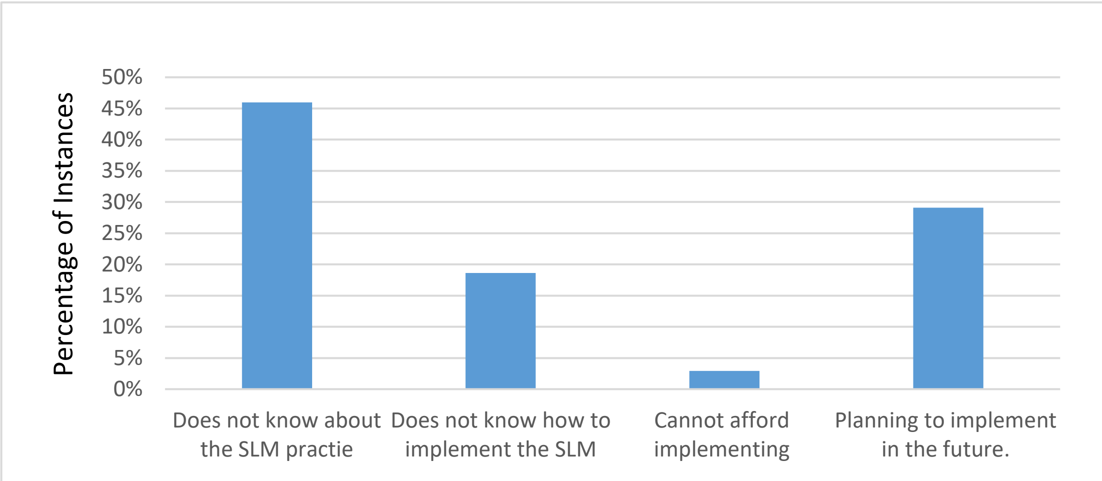


Figure 2.3. Reasons for not implementing SLM practices

From the four provided reasons for not using a relevant SLM practice, the 'lack of awareness' (don't know about the SLM practice) was the most cited reason at 45 percent of total instances (Figure 2.3). 'Affordability' is quoted the least as the reason for not practicing a relevant SLM practice (at less than 5%). However, it is important to note that respondents were only asked to choose one option. Therefore, the category of farmers who cannot afford a particular practice may be largely underestimated, for there may be farmers of the categories "Does not know about the SLM" and "Does not know how to implement the SLM" who have no frame of reference to understand the costs involved with a particular SLM practice. It can therefore be assumed that the lack of awareness includes farmers that cannot afford to implement the SLM practice.

Figure 2.4 and Table 2.1 (below) depict which SLM practices are not used by farmers even though it is relevant for their lands. Figure 2.4 shows the 'number of instances of absence for a particular SLM practice'. Table 2.1 shows the 10 SLM practices that were least used (i.e. the SLM practices that had the highest number of responses for not being present on the respective land). For instance, the Leaf colour index card, Integrated nutrient and pest management, and Eco-certification are the least used SLM practices by farmers (155, 146 and 134 responses respectively, Table 2.1) even though it is relevant to their farmlands.

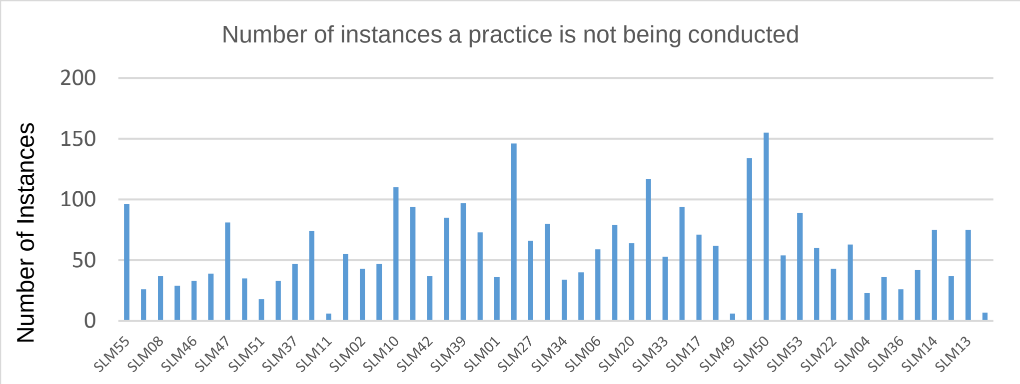


Figure 2.4. Total instances of absence recorded for a particular SLM practice

Table 2.1. The 10 relevant SLM practices that are least used

SLM Practice	No. of Responses for not using the SLM	Percentage of Responses for not using the SLM (%)
SLM50 **Leaf colour index cards**	155	89.60
SLM09 **Integrated nutrient and pest management**	146	71.92
SLM64 **Eco-certification**	134	97.81
SLM41 **Split application Fertilizer**	117	54.42
SLM10 **Rain water collection**	110	86.61
SLM39 **Underutilized crops**	97	82.20
SLM55 **Waste management**	96	44.44
SLM28 **Grass strips**	94	67.63
SLM25 **Soil rehabilitation (planting grasses)**	94	85.45
SLM53 **Integrated Weed management**	89	38.03

Figures 2.5 – 2.8 depict the percentage of responses received for each reason for not using a relevant SLM practice. The percentage is calculated with regard to the number of relevant practices that are not being implemented (i.e. percentage of responses for lack of awareness, lack of implementation of knowledge, unaffordability and planning to implement from the total of all four of these). The base values used for the calculation of percentages are the values which correspond with the relevant SLM practice depicted in Figure 2.4.

Of the instances where a relevant SLM practice was not conducted in an agricultural land, Figure 2.5 shows the percentage of responses that cited a lack of awareness (or the percentage of responses that were classified as "did not know about the relevant SLM practice"). It can be observed that lack of awareness is high for SLM practices sanitising animal husbandry (SLM57, 100%), sloping agricultural land technology or SALT (SLM5, 89%), envelope forking (SLM 52, 80.9%) and intercropping perennials (SLM36, 80.7%) (Figure 2.5 and Annex 1). This demonstrates that lack of awareness was the only reason for respondents not practicing "Sanitising Animal Husbandry".

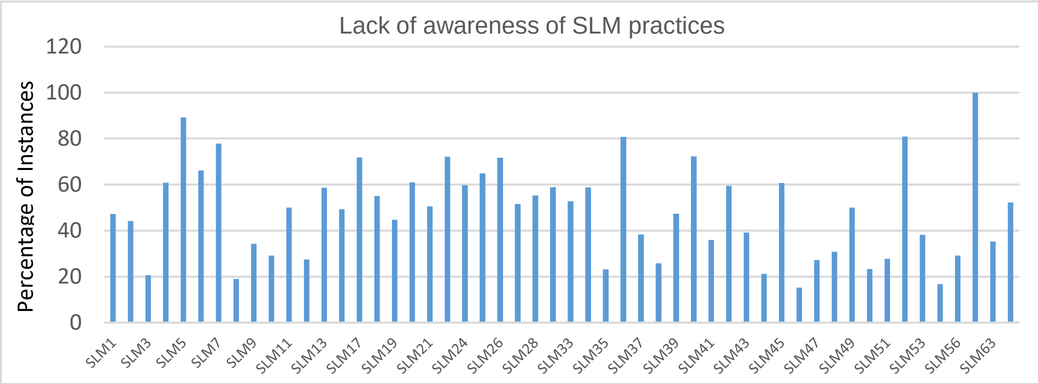


Figure 2.5. Percentage of responses which were classified as "did not know about the relevant SLM practice"

Of the instances where a relevant SLM practice was not conducted in an agricultural land, Figure 2.6 shows the percentage of responses that cited a lack of implementation of knowledge (or the percentage of responses that were classified as "Does not know how to implement the SLM practice"). This demonstrates that lack of implementation of knowledge is the main reason for farmers not using a leaf colour index chart (SLM50, 61%), integrated Weed Management (SLM53, 48%) and constructing lateral and leader drains (SLM63, 48%) (Figure 2.6 and Annex 1).

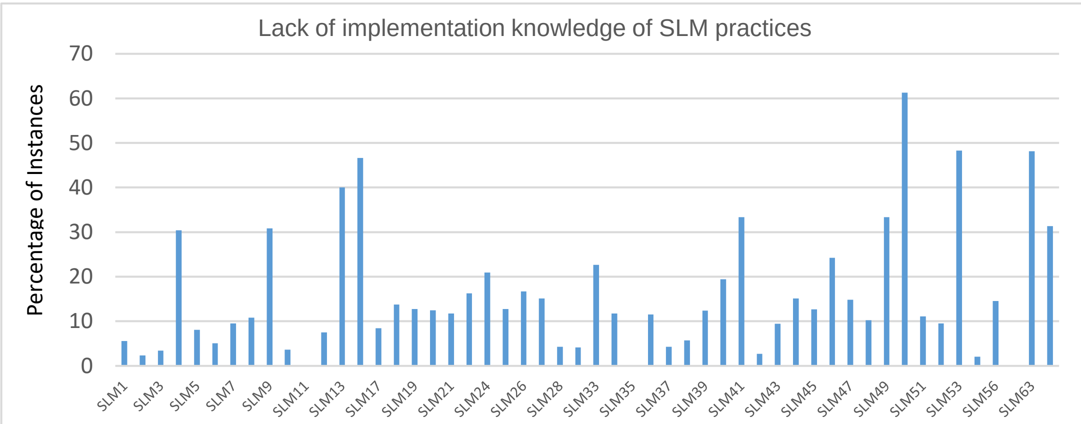


Figure 2.6. Percentage of responses which were classified as "does not know how to implement the SLM practice"

Of the instances where a relevant SLM practice was not conducted in an agricultural land, Figure 2.7 shows the percentage of responses that cited unaffordability of each SLM practice (or the percentage of responses that were classified as "Cannot afford the SLM practice"). It can be seen that the implementation of Micro Irrigation Systems (SLM12), Rainwater Collection Units (SLM10) and Stone Bunds (SLM03) received the highest number of responses (37.50%, 28.18%, 13.79% respectively) citing unaffordability as the reason for not conducting these SLM practices.

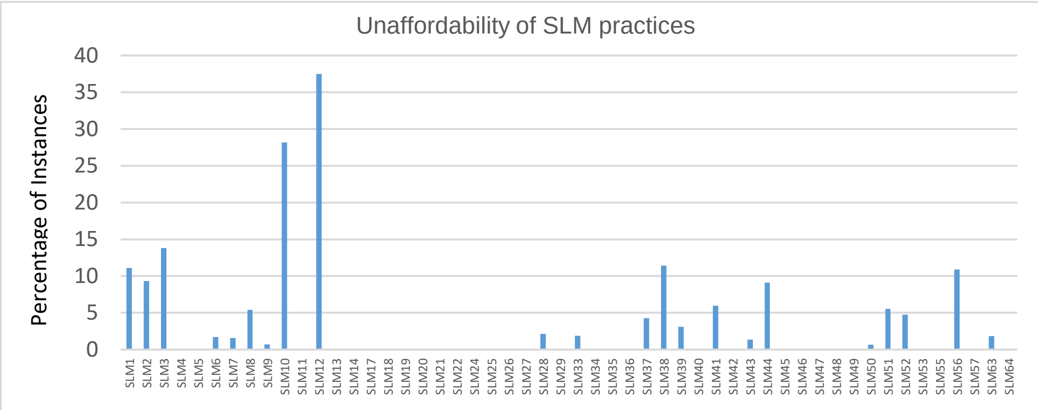


Figure 2.7. Percentage of responses which were classified as "cannot afford the SLM practice"

Of the instances where a relevant SLM practice was not conducted in an agricultural land, Figure 2.8 shows the percentage of responses that cited the intention to implement a particular SLM practice in the near future (or the percentage of responses which were classified as "Planning to implement in the future"). Planning to implement in the future was the main reason for not using proper waste management practices (SLM55), crop rotation (SLM35) and constructing 'Lock and Spill' drains (SLM08) (81.25%, 76.92%, 64.86% respectively).

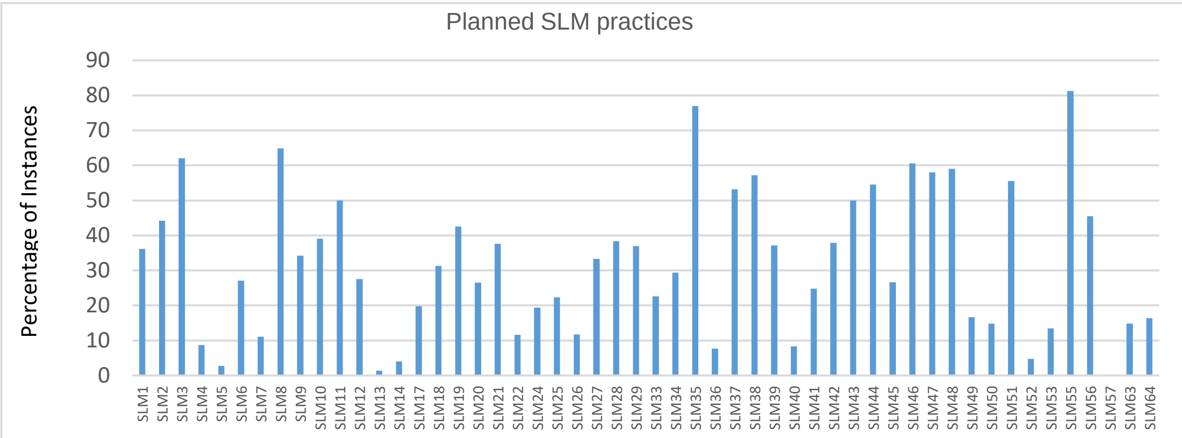


Figure 2.8. Percentage of responses which were classified as "planning to implement in the future"

Results of sustainable land management practices by agricultural land type

The above section analysed the responses across all of the four agricultural types. Given that some SLM practices are land type-specific, this section describes the same analysis broken down by agricultural land use type.

Tea lands

There was a total of 72 tea lands/farmers visited by the enumerators to collect data on SLM practices. The average land size of the assessed tea lands is 0.9 acres, the average number of household members is four and the average income per HH from Tea cultivation is Rs 19 360 per month. However, these values vary from farmer to farmer depending on the extent of land cultivated. Of the tea lands assessed, 12 are private lands, 20 are Jayaboomi[1], 22 are

[1] Lands given as state lands with certain conditions.

state lands with permits and 13 are state leaseholds[2] with the remaining falling under other types of lands.

The total number of responses pertaining to SLM practices relevant to these lands was 2 074, of which the instances where the records referring to their presence and absence were almost equal (See Figure 2.9 on p. 13).

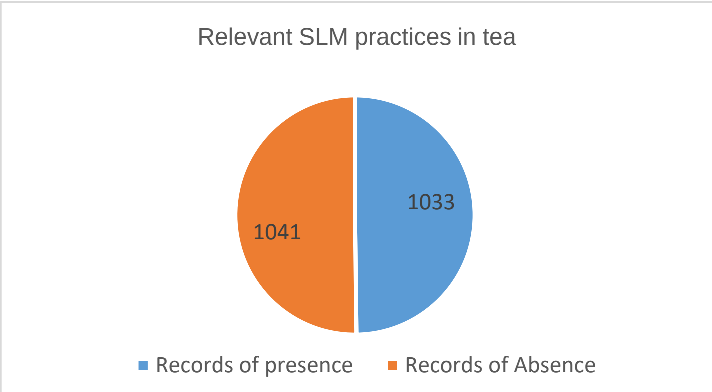


Figure 2.9. Records of presence/absence of relevant SLM practice in tea lands

The study found that of the reasons for not using relevant SLM practices on tea lands, lack of awareness is still the main reason (50 percent of responses) (Figure 2.10). However, nearly 38 percent of the responses depict that SLM practices are being planned for the future.

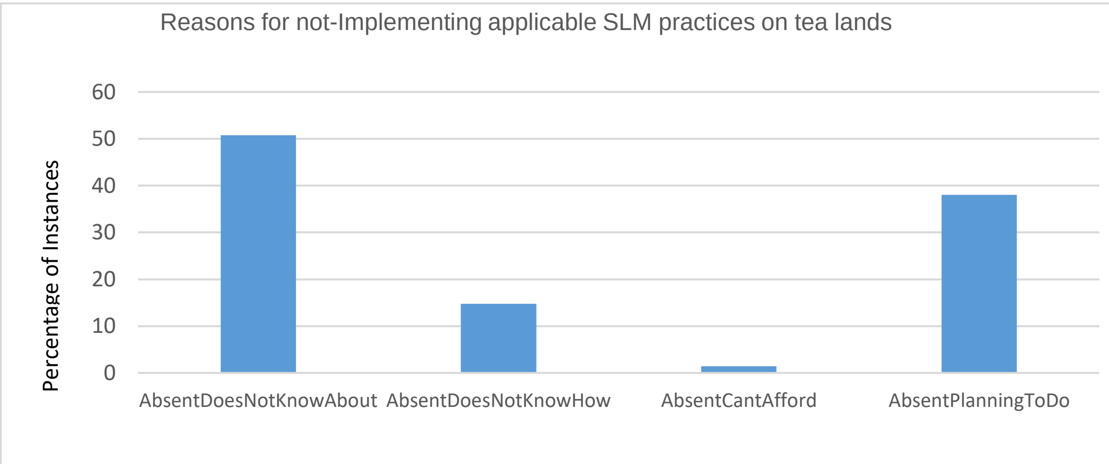


Figure 2.10. Reasons for not-implementing applicable SLM practices on tea lands

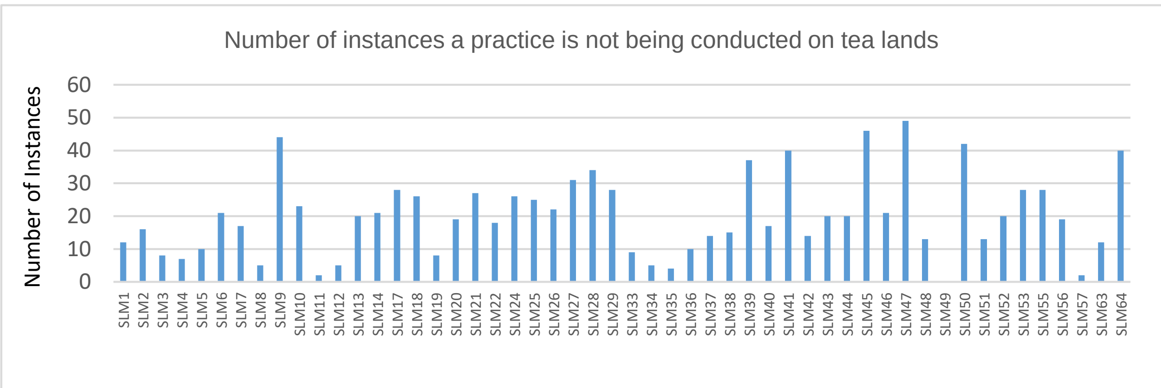


Figure 2.11. Instances where the absence of a particular SLM practice was recorded on tea lands

[2] Lands under the land development ordinance.

Figure 2.11 depicts which SLM practices are not being used by farmers of tea lands even though it is relevant (i.e. the number of instances the absence of a particular SLM practice was recorded). It can be observed that pruning and training of trees (SLM47, 49 instances), burying pruned branches (SLM45, 46 instances), integrated nutrient and pest management (SLM9, 44 instances) and leaf colour index cards (SLM50, 42 instances) are the least used SLM practices on tea lands.

Figures 2.12 – 2.15 depict the percentage of responses received for each reason for not using a relevant SLM practice in tea lands (i.e. percentage of responses for lack of awareness, lack of implementation of knowledge, unaffordability, and planning to implement from the total of all four of these). The respective values in Figure 2.11 were used as the base value when calculating the percentage of responses for each specific reason.

Of the instances where a relevant SLM practice was not conducted on a Tea land, Figure 2.12 shows the percentage of responses that cited a lack of awareness (or percentage of responses that were classified as “did not know about the relevant SLM practice”). The study found lack of awareness was the only reason for SALT (SLM5) and Sanitising animal husbandry (SLM57) not being practiced on tea lands. Lack of awareness is also the main reason for terracing (SLM1), construction of silt traps (SLM13) and intercropping with perennials (SLM36) (91.6%, 90% and 90% respectively) not being practiced on tea lands.

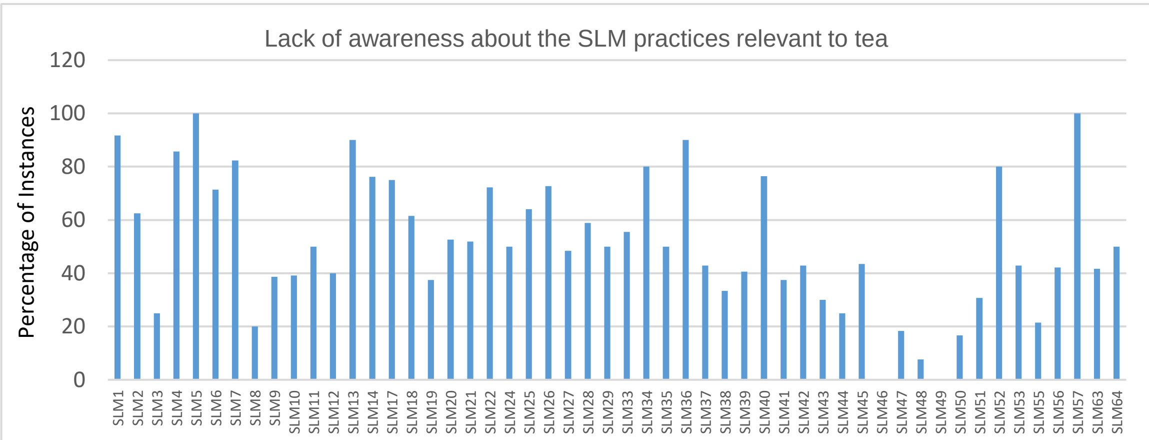
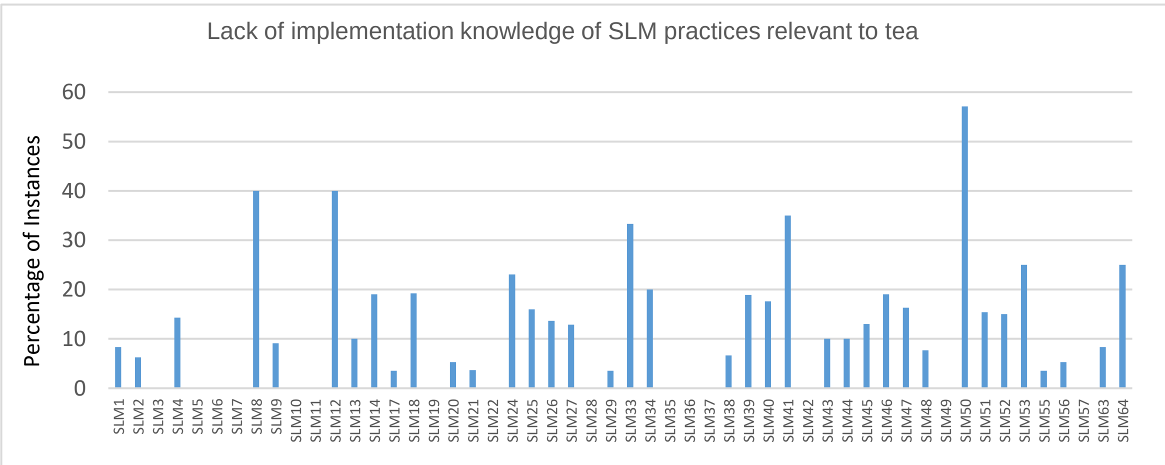


Figure 2.12. Percentage of responses for lack of awareness about SLM practices relevant to tea

Of the instances where a relevant SLM practice was not conducted in a Tea land, Figure 2.13 shows the percentage of responses that cited a lack of implementation of knowledge (or the percentage of responses which were classified as “Does not know how to implement the SLM



practice”). The lack of implementation knowledge is the main reason for leaf Colour Index (SLM50), micro-irrigation Systems (SLM12) and construction of Lock and spill drains (SLM8) (57%, 40% and 40% respectively) not being practiced on tea lands.

Figure 2.13. Percentage of responses for lack of implementation knowledge of SLM practices relevant to tea

Of the instances where a relevant SLM practice was not conducted in a Tea land, Figure 2.14 shows the percentage of responses that cited unaffordability (or the percentage of responses that were classified as “Cannot afford the SLM practice”). Rainwater collection (SLM10) received the highest number of responses (34.8%) citing unaffordability as the reason for not being practiced in tea lands. The percentage of responses for the other 6 practices are below 20 percent.

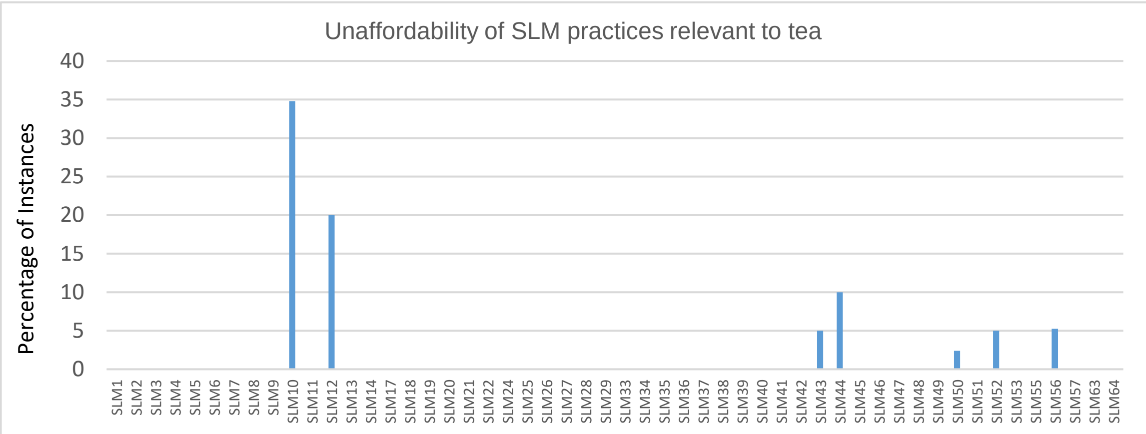


Figure 2.14. Percentage of responses for not able to afford SLM practices relevant to tea

Of the instances where a relevant SLM practice was not conducted in a Tea land, Figure 2.15 shows the percentage of responses that cited the intention to implement a particular SLM practice in the near future (or the percentage of responses which were classified as “Planning to implement in the future”). The implementation of proper shade management practices (SLM48), maintaining a plucking table (SLM46) and practicing waste management (SLM55) received the highest number of responses (84.62%, 80.95% and 75.00% respectively) citing planning to implement as the reason for not using these SLM practices.

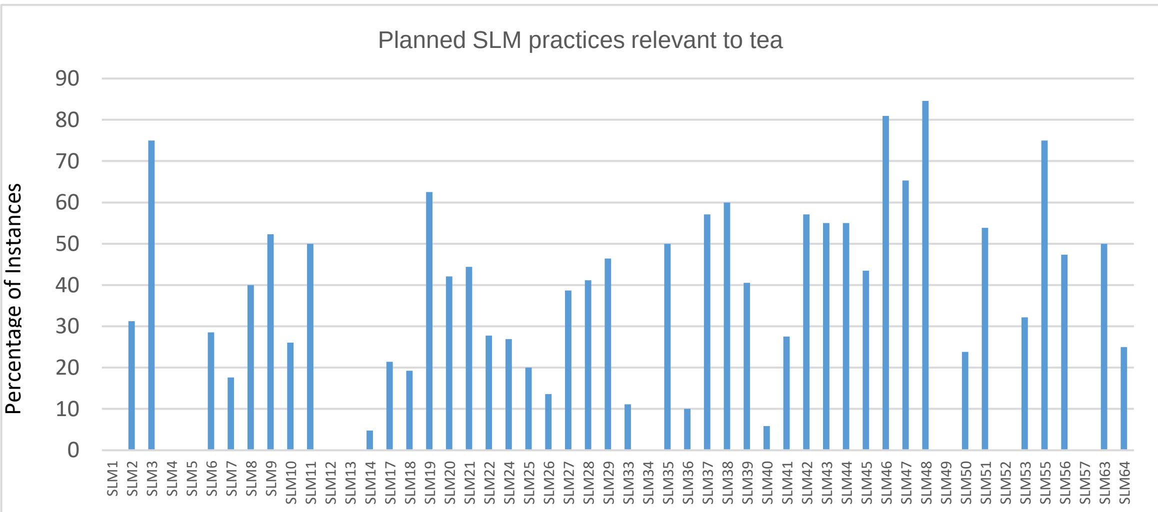


Figure 2.15. Percentage of responses for planning to implement SLM practices in the near future

Paddy lands

There was a total of 48 Paddy lands/farmers visited by the enumerators to collect data on SLM practices. The average land size of the assessed tea lands is 0.5 acres, the average number of household members is four and the average income per HH from Paddy cultivation is Rs 22 660 per season. However, these values vary from farmer to farmer depending on the extent of land cultivated. Of the Paddy lands assessed, the majority (39 lands) are private lands and others fall into Jayaboomi[3], state lands with permits and state leaseholds[4] or other types.

The total number of responses pertaining to SLM practices relevant to these lands was 705, of which the responses for the presence and absence of SLM practices were 53.2 percent and 46.8 percent respectively (See Figure 2.16 below).

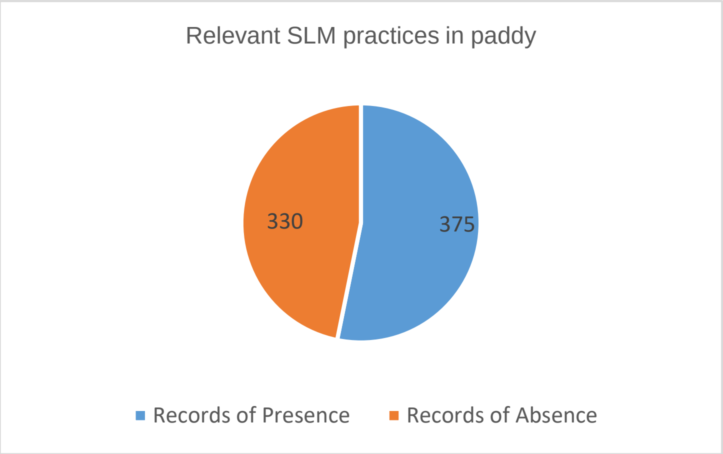
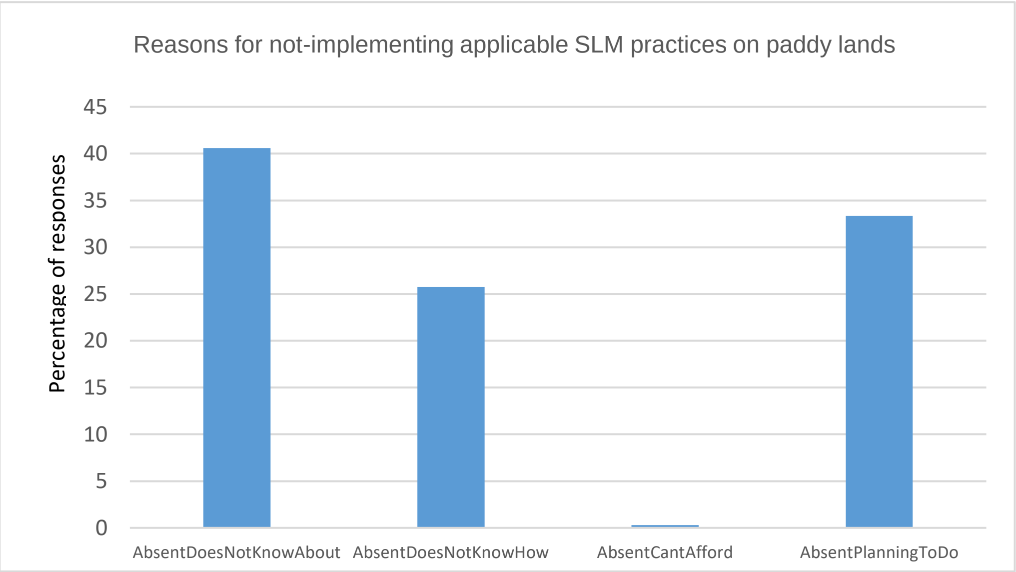


Figure 2.16. Records of presence/absence of relevant SLM practice in paddy lan*ds*

Figure 2.17 portrays the reasons why relevant SLM practices were not adopted on paddy lands. Similar to Tea lands, lack of awareness (40 percent of responses) and planning to implement (33% of responses) are the two main reasons for not implementing SLM practices in paddy lands.



[3] Lands given as state lands with certain conditions.
[4] Lands under the land development ordinance.

Figure 2.17. Reasons for not-implementing applicable SLM practices on paddy lands

Figure 2.18 shows which SLM practices are not being used by farmers of paddy lands even though it is relevant (i.e. the number of instances the absence of a particular SLM practice was recorded). It can be observed that leaf colour index cards (SLM50, 27 instances), eco-certification (SLM64, 25 instances), and integrated nutrient and pest management (SLM9, 21 instances) are the least used SLM practices on paddy lands.

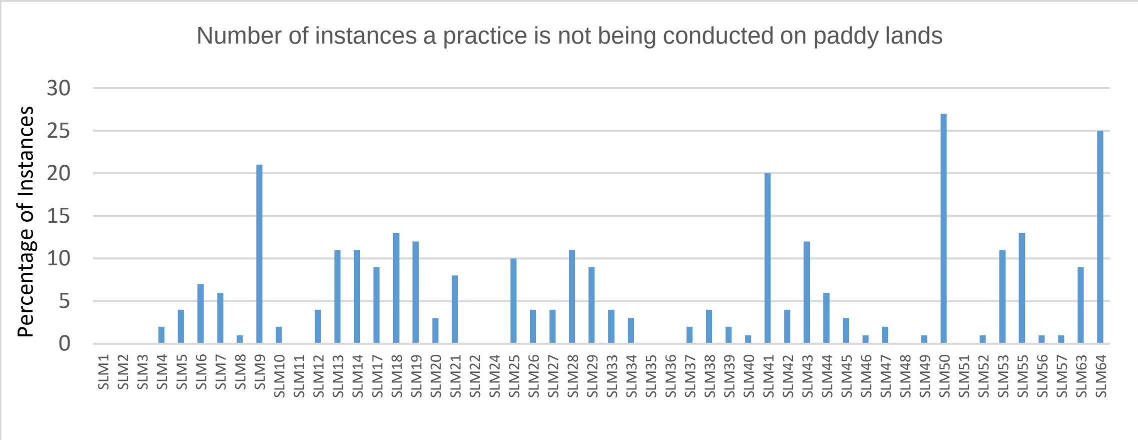
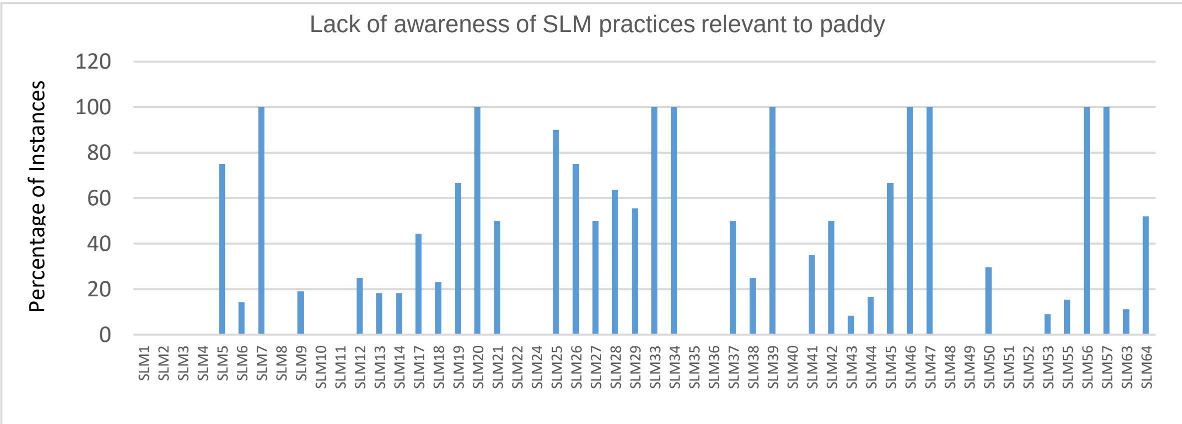


Figure 2.18. Instances where the absence of a particular SLM practice was recorded on paddy lands

Figures 2.19 – 2. 22 depict the percentage of responses received for each reason for not practicing a relevant SLM practice in paddy lands (i.e. percentage of responses for lack of awareness, lack of implementation of knowledge, unaffordability, and planning to implement). The respective values in Figure 2.18 were used as the base value when calculating the percentage of responses for each specific reason. In the data collected for paddy lands, sampling errors by the enumerators have been observed in instances where an SLM practice that is not relevant in paddy lands (such as maintaining a plucking table) has been marked as one of the reasons (lack of awareness) rather than irrelevant. This leads to a limitation in the calculation of percentages (for each reason for not implementing SLM, below) for paddy lands.

Of the instances where a relevant SLM practice was not conducted in an agricultural land, Figure 2.19 shows the percentage of responses that cited a lack of awareness (or the percentage of responses that were classified as "did not know about the relevant SLM practice").

The use of contour drains (SLM07), cover crops (SLM20) and contour planting (SLM33), individual platform method (SLM34), underutilised crops (SLM39), maintaining plucking table (SLM46), pruning of trees (SLM47), bee-keeping (SLM56) and sanitising animal husbandry



(SLM57) received the highest percentage of responses. However, these practices appear to be irrelevant to this particular land use category and due to the low number of overall responses received for their relevance (relevant but not implemented, Figure 2.18), these values may be due to a sampling error.

Figure 2.19. Percentage of responses for lack of awareness about SLM practices relevant to paddy

Of the instances where a relevant SLM practice was not conducted in a Paddy land, Figure 2.20 shows the percentage responses that cited a lack of implementation knowledge (or the percentage of responses that were classified as “Does not know how to implement the SLM practice”). Integrated Weed Management (SLM53), lateral and leader drains (SLM63), and silt traps (SLM13) received the highest number of responses (90.91%, 88.89%, 72.73% respectively) citing the lack of implementation knowledge as the reason for not conducting these SLM practices.

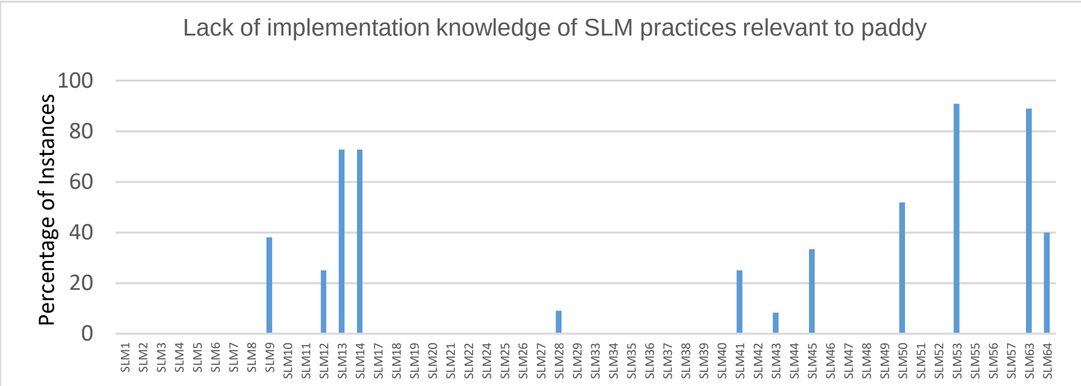


Figure 2.20. Percentage of responses for lack of implementation knowledge on SLM practices relevant to paddy

Of the instances where a relevant SLM practice was not conducted in a paddy land, Figure 2.21 shows the percentage of responses that cited unaffordability (or the percentage of responses that were classified as “Cannot afford the SLM practice”). Micro-irrigation Systems was the only SLM practice where unaffordability was provided as a reason for not conducting the practice. Unaffordability constitutes 25 percent of the reasons for when this SLM practice was relevant and yet not conducted. However, the 4 instances recorded may be a sampling error, for paddy cultivation practices in this project area do not use micro-irrigation systems.

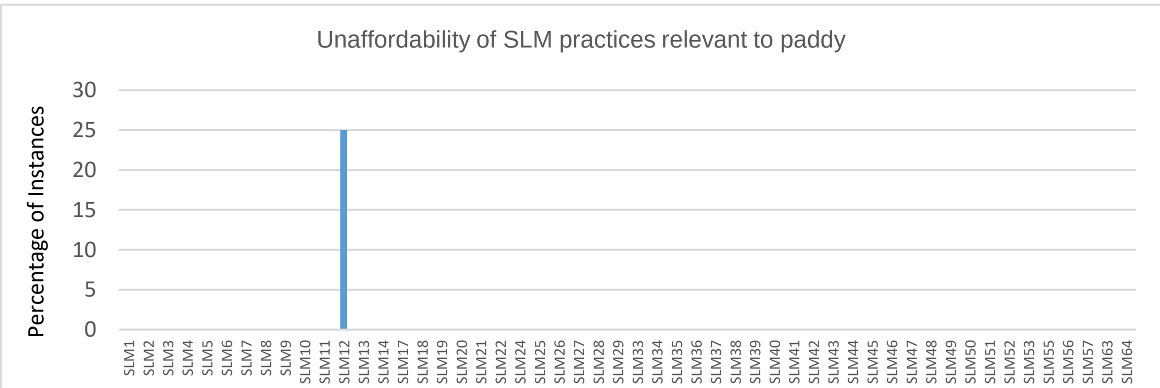


Figure 2.21. Percentage of responses for lack of ability to afford SLM practices relevant to paddy

Of the instances where a relevant SLM practice was not conducted in an agricultural paddy, Figure 2.22 shows the percentage of responses planning to implement a particular SLM practice (or the percentage of responses that were classified as “Planning to implement in the future”). Sunken Beds (SLM4), rainwater collection units (SLM10), lock and spill drains (SLM8), multi-layered high-density crops (SLM40), site-specific crop selection (SLM49) and Envelope Forking (SLM 52) are practices where the only reason for not being used is because farmers plan to implement these in the future (100 percent of responses).

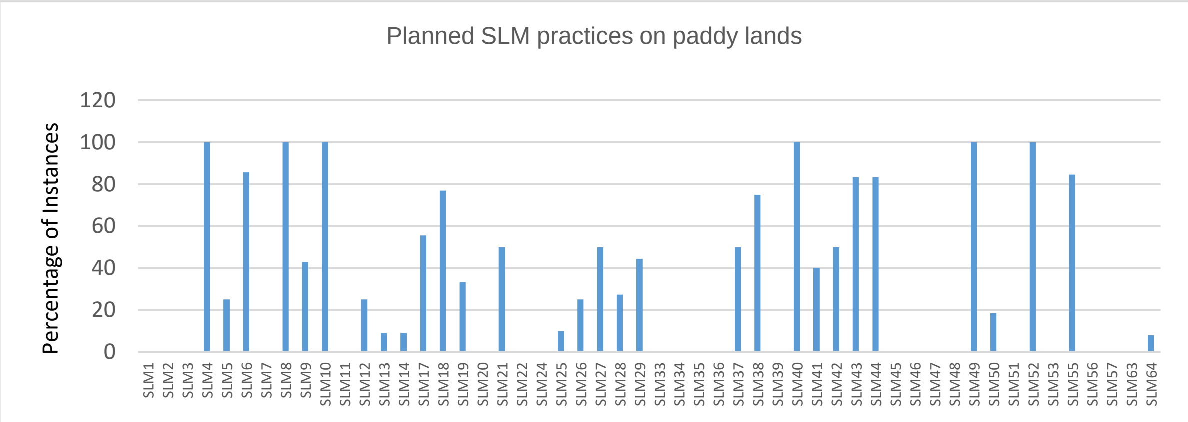


Figure 2.22. Percentage of responses for plans to implement SLM practices in the near future

In general, and from the findings for Paddy lands, it can be observed that these lands have a certain level of sustainable practices inbuilt into the cultivation process and therefore differences in well-managed and poorly managed paddy lands may not be discernible.

Vegetable lands

There was a total of 75 Vegetable lands/farmers visited by the enumerators to collect data on SLM practices. The average land size of the assessed vegetable lands is 0.57 acres, the average number of household members is four and the average income per HH from vegetable cultivation is Rs 18 268 per month. However, these values vary from farmer to farmer depending on the extent of land cultivated. Of the vegetable lands assessed, 19 are private lands, 13 are Jayaboomi[5], 25 are state lands with permits the remaining falling under other types of lands.

The total number of responses pertaining to SLM practices relevant to these lands was 1 766, of which the responses regarding the presence and absence of these SLM practices were 52.3 percent and 47.7 percent respectively (See Figure 2.23 on P. 22).

[5] Lands given as state lands with certain conditions.

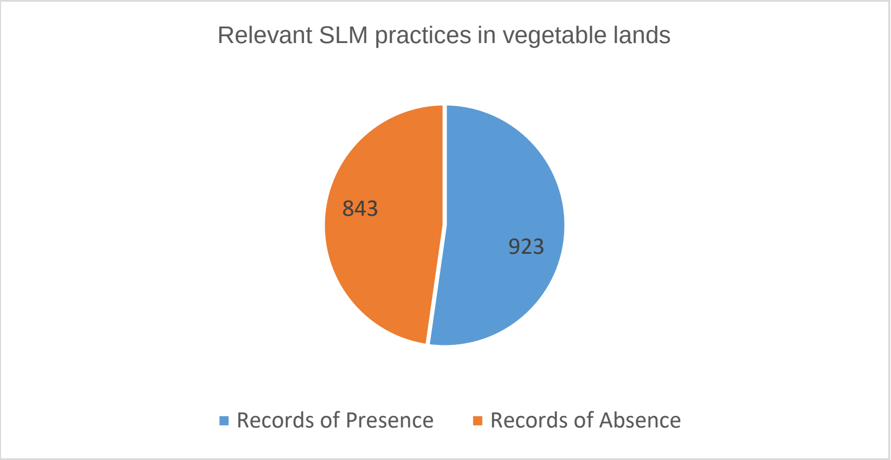


Figure 2.23. Records of presence/absence of relevant SLM practice in vegetable lands

Figure 2.24 displays the reasons why relevant SLM practices were not practiced in vegetable lands. It is important to note that close to 50 percent of the negative responses were due to a lack of awareness about the SLM practice.

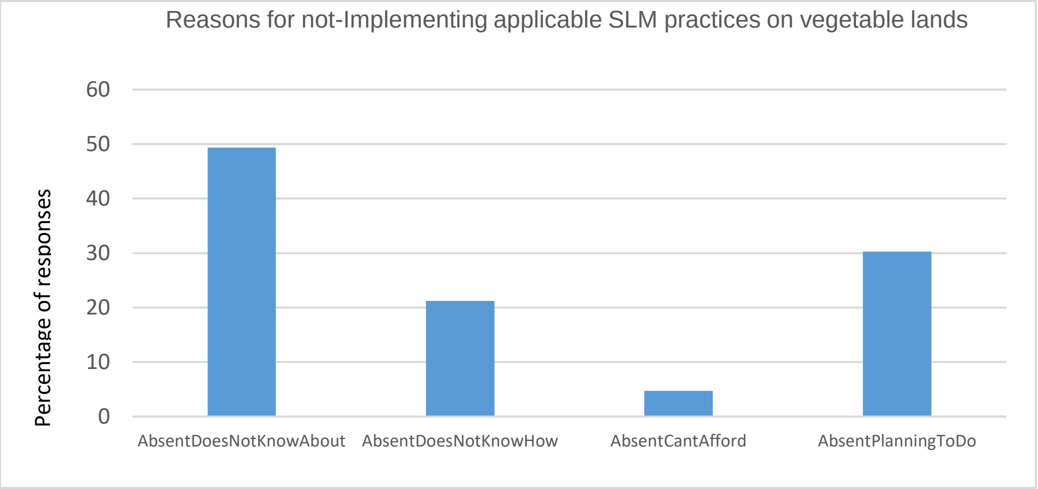


Figure 2.24. Reasons for not-implementing applicable SLM practices on vegetable lands

Figure 2.25 shows which SLM practices are not being used by farmers of vegetable lands even though it is relevant (i.e. the number of instances the absence of a particular SLM practice was recorded). It can be observed that leaf colour index cards (SLM50, 50 instances), integrated nutrient and pest management (SLM9, 44 instances) and eco-certification (SLM64, 39 instances) are the least used SLM practices on vegetable lands.

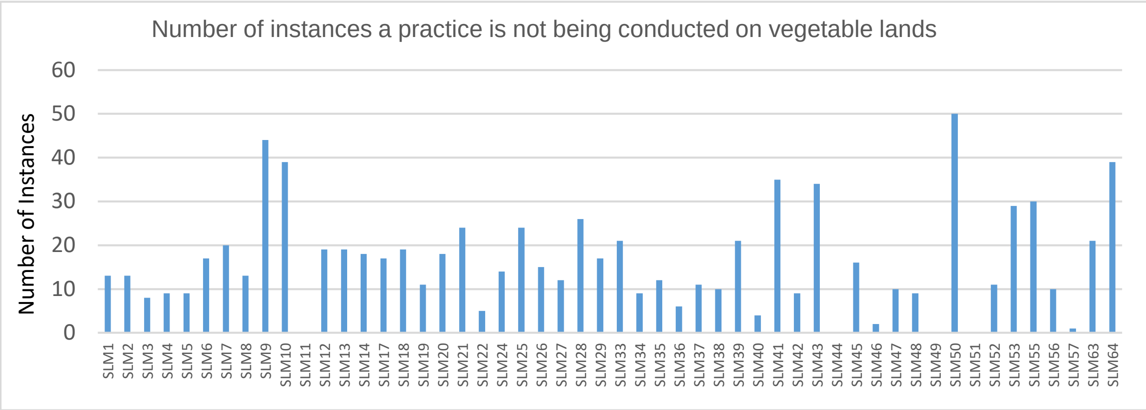


Figure 2.25. Instances where the absence of a particular SLM practice was recorded on vegetable lands

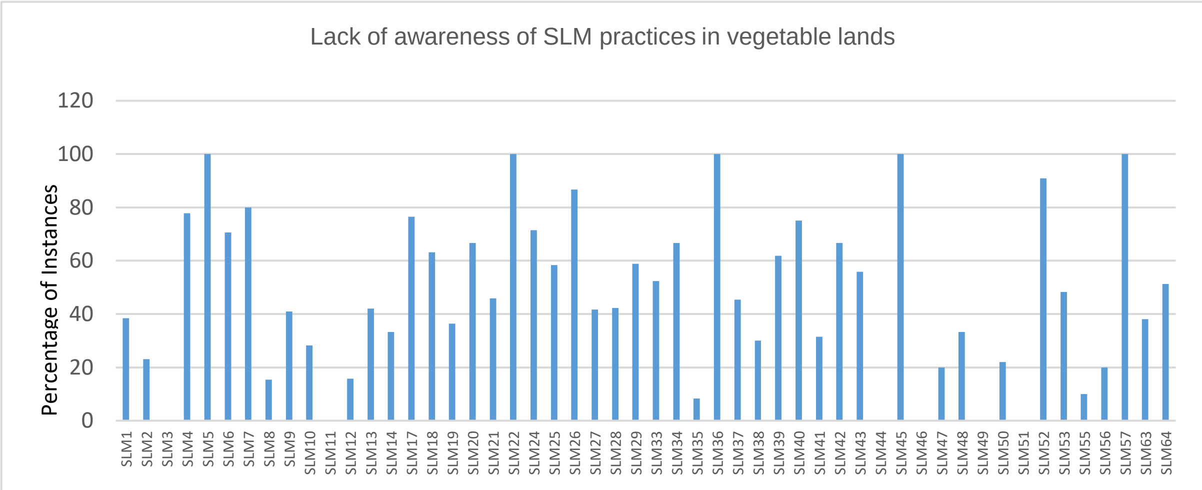


Figure 2.26. Percentage of responses for lack of awareness about SLM practices relevant to vegetable

Figures 2.26 – 2.29 depict the percentage of responses received for each reason for not practicing a relevant SLM practice in vegetable lands (i.e. percentage of responses for lack of awareness, lack of implementation of knowledge, unaffordability, and planning to implement). The respective values in Figure 2.25 were used as the base value when calculating the percentage of responses for each specific reason.

Of the instances where a relevant SLM practice was not conducted in a vegetable land, Figure 2.26 shows the percentage of responses for lack of awareness (or the percentage of responses that were classified as “did not know about the relevant SLM practice”). Lack of awareness is the only reason for the practices of Sloping Agricultural Land Technology (SALT) (SLM5), High-density planting/relay cropping (SLM22), Intercropping with perennials on rain-fed agriculture (SLM36), Burying pruned branches (SLM45), and Sanitising animal husbandry (SLM57) not being used on vegetable lands.

Of the instances where a relevant SLM practice was not conducted in a vegetable land, Figure 2.27 shows the percentage responses which cited a lack of implementation of knowledge (or the percentage of responses that were classified as “Does not know how to implement the SLM practice”). Although maintaining a plucking table (SLM46) has the highest percentage of responses, this is an SLM practice that is irrelevant to vegetable cultivation (and had only 2 responses citing this reason). The use of a Leaf colour index chart (SLM50), construction of

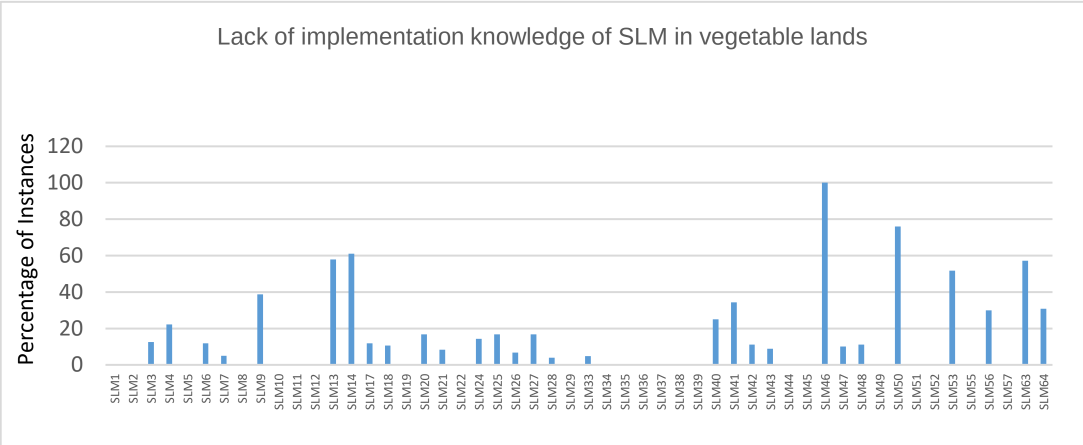


Figure 2.27. Percentage of responses for lack of implementation knowledge to conduct SLM practices relevant to vegetable

Percolation pits (SLM14) and Silt traps (SLM63) received the highest percentage of responses (76%, 61.11%, 57.89% respectively) citing the lack of implementation knowledge as the reason for not conducting these SLM practices.

Of the instances where a relevant SLM practice was not conducted in a vegetable land, Figure 2.28 shows the percentage responses which cited unaffordability of each SLM practice (or the percentage of responses that were classified as “Cannot afford the SLM practice”). The use of Micro-irrigation systems (SLM12), Rainwater collection (SLM10) and conducting beekeeping (SLM56) received the highest number of responses (47.37%, 30.77% and 30.00% respectively) citing the unaffordability as the reason for not conducting these SLM practices.

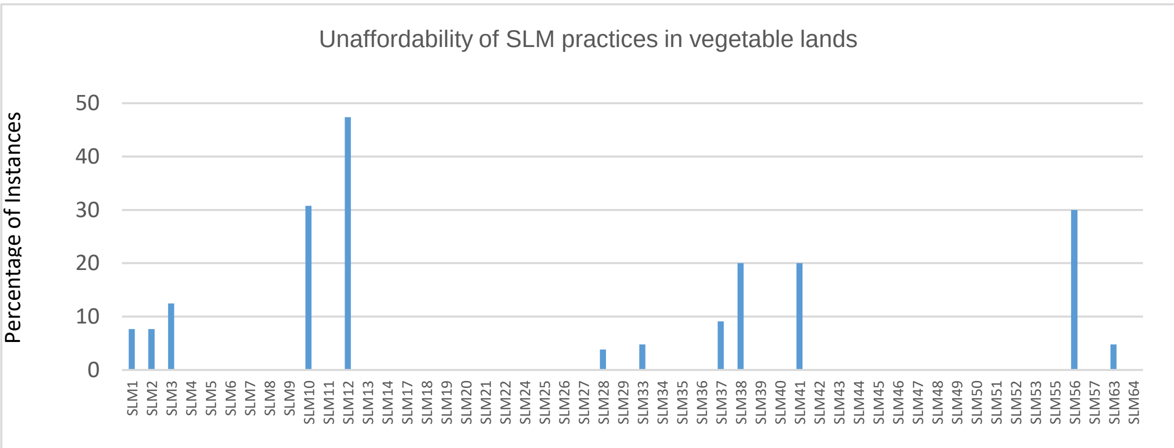


Figure 2.28. Percentage of responses for lack of ability to afford SLM practices relevant to vegetable

Of the instances where a relevant SLM practice was not conducted in a vegetable land, Figure 2.29 shows the percentage of responses that cited planning to implement (or the percentage of responses that were classified as “Planning to implement in the future”). The implementation of crop rotation practices (SLM35), waste management practices (SLM55) and the construction of lock and spill drains (SLM8) received the highest number of responses (91.67%, 90.00% and 84.62% respectively) for planning to implement these practices in the near future as the reason for not conducting these SLM practices.

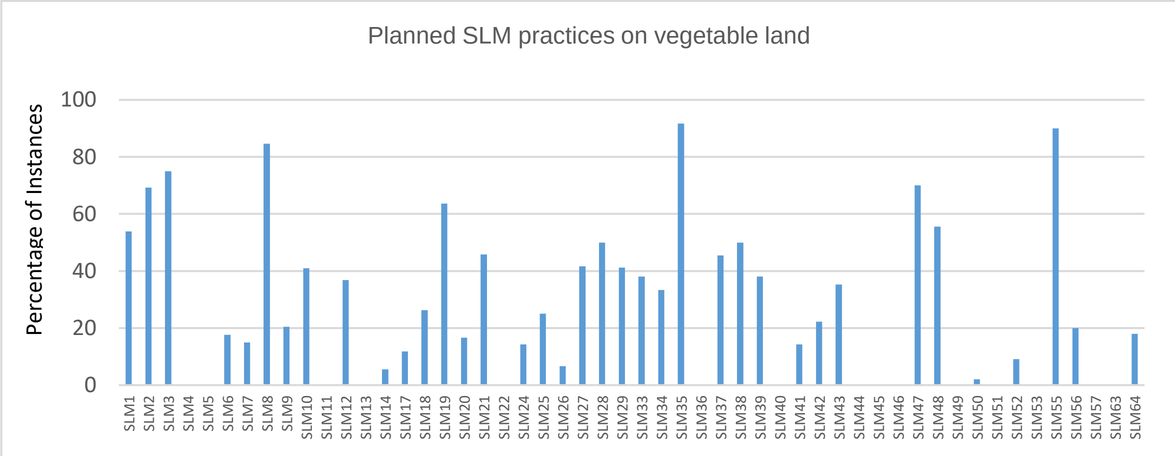


Figure 2.29. Percentage of responses pertaining to plans to implement SLM practices in the near future in vegetable lands

Home gardens

There was a total of 66 Home gardens visited by the enumerators to collect data on SLM practices. The average land size of the assessed home garden is 0.39 acres, the average number of household members is 4 and the average income per HH is Rs 16 074 per month. However, these values vary from farmer to farmer depending on the extent of land cultivated/owned. Of the home gardens assessed, 20 are private lands, 11 are Jayaboomi[6], 13 are state lands with permits and 12 are state leaseholds[7] with the remaining falling under other types of lands. The total number of responses pertaining to SLM practices relevant to these lands was 1729, of which the responses for presence and absence of SLM practices were 46.10 percent and 53.90 percent respectively (See Figure 2.30 below).

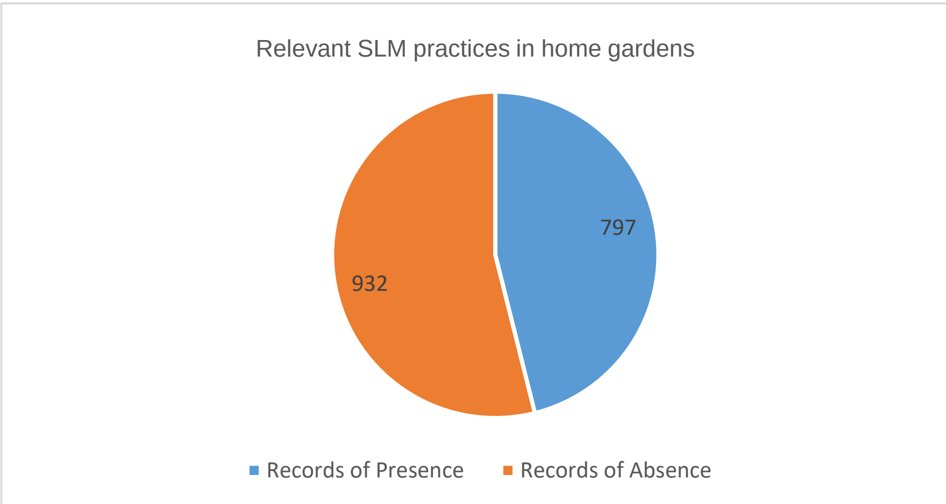


Figure 2.30. Records of presence/absence of relevant SLM practice in home garden

[6] Lands given as state lands with certain conditions.
[7] Lands under the land development ordinance.

Figure 2.31 demonstrates the reasons why relevant SLM practices were not practiced in home gardens. As in the other agricultural land use types, lack of awareness is the main reason (50 percent of responses) for not using SLM practices. It is important to note that close to 50 percent of the negative responses were due to a lack of awareness about the SLM practice.

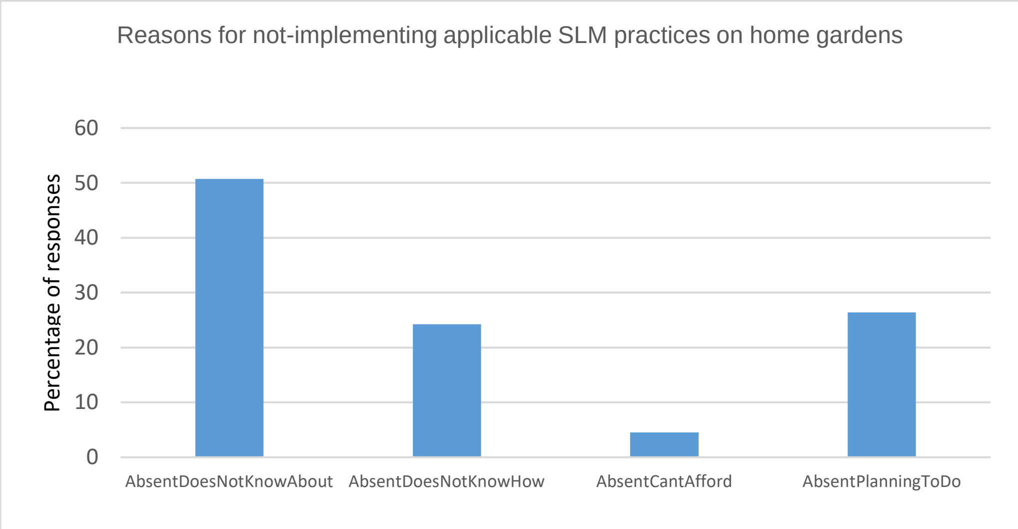
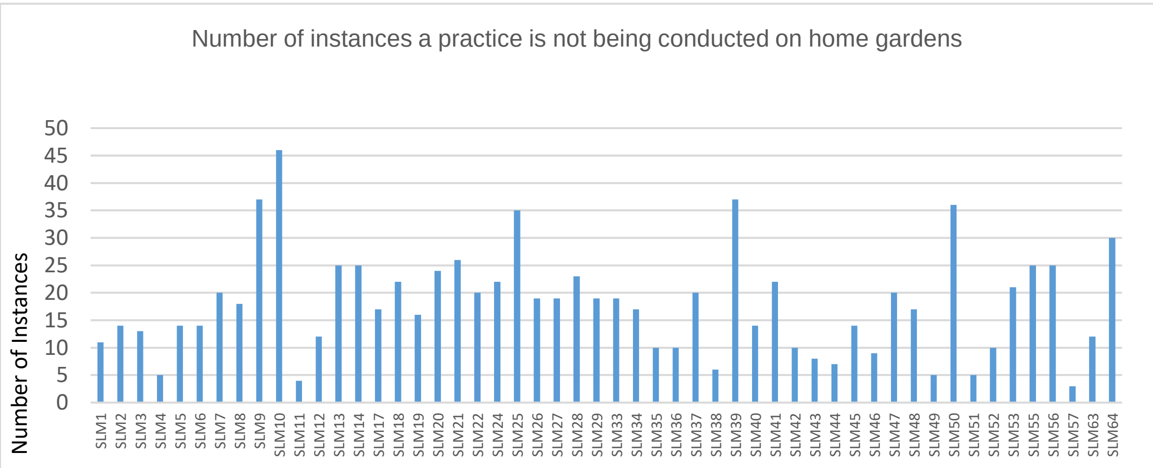


Figure 2.31. Reasons for not-implementing applicable SLM practices on home gardens

Figure 2.32 shows which SLM practices are not being used by farmers of home gardens even though it is relevant for their lands (i.e. the number of instances the absence of a particular SLM practice was recorded). It can be observed that rainwater collection (SLM10, 46 instances), integrated nutrient and pest management (SLM9, 37 instances) and underutilised



crops (SLM39, 37 instances) are the least used SLM practices on vegetable lands.

Figure 2.32. Instances where the absence of a particular SLM practice was recorded on home gardens

Figures 2.33 – 2.36 depict the percentage of responses received for each reason for not practicing a relevant SLM practice in home gardens (i.e. percentage of responses for lack of awareness, lack of implementation knowledge, unaffordability, and planning to implement). The respective values in Figure 2.32 were used as the base value when calculating the percentage of responses for each specific reason.

Of the instances where a relevant SLM practice was not conducted in a home garden, Figure 2.33 shows the percentage of responses for lack of awareness (or the percentage of responses which were classified as “did not know about the relevant SLM practice”). The findings demonstrate that the only reason for not practising sanitising animal husbandry (SLM57) is due to lack of awareness (100 percent of responses). Dolomite application (SLM42), Envelope forking (SLM52), Sloping Agricultural Land Technology (SLM05) and construction of Lateral Drains (SLM06) have a high percentage of responses (80.00%, 80.00%, 78.57% and 78.57% respectively) citing the lack of awareness as the reason for not conducting these SLM practices.

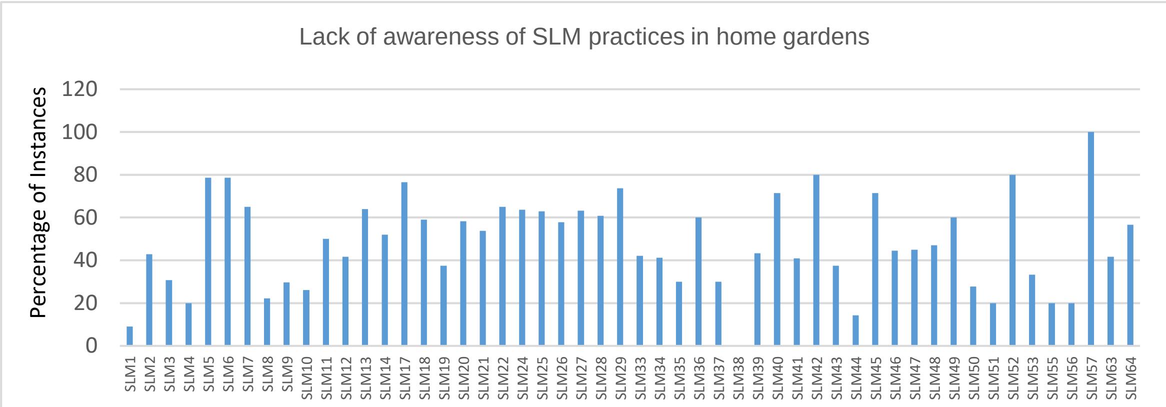


Figure 2.33. Percentage of responses for lack of awareness about SLM practices relevant to home gardens

Of the instances where a relevant SLM practice was not conducted in home gardens, Figure 2.34 shows the percentage of responses that cited a lack of implementation of knowledge (or the percentage of responses that were classified as “Does not know how to implement the SLM practice”). The main reason for not creating sunken beds (SLM4), using leaf colour index cards (SLM50) and integrated weed management (SLM53) is due to lack of implementation of knowledge (80.00%, 52.78% and 52.38% respectively).

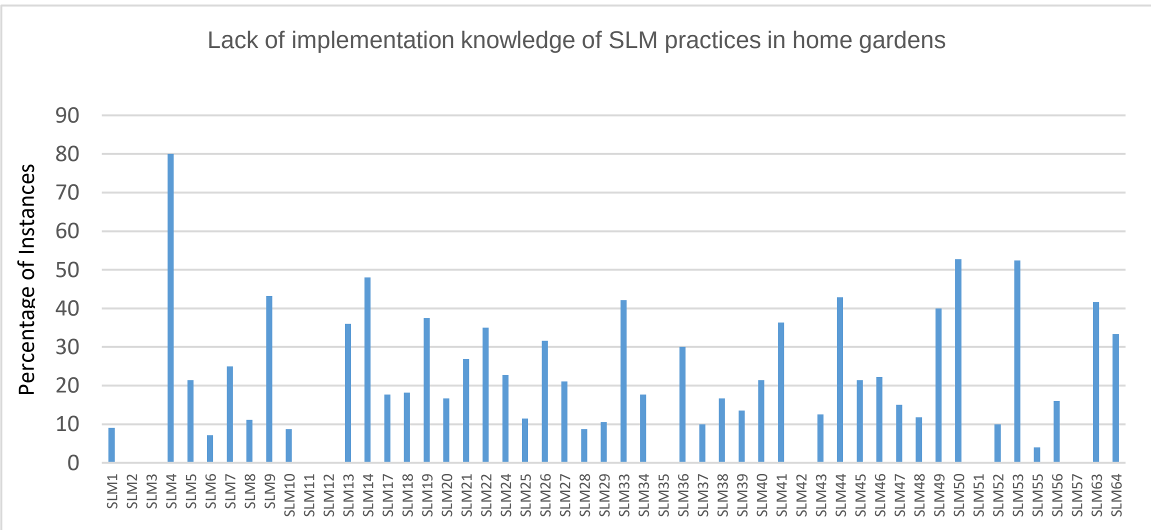


Figure 2.34. Percentage of responses which were classified as “does not know how to implement the SLM practice” on home gardens

Of the instances where a relevant SLM practice was not conducted in home gardens, Figure 2.35 shows the percentage of responses that cited unaffordability of each SLM practice (or the percentage of responses that were classified as “Cannot afford the SLM practice”). Crop diversification (SLM28), Micro irrigation systems (SLM12) and Terracing (SLM01) received the highest number of responses (33.33%, 33.33% and 27.27% respectively) citing unaffordability as the reason for not conducting these SLM practices.

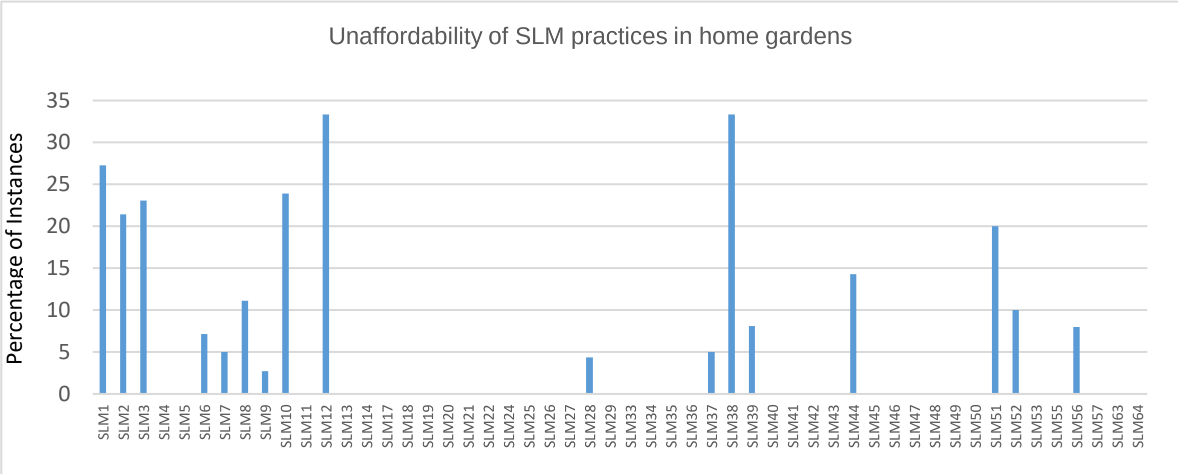


Figure 2.35. Percentage of responses for not able to afford SLM practices relevant to home garden

Of the instances where a relevant SLM practice was not conducted in home gardens, Figure 2.36 shows the percentage of responses that cited planning to implement (or the percentage of responses that were classified as “Planning to implement in the future”). Proper waste management practices (SLM55), implementing Crop rotation (SLM35), infilling Tea plants (SLM51) and beekeeping (SLM56) received the highest number of responses (76%, 70.00%, 60.00% and 56.00% respectively) for planning to implement these practices in the near future, as the reason for not conducting these SLM practices. The 5 instances where infilling of tea plants was recorded, could be as a result of some home garden owners also cultivating tea and responding considering the tea land and not the home garden.

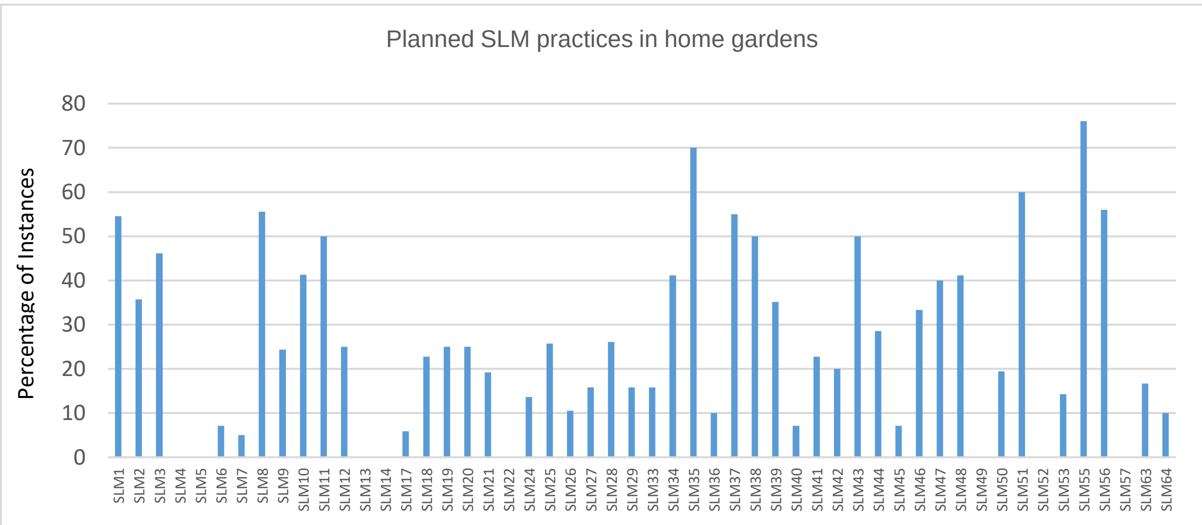


Figure 2.36. Percentage of responses pertaining to plans to implement SLM practices in the near future on home gardens

3. Identification and mapping of agricultural ecosystem services

The Millennium Ecosystem Assessment (2005) provided the basis for the classification of ecosystem services and this was further tailored through reviewing the literature on agroecosystems and their services in order to fully understand the ecosystem services used and created by agricultural lands, as well as the disservices to and from agricultural lands (Dale and Polasky 2007; Swinton *et al*. 2007; Power 2010; Stallman 2011; Garbach *et al.* 2014; Hardelin and Lankoski 2018). Based on this literature and in-house expertise, a data entry sheet was developed (Annex 3) in order to conduct a rapid assessment of ecosystem services of the four agricultural land use types (paddy, vegetable, home gardens and tea lands). Given the short time frame of the project, which was in the order of months, it was not possible to do a more comprehensive analysis of ecosystem services in the project area that would involve soil and water quality measures, mapping hydrological flows, detailed ecological sampling and identification of economic returns. Therefore, the rapid assessment of the ecosystem services method that was used presents the best way to obtain information on ecosystem services in the project area given the short time frame.

Approach

The data entry sheet for the rapid ecosystem assessment included a pre-selected list of 25 ecosystem services under the broader categories of provisioning, regulating and cultural ES. However, data collection was not limited to this list and other observed ES were noted where applicable. Supporting services was omitted, as this group of ES feeds into the other three categories (MEA 2005) and is not easily observed visually during a rapid assessment. The structure of the ES assessment allowed both qualitative and quantitative information to be gathered on the flow, scale, importance and the stakeholders involved of each ecosystem service as well as insight into how different SLM practices may affect the delivery of these ESs (Annex 3).

Figure3.1. IUCN team conducting field surveys for ES assessment

The selection of field sites for the ecosystem services identification assessment involved analysing data from the SLM assessment and stratifying based on land use type, slope, sustainability rating and number of SLM practices conducted. The sustainability rating of each site was provided by the enumerators due to their expertise as extension officers. Ultimately, 40 field sites were chosen: 10 representing each of the land use types (Paddy, Vegetable, Home-garden and Tea) in the three districts Kandy, Nuwara Eliya and Badulla (Annex 4).

The data collection occurred over six days and involved a team of experts from a diverse range of fields, including biodiversity, soil and water and environmental economics. As mentioned in the introduction, the time constraint led to documentation of observed ecosystem services in agricultural lands between the 6 August and 11 August 2019 and did not account for temporal and seasonal changes in agroecosystems. This is a significant limitation of this work. A study conducted over a longer period is therefore recommended to provide a more detailed profile of the ecosystem services and their values which takes into account the temporal variation. Further due to bad weather and long travel hours, two of the sites were not visited during the field assessment and a total of 38 sites were surveyed.

Biodiversity assessment

A biodiversity assessment was conducted simultaneously by IUCN biodiversity experts where the Visual Encounter Survey (VES) method was used to document both flora (flowering plants) and fauna in each of the agroecosystems. In each of the 38 sites, approx. 45-60 minutes were spent to gather the following species data.

• **Species Richness**	• **National Pest Control**
• **Species Status**	• Medicinal Species
• **Threatened Status**	• Species important for timber
• **Invasive Alien Species**	• Species of wild relatives
• **Pest Species**	• Crop species
• **Pollinator Species**	n.a.

The gathered data was categorized in to two key sections considering faunal assemblage i.e.

(i) Lowland wet and intermediate (Deltota, Doluwa and Walapane)

(ii) Highland wet and intermediate (Kurawatta, Bomuruella, Uva Paranagama).

For floral analysis the data is organized into two major groups considering floral similarity i.e.

(i) Lowland wet and intermediate (Deltota, Doluwa, Kurawatta and Walapane)

(ii) Highland wet and intermediate (Bomuruella, and Uvaparanagama).

Flora

In this rapid assessment, Visual Encounter Survey (VES) method was used to document general flora (flowering plants) in different agrobiodiversity ecosystems. There are three standard sampling designs for visual encounter surveys: opportunistic or randomized walk, walking along a line transects and the quadrat or plot sampling (Crump and Scott, 1994), and the present survey made use of the opportunistic or randomized walk within different habitat patches to capture maximum diversity. Visual encounter surveys can determine species richness, provide information for compilation of a species list, and provide data used to estimate proportion of area surveyed that is occupied by target species. Photographic records were made to identify less familiar species, and standard taxonomic keys and other scientific literature mentioned in the list of references were used in the process. During the analysis, medicinal plants were identified using the Ayurveda Medicinal Plant Database, University of Ruhuna (Anon, 2018).

Fauna

All groups of vertebrates (amphibians, reptiles, birds and mammals) and selected invertebrate taxa (butterflies and dragonflies) was sampled and documented. The Visual Encounter Survey (VES) method was used to sample different groups of fauna in the project area (Table 1, Annex 5). All efforts were made to document the animals in a non-destructive manner. Other than opportunistic or randomised walk faunal data was also gathered by consulting farmers and/or other members of the household to list the nocturnal species.

Identification of taxa

The species of plants and animals were identified and classified using the latest standard published guides, peer reviewed journal papers and keys available in Sri Lanka. Some of the key references that were used to identify flora and fauna are given in Tables 2 and 3, Annex 5. Threatened status of recorded species was obtained from the 2012 National Red List of Sri Lanka and IUCN global Red List (https://www.iucnredlist.org/).

The observations of the biodiversity assessment (Annex 5) are included in the findings of the overall ES assessment. Biodiversity plays an important role in determining the availability of ecosystem services available on agricultural lands, therefore it is imperative to understand the current state of biodiversity and also the different ways in which agricultural practices affect it. Therefore the biodiversity assessment that was conducted on these lands contributed towards this understanding of the presence/availability of the pre-selected list of ecosystem services on these agricultural lands. For example, the presence of harvestable resources described the provisioning ecosystem services available in the land, and the presence of pollinators and diversity of habitats informed the understanding of regulatory ecosystems. Likewise, the methods of pest/weed control practices in operation would inform the impact agricultural practices have on these ecosystem services. Furthermore, species richness data was also used as a quantity of ES for the above-mentioned listed ESs.

Findings

An illustration of the observed ecosystem services in the different types of agricultural lands is presented in Table 3.1. The questionnaire for the ES assessment allowed for the visual observation of each ES to be recorded in each of the sites visited. There was a total of 10 sites visits for each agricultural land-use type, with the exception of Paddy which had a total of 8 sites (due to distance and weather-related delays). The percentage of sites under each agricultural land type having a particular ES was calculated. For example, soil retention was observed in 60 percent of the home garden sites and 100 percent in the vegetable sites (Table 3.1 and Annex 6). However, it is important to note that the conducted study was a rapid assessment study with a small sample size of 8–10 sites per agricultural land use type. Hence, the ecosystem services observed may not be generalizable to typical agricultural land, and also, statistically significant differences between lands cannot be examined.

This study provides a general understanding of agricultural ecosystem services found in the different land types, the ones that are not found and the ones not applicable (Table 3.1). Of the cultural ecosystem services, recreational value was largely not observed (81-100 percent of lands), mainly due to the location of the agricultural lands which were away from the main road and not easily approachable. However, it may have been such that the recreational ES was noted with tourism in mind and not the recreational value that the children of the household may obtain from the land. When considering the aesthetic value of the different agricultural lands, it can be seen that Paddy lands (81-100 percent) and Tea lands (61-80 percent) are more visually pleasing.

For the educational value of these types of agricultural lands, the passing of generational knowledge and the interest/awareness of children of the household with regard to agriculture and their surrounding environment, in general, were considered. Although the educational value was observed to some extent in all of the land types, there were more observations in paddy lands (61–80 percent) including the use of some paddy lands for workshops and training for the community. Cultural or heritage/historical value was also largely not observed (100 percent of lands) in any of the lands and this is mainly because the cultural uses of certain plants such as Banana leaves for decorating food tables in various festivities were captured under the religious/spiritual significance of the agricultural land.

Key			
Percentage of sites (%)	**ES observed**	**ES not observed**	**ES not applicable**
0-20	●	●	○
21-40	●●	●●	○○
41-60	●●●	●●●	○○○
61-80	●●●●	●●●●	○○○○
81-100	●●●●●	●●●●●	○○○○○

**A total of 6 circles can be present for a given ES in an agricultural land as it denotes a percentage range of sites sampled, not a specific value. I.e. soil retention is observed in 80 percent of tea lands and not observed in 20 percent.*

Table 3.1. Observed ecosystem services according to each agricultural land use type (● denotes ecosystem service observed, ● denotes ecosystem service not observed, and ○ denotes ES not applicable) *.

	Ecosystem Service	**Agricultural Land Use Type**			
		Home garden	**Paddy**	**Tea**	**Vegetable**
REGULATING	Soil retention	●●● ●● ○	●●●●●	●●●●● ●	●●●●●
	Water purification/quality	● ●●● ○○	●●●●●	●●●●●	●●●●●
	Water flow regulation	● ●●● ○	●●●●●	●●●●● ●	●●●●●
	Pest/weed control	●●●●● ●	●●●●●	●●●●● ●	●●●●●
	Carbon sequestration	●●●●●	●●●●● ●	●●● ●●●	●● ●●●

Ecosystem Service		Agricultural Land Use Type			
		Home garden	Paddy	Tea	Vegetable
	Invasive species resistance/ prevention	●● ●●	●●●●●	●●● ●	●●●● ●
	Natural Hazard protection	●● ●● ○○	●●●●● ○	● ●●●● ○	● ●●● ○○
PROVISIONING	Fuelwood	●●●● ●	●●●● ○○	●●●● ●	● ●●●● ○
	Fibre	●●●●●	●●●●●	●●●●●	●●●●●
	Fodder	● ●●●●	●●●●●	●●●●●	●●●●●
	Fresh water Storage	●● ●●●	●● ●●●●	● ●●●●●	●●●● ●●
	Fresh water Supply for irrigation	●● ● ○○○	●●● ○○○	● ○○○○	●●●● ●
	Fresh water Supply for HH use	● ●● ○○○	●● ○○○○	● ○○○○○	● ●●● ○
	Fresh water consumption by domestic animals	● ● ○○○○	●● ○○○○	● ○○○○○	●●●● ○○
	Fresh water supply for commercial purposes	●● ○○○○	●● ○○○○	● ○○○○○	●●●● ○○
CULTURAL	Aesthetics	●●● ●●●	●●●●●	●●●● ●●	●●●● ●
	Educational	●●● ●●●	●●●● ●	●● ●●●●	●●● ●●●
	Cultural/heritage	●●●●●	●●●●●	●●●●●	●●●●●
	Recreational	● ●●●●●	●●●●●	●●●●●	●●●●●
	Religious/Spiritual significance	●●●● ●	●●●●●	●●● ●●●	●●●● ●

Table 3.2. The average percentage of ecosystem service found in each agricultural land use type (results from biodiversity assessment Annex 5)

Ecosystem service		Agricultural land use type			
		Home garden	Paddy	Tea	Vegetable
Regulating	Pollinators - Fauna	20.34%	16.33%	14.83%	16.76%
	Habitat provision:				
	Species Richness - Fauna	23.11%	26.63%	21.02%	23.94%
	Species Richness - Flora	24.28%	15.43%	17.62%	14.98%
Provisionin g	Food (Percentage of crop plants)	12.79%	4.83%	6.72%	5.84%
	Medicinal plants	5.31%	4.03%	4.18%	3.8%
	Timber	2.44%	0.55%	3.31%	0.48%

From the provisioning services (Table 3.1), it was found that the ESs fibre and fodder were not found in any agricultural land type except for one home garden which used crop residue for goat feed. It was also observed that freshwater supply from the land for irrigation, household use, consumption by domestic animals and commercial purposes was mostly not applicable when there were no freshwater storage systems on the lands. Freshwater storage is mainly not seen on Tea lands (81–100 percent) due to plants being rain-fed, whereas most vegetable lands (61–80 percent) have some sort of freshwater storage. As expected, fuelwood collection occurs more in home gardens and tea lands (at 61–80percent of sites) due to the types of plants/crops grown. Although tea lands are mono-cultivations, some of the lands are interspersed with Gliricidia and almost all have larger trees on the boundaries of the land.

For observations on food crops, medicinal and timber trees, the results from the biodiversity assessment (Annex 5) allow for comparisons between types of lands (Table 3.2). Home gardens have the highest average percentage of food crops (12.79 percent) as expected, and that of tea lands is more than vegetable and paddy lands (Table 3.2). Home gardens have a higher percentage of medicinal plants compared to the other land types, and Tea lands have the highest percentage of Timber. However, the timber from tea lands was generally used or sold at the initial time of land clearing.

Visually observing regulating ecosystem services proved a difficult task due to the nature of the category. Data collection over a longer period would be necessary to better understand the quantity and state of the ES available, for instance, to measure the nutrients in the soil and quality of water. In general, the regulating ecosystem services listed were observed in all of the agricultural land types. It is important to note that where there were no observations, this can be interpreted as an ecosystem *disservice* from the agricultural land. There was no water purification observed because of the use of chemical fertiliser and pesticides which contributed to water pollution (disservice). It can be seen that soil retention and water flow regulation efforts are less evident in home gardens than in the other three agricultural land types.

Certain regulation services such as pollination and habitat provision can arguably be observed in almost all of the lands. In order to evaluate differences between land-use types, the data from the biodiversity assessment will be used (Table 3.2). This demonstrates that a higher percentage of pollinators is observed in home gardens than the other types of agricultural land. For habitat provision, the species richness of flora and fauna were considered. Paddy lands have the highest average faunal species richness; however, this isn't significantly greater than the other types of lands. The flora species richness does vary, indicating that home gardens have the highest average species richness (24%) and therefore a stronger habitat provision, compared to vegetable lands which have the lowest flora species richness (14.98%).

The use of pesticide and manual weeding was considered for observed ES pest and weed control as well as for invasive species resistance, and the presence of IAS plants were also taken into consideration for the latter. There are no major differences in the agricultural land types for these ecosystem services. The 'ES not observed' indicator for natural hazard protection also indicates that there were no natural forms of protection against landslides and wind despite there being a significant need for it. Natural hazard protection was only not applicable in some home-garden and vegetable lands.

Sustainable land management and identification of ecosystem services conclusion

The overall ES assessment (including the SLM assessment) allows us to further understand, in the context of degraded agricultural lands, the practices that contribute to 'disservices' and the reasons for not adopting sustainable land management. The study observed that the use of chemical fertilisers and pesticides can be a major problem affecting water quality and can therefore produce a disservice (water pollution). It was also identified that lack of awareness is one of the main reasons for not implementing sustainable land management practices. Raising awareness of farmers is therefore key in addressing issues such as the overuse of chemical fertilisers and pesticides. Innovative finance mechanisms such as eco-certification that promotes organic farming and the establishment of direct market linkages will complement awareness raising and enable farmers to adopt SLM practices.

Natural hazards (mainly strong winds and landslides) are an issue faced by many of the farmers visited where crop productivity and safety of the household are affected; only a few farmers maintained or engaged in practices that would protect their lands from natural hazards. This confirms the need for awareness-raising on SLM.

The assessment also provided insight into the ecosystem services that are predominant on different agricultural land types. Paddy scored the highest on educational value compared to the other types of land and this may be because of the traditional knowledge passed down from one generation to the other. It was also found that paddy lands are used as an example for workshops and training due to a higher number of sustainable land management practices already adopted (section 2). Lessons learned from paddy lands can be drawn to the other lands for awareness-raising and training on SLM approaches.

As mentioned earlier, a rapid assessment methodology was undertaken in order to complete this assessment of SLM practices and ecosystem outcomes within the allocated time frame of component three within the larger FAO project. The study would have benefitted from a longer period: the short time frame may have led to an underrepresentation of ecosystem services, as the temporal dynamics and seasonality of the agroecosystems were not fully captured (ideally field measurements should be conducted over a minimum of one year targeting each agricultural and climatic season).

Nevertheless, the findings of this study also allow for the development of innovative financing mechanisms that may be more applicable to the context/issue. For instance, agrotourism may not be entirely successful in these lands because they are in remote areas making it difficult to get to and be seen from roads or transport routes. However, it was noted that tea and paddy do contribute to aesthetics and are therefore important in contributing to the rest of the landscape of the central highlands which does gain a lot of tourist attraction. The development of Spice gardens for agro tourism could be considered and further researched since home gardens provide more habitat provision, pollination and have a higher number of food crops and there are already some examples of spice gardens as tourists' attractions in Sri Lanka. Other IFMs that could be developed include the Eco-certification mentioned above and the re-allocation of public budgets away from harmful subsidies and towards SLM. This will be further evaluated by IUCN in the upcoming reports on innovative financing mechanisms for sustainable land management in Sri Lanka, where potential IFMs will be designed and general guidelines for their implementation will be developed.

4. Valuation of ecosystem services of agricultural lands in the central highlands

From the previous sections, approaches were undertaken to understand which SLM practices are being used or not being used in the Central Highlands of Sri Lanka and the reasons that may be preventing the adoption of sustainable practices. The assessment also identified which ecosystem services are observed in the different agricultural land use types (Paddy lands, Vegetable cultivations, Home gardens and Tea lands) and assessed how practices may affect the delivery of these ecosystem services.

The broader objective of the FAO/GEF *Rehabilitation of Degraded Agricultural Lands* project is to promote sustainable land management in the Central Highlands of Sri Lanka. Hence, understanding the value of the identified agricultural ecosystem services will be extremely useful in the development of policies, financing mechanisms and management or planning decisions relating to SLM. For example, understanding the value of soil conservation practices to farmers, the external benefits to those downstream and the general public, as well as the cost to the farmers by adopting these practices will enable the development of appropriate financing mechanisms to encourage sustainable practices. At the same time, we can communicate the importance of soil conservation to the farmer.

To value the goods and services provided by the natural environment, economists have created a set of methods commonly referred to as non-market valuation methods that are derived from a foundational framework on decision making and utility maximization (Dissanayake 2018, Johnston *et al.* 2017, Swinton *et al.* 2007). There are four main methods classified into two categories: (1) revealed preference valuation methods and (2) stated preference valuation methods.

Revealed preference methods use existing data from a related market to value non-market or environmental goods and policies and consist of travel cost and hedonic pricing approaches.

Stated preference methods elicit values from the public using surveys and consist of contingent valuation and choice experiments.

In addition to these theoretically derived methods, practitioners also use avoided damage, replacement cost and other measures to value ecosystem services. When primary data collection is difficult or not possible due to location, resource or time constraints, economists use benefit transfer techniques to apply values to new goods, policies and scenarios (Dissanayake 2018).

The third main objective of the ES assessment report is to value the ecosystem services of agricultural lands by building on the previous section that identified ecosystem services in the different agricultural land use types. Understanding the value of agricultural ecosystem services further highlights the importance of SLM practices and aids in the communication of its significance. This objective can be broken down into two parts:

1. Comparison of ecosystem services between well-managed and poorly managed lands.
2. Assessing the values of ecosystem services arising from well-managed lands or lands that have adopted SLM practices.

Approach

As mentioned above, the valuation study follows the ES identification and mapping assessment, which examined the extent and distribution of ecosystem services in each land use type.

Method of comparing ecosystem services of well-managed and poorly managed lands

As part of the valuation assessment, in order to understand how sustainable land management practices contribute to providing ecosystem services, a comparison of the availability of ecosystem services between well-managed or good sites and poorly managed sites was conducted. Good sites are sites (farmlands) that are currently implementing a relatively high number of SLM practices, and poor sites are the ones that have not adopted many SLM practices[8]. The classification of sites was done by using the data gathered during the SLM assessment (see page 5). Of the 264 farmers and farmlands that were assessed during the SLM assessment, 40 sites were chosen for the ES identification and valuation assessments based on the number of SLM practices, quality as indicated by the enumerators, the slope of the land and the agricultural land use type. The data summaries presented below represent the average over five sites for each agricultural type and quality (i.e. five good home gardens, five poor home gardens, five good tea lands and so on) and the results for the comparison are discussed in the next section. It's important to note that given the limited amount of data, a statistical comparison of differences cannot be conducted, and this limitation is further discussed at the end of the report.

Method for valuation of agricultural ecosystem services of well-managed lands

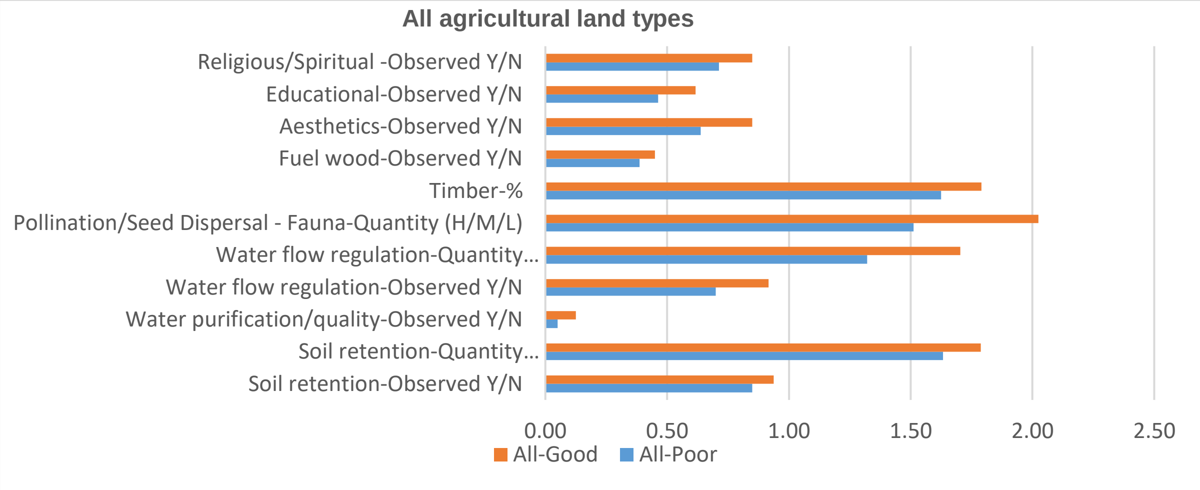
In order to understand the values of ecosystem services resulting from adopting SLM practices, the MEA framework is followed and the benefit transfer method is used based on The Economics of Ecosystems and Biodiversity (TEEB 2018) (see Dissanayake 2018 for an introduction to these approaches). Ideally, an ES valuation process would require multiple years of work that involves a detailed study of the landscape and an integrated modelling framework that links the physical-geo-hydrological-and social systems, as well as richer data sets and funding commitments (see Vogl *et al.* 2017 for an example applied to Kenya). Given the short timeframe and the data limitation of the study, the benefit transferring method is used and with generalised values for selected ecosystem services in well-managed sites. It is important to note that this study does not present a causal link between the adoption of specific SLM practices to ecosystem outcomes or values.

Comparison of ecosystem services of well-managed and poorly-managed lands

Figure 4.1 depicts a comparison of ecosystem services across the well-managed and poorly managed sites of all agricultural land use types. However, given that the SLM practices and the ecosystem outcomes vary by type of land use, Figures 4.2 – 4.5 present a comparison by agricultural land use type to better understand the ecosystem services within each landscape. Graphical comparison is presented for selected ecosystem services; however, the full comparison tables are provided in Annex 7. The units of observation are either absolute numbers or percentages depending on the ecosystem service. For example, the observation of soil retention is recorded as yes (value = 1) or no (value = 0), and Figure 1 (and Table 1, Annex 7) depicts the average of observed soil retention in all agricultural land types, according to categories well-managed (denoted by Good) and poorly managed (denoted by Poor). In

[8] Based on the enumerator rating for sustainability of sites.
i.e. Sites with many SLM practices used = High sustainability rating = Well-managed sites.
Sites with no/low SLM practices = Low sustainability rating = Poorly managed sites.

other words, the average soil retention is 0.94 in good sites and 0.85 in poor sites. Some ecosystem services such as medicinal plants depict the percentage of plants out of a total possible for that landscape type from the data gathered with the biodiversity assessment. Other ecosystem services such as pollination/seed dispersal are recorded as high, medium, low quantities in agricultural lands (quantified as High = 3, Medium = 2, Low = 1). The results are shown on two graphs to account for the variation in the scale of measured outcomes.



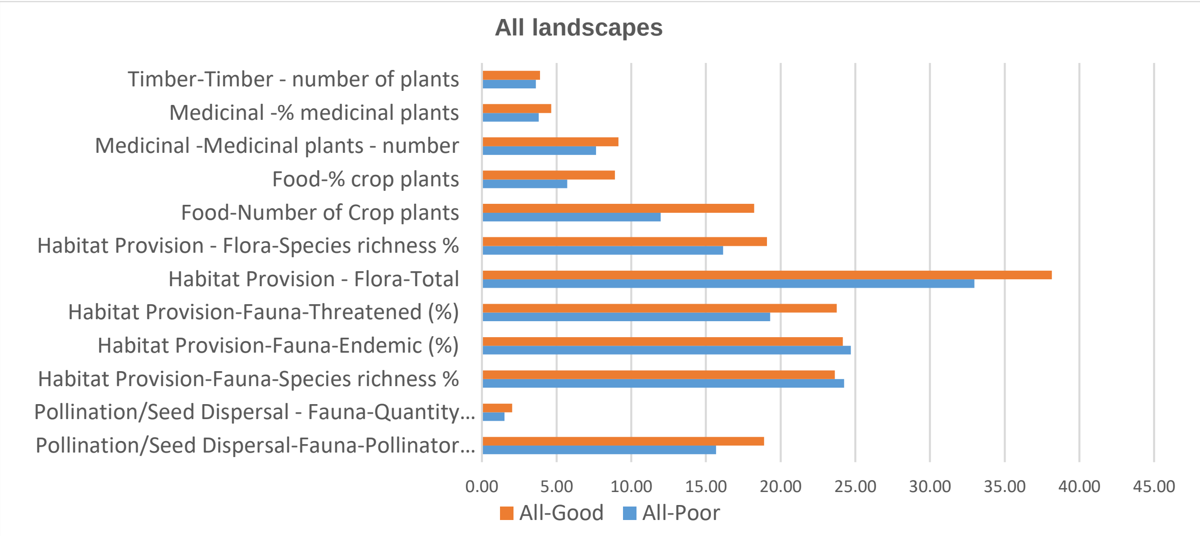
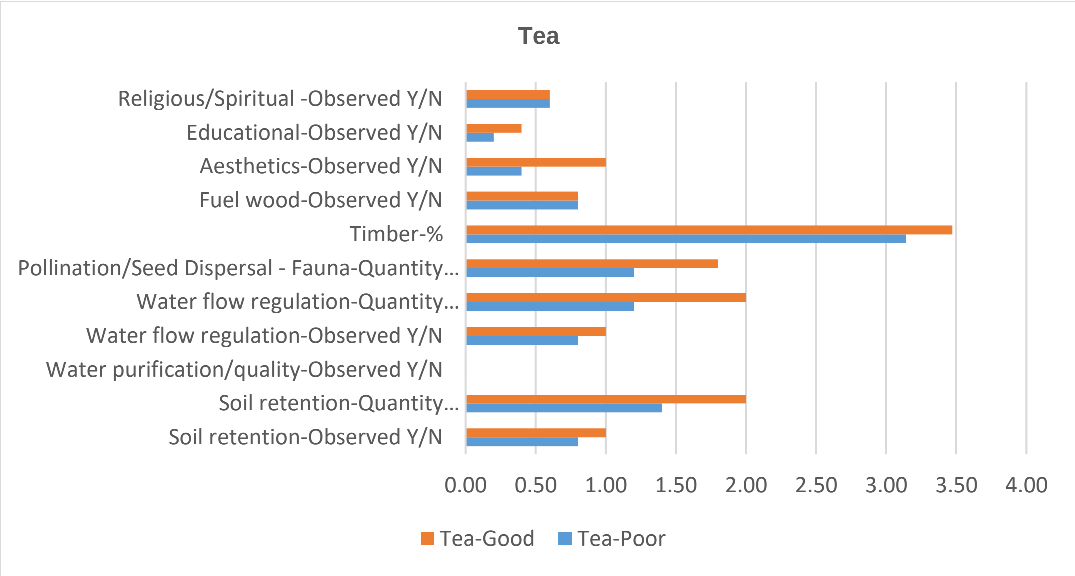


Figure 4.1. Comparison of ecosystem outcomes from good and poor sites from all landscapes

The comparison indicates that for most ecosystem services, a good site (with a large number of SLM practices) shows a relatively higher amount of ecosystem service provision (Figure 4.1). The two exceptions are for Species Richness and Threatened Fauna Species, but as discussed below this is being driven primarily by the lack of species diversity in tea and paddy lands.

Tea lands



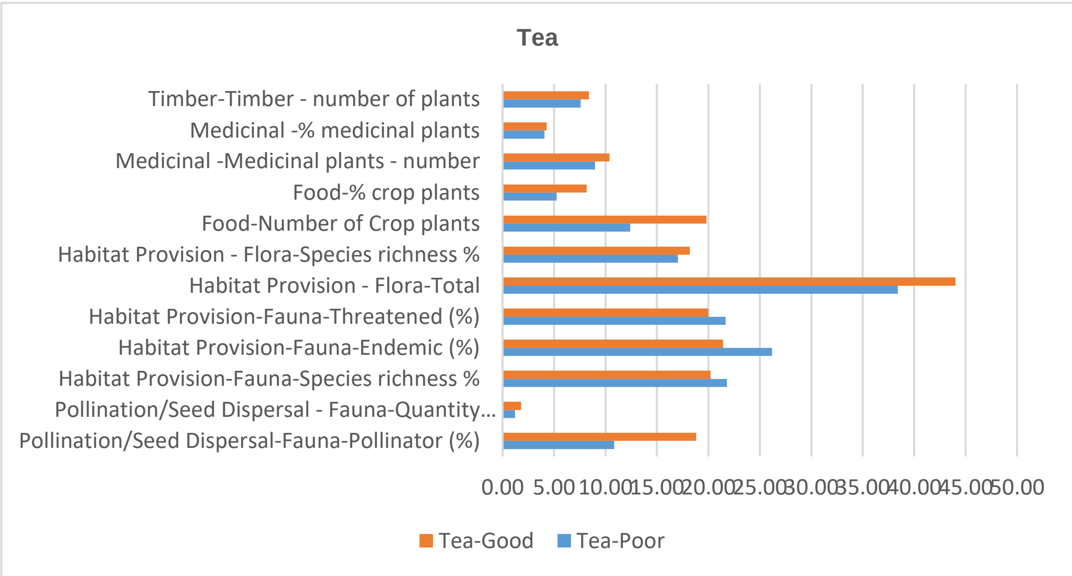
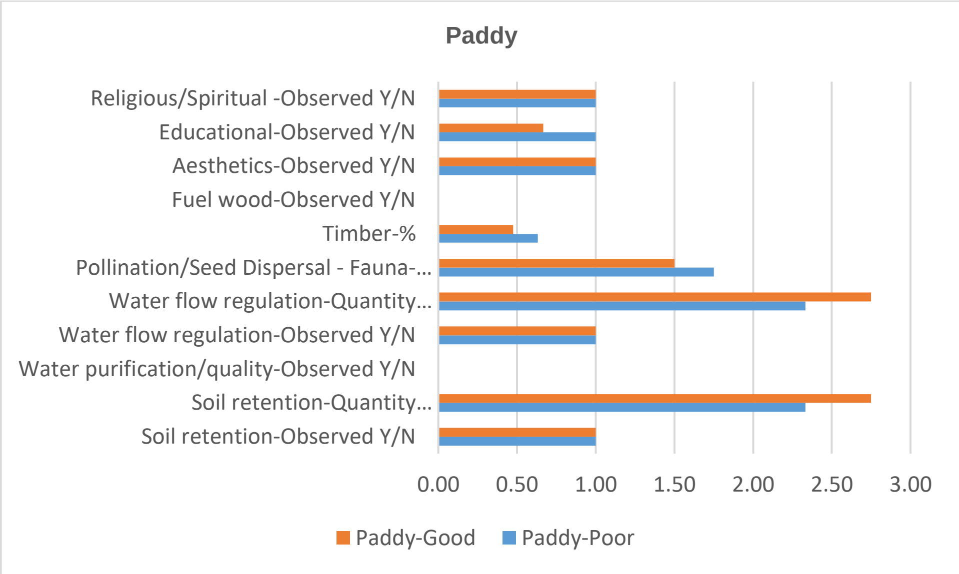


Figure 4.2. Comparison of ecosystem outcomes from good and poor sites from tea lands

Similarly, for tea lands the good sites do not always depict in a higher production of ecosystem services compared to the poorly managed sites. For some of the ecosystem services such as habitat provision, poorly managed lands provide a higher amount of ecosystem services (Figure 4.2).

Paddy lands



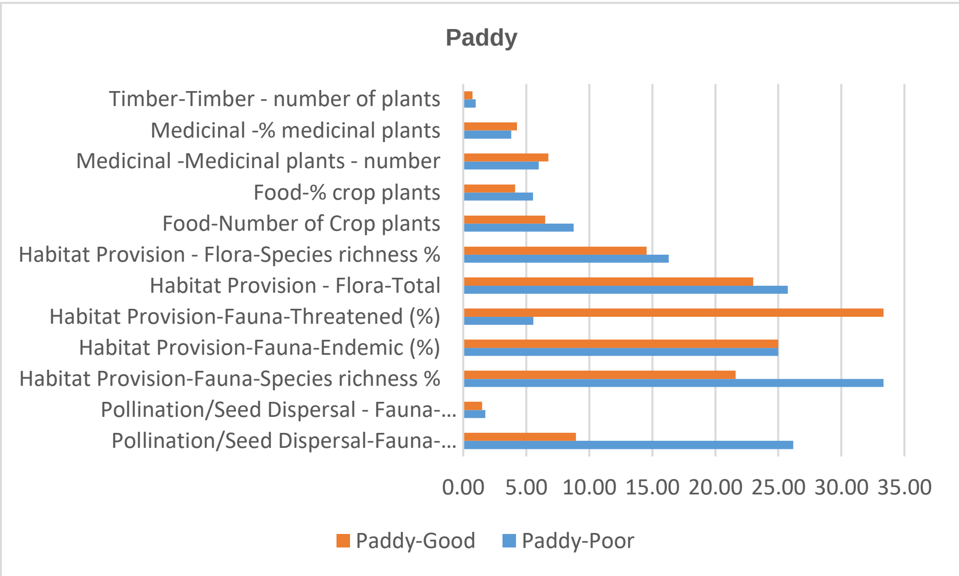


Figure 4.3. Comparison of ecosystem outcomes from good and poor sites from paddy lands

For paddy lands the well-managed sites do not always result in a higher production of ecosystem services compared to the poorly manages sites (Figure 4.3). It can also be observed that for some of the ecosystem services, poorly managed lands provide a higher amount of ecosystem services. One possible explanation for this is that some of the poorly managed paddy lands may support a more natural habitat if the paddy lands are not well functioning. Another possibility is that unlike in the other land types, in paddy lands most farmers adopted a range of practices, so there was not a large difference between the good and poor lands with regard to the number of practices. However further assessments and time would be required to look deeper into these differences.

Vegetable lands

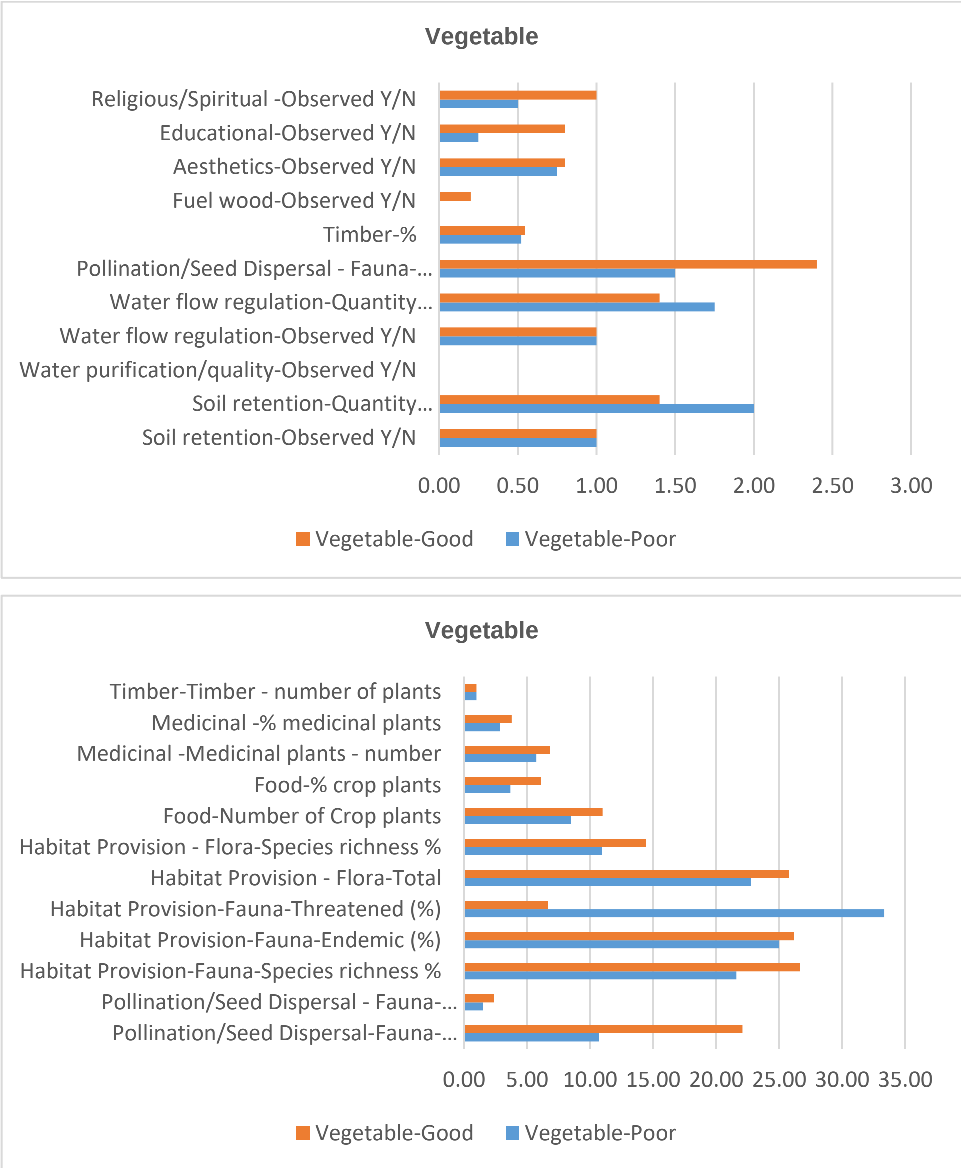
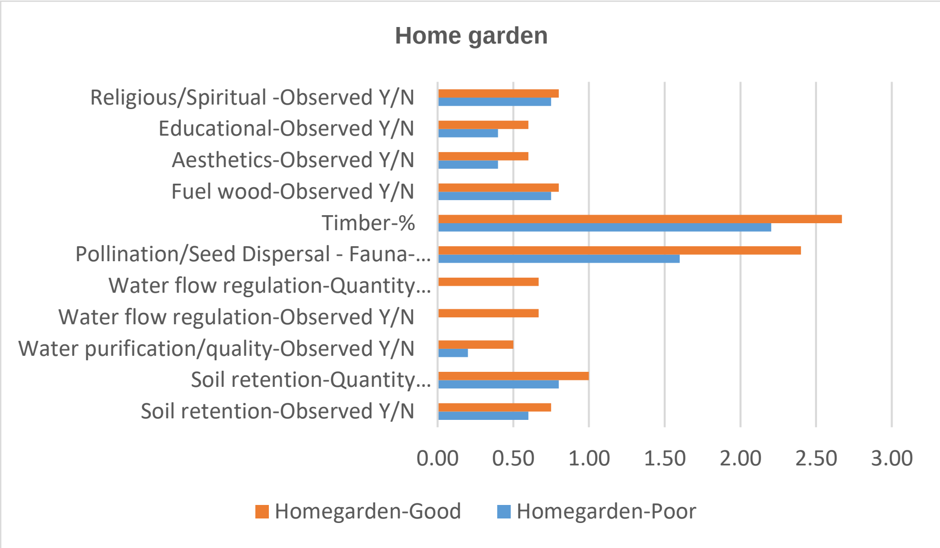


Figure 4.4. Comparison of ecosystem outcomes from good and poor sites from vegetable lands

For vegetable gardens the well managed sites show a relatively much higher production of ecosystem services compared to the poor sites (Figure 4.4). This is true across most of the selected ecosystem services in Figure 5 except for water flow regulation, soil retention and threatened fauna.

Home gardens



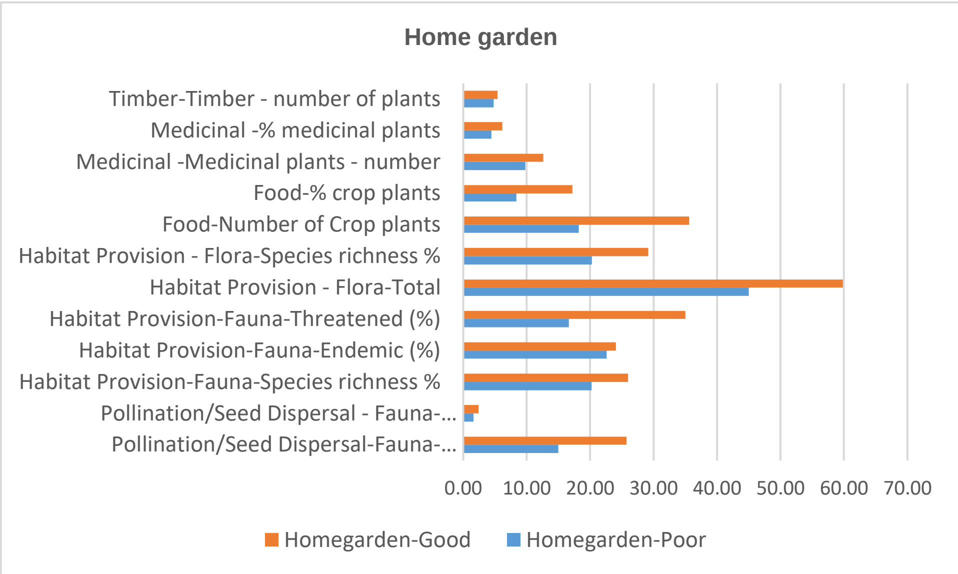


Figure 4.5. Comparison of ecosystem outcomes from good and poor sites from home gardens

The well-managed home gardens depict a relatively higher production of ecosystem services compared to the poorly managed sites, and this is true across all of the selected ecosystem services depicted in Figure 4.5.

Values of agricultural ecosystem services of well-managed lands

In order to conduct a comprehensive valuation study of agricultural ecosystem services a large amount of time and financial resources is required in order to capture the spatial and temporal variations of ecosystem services. Understanding the dynamics and functions of ecosystems (including agricultural lands) and how human activities affect the linkages between ecosystem services is complex and therefore thorough assessments are needed in order to inform proper management decisions and in the context of agriculture, sustainable practices. The main limitation of this study is that it was a rapid assessment of agricultural ecosystem services and therefore a primary valuation study is not possible. Benefit transfer method is generally used to support the findings of a primary valuation, however given time and resource constraints the methodology is used in this study for the purpose of communicating the importance of ecosystem services and to highlight the need for further research in this context in Sri Lanka.

The Environmental Economic Valuation Review (EEVR) Database from the BIOFIN-Sri Lanka study (UNDP 2018) was consulted and agricultural ecosystem service valuation studies were selected and reviewed for this report. It was noted that some studies have calculated the costs to the farmer for poorly managed lands. When considering soil erosion for example, a study by Samarakoon and Abeygunawardena (1995) valued the costs of the impacts of soil erosion to potato cultivation in the Nuwara Eliya District. It was found that 9–15 tonnes of soil per hectare was lost depending on the season, and based on this the NPK and organic matter lost was calculated. The study estimated the replacement cost ranges from Rs 2 305 to 3 443 per hectare. However, it is noted that the temporal and spatial aspects need to be included (Samarakoon and Abeygunawardena 1995). Similarly, Premachandra and Kotagama (1995) assessed the onsite impacts of soil erosion in tea lands in the Kandy District, and found that the cost of erosion is Rs 1.56 million/year. Dharmasena and Bhat (2011) assessed the nutrient losses from soil erosion and estimated the replacement cost of 1 ha for old seedling tea fields as Rs 18 011 per year and for vegetative propagation fields as Rs 8 270 per year. In addition, Banda and Sangakkara (1995) compared the impacts of soil erosion on lands that had organic matter and paddy straw and lands that did not, and found that the replacement cost of soil erosion is lower with organic matter and paddy straw.

The general ecosystem service values that could be generated from the assessed agricultural lands if they are managed well are presented below. As noted in the methods section, data from the TEEB database (Van der Ploeg and de Groot 2010) is used for selected ecosystem services. Table 4.1 highlights the ecosystem service values from general agricultural lands. Applying these values would indicate that on average and in general, a farmer with 1-acre site, would generate approximately Rs 25 000 worth of water quality and purification benefits, about Rs 6 000 worth of air quality benefits, Rs 10 000 worth of climate regulation benefits and about Rs 17 000 worth of soil fertility benefits per year. Alternatively, the total economic value (TEV) can be calculated at about Rs 79 000 per year[9].

Table 4.1. Values from general agricultural lands

Ecosystem services values from general agricultural lands	
Assuming Croplands	
Ecosystem Service	**Value (1000 SLR/acre/year)**
Water Quality/ Soil Erosion	6.89
Air Quality	5.74
Climate	10.22
Soil Fertility	16.77
Water Purification/Filtration	18.83
TEV	79.35

[9] It's important to note that TEV analysis and ecosystem service analysis are complimentary but different. The TEV is not the sum of the ecosystem services. These values are obtained from separate studies using separate methods and frameworks.

Table 4.2 highlights the ecosystem service values from home gardens under the assumption that they represent an Analog forest with benefits similar to an agroforestry system. Studies have identified specific values for pollination (or crops), carbon sequestration, and the TEV. Applying these values would indicate that on average and in general, a farmer with 1-acre home garden would generate approximately Rs 4 000 worth of pollination benefits and about Rs 177 000 worth of carbon sequestration benefits per year. Alternatively, the total economic value (TEV) can be calculated as about Rs 225 000 [10].

Table 4.2. Values from home gardens

Ecosystem service values from home gardens	
Assuming Analog Forestry/Agro-forestry	
Ecosystem Service	**Value (1000 SLR/acre/year)**
Pollination (of crops)	4.39
Carbon Sequestration	177.50
TEV[10]	225.97

Understanding the costs of soil erosion to the farmer and community or the benefits of soil conservation measures demonstrate the significance of adopting sustainable practices on agricultural lands. From the local valuation studies in the database, it was observed that most agriculture related studies covered assessments on regulating ecosystem services/disservices (such as soil erosion, water irrigation). However, it was noted that there is a lack of comprehensive studies on the total economic value and other categories of agricultural ecosystem services.

In addition to the above discussed ecosystem benefits, adopting SLM practices and improving land management can also lead to increases in yields and farmer revenue. A study of a similar landscape conducted in Kenya (Vogl *et al.* 2017) identifies an increase of farmer revenues by about 0.9 percent for general agriculture and 0.4 percent for tea-lands. In a similar manner we can also expect private benefits of yield increase that accrue to farmers and the landowners in addition to the above-mentioned ecosystem service values.

Ecosystem valuation conclusion

This report builds on the previous sections; using the data, the increases (and decreases) in ecosystem services for agricultural lands that use more SLM practices (well-managed sites) is evaluated. Thereafter a general valuation is conducted using benefit transfer method to highlight the values of good agricultural lands. Ideally the process completed for this report would require multiple years of work that involves a detailed study of the landscape and an integrated modelling framework that links the physical-geo-hydrological-and social systems and much richer data sets and funding commitments. In this instance given the short time frame, a rapid assessment was conducted to assess the adoption of sustainable land management practices of four agricultural land use types, identify and map the associated ecosystem services, and utilise existing frameworks and databases to quantify the ecosystem service values.

The comparative study of well-managed lands and the poorly managed lands highlight the resulting ecosystem services that can be generated with good agricultural practices. A

[10] The TEV in Table 4.2 is calculated as NPV (net present value)

generalized valuation highlights that these ecosystem services have significant value for both society and for farmers and landowners. Therefore, identifying and implementing mechanisms to encourage farmers to adopt sustainable land management practices on their farmlands can generate both private and public values.

Overall conclusions and key findings

- **The main reason for not adopting sustainable land management practices is lack of awareness. However, this could also include lack of finances as the farmer is unaware of the cost of implementing the SLM practice.**
- **The 10 least used SLM practices include split application fertilizer, rainwater collection, waste management, soil rehabilitation, integrated weed management, and eco-certifications.**
- **Agricultural lands produce a disservice of water pollution due to current practices, and eco-certification could potentially address this issue.**
- **Lack of awareness is the main obstacle to the adoption of sustainable land management practices, but Paddy lands have a higher educational value and use of relevant SLM. Further understanding into the transfer of knowledge in paddy cultivation may aid in the adoption of SLM in other lands.**
- **Tea and paddy lands have a higher aesthetic value, home gardens have more biodiversity and there may be potential for agrotourism based financing mechanism.**
- **In order to conduct a full ecosystem service assessment, temporal and spatial variations must be taken into consideration.**
- **The total economic value (including ecosystem benefits) for one acre of cropland could be as high as Rs 79,000 per year and from one acre of well-managed home gardens as much as Rs 225,000 per year.**
- **Further assessments into farmer perceptions of ecosystem services/disservices of agricultural lands will aid the development of applicable innovative financing mechanisms.**

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Annex 1. List of sustainable land management practices

Number	SLM Practice	Category
SLM01	Terracing	Physical
SLM02	Stone Terracing	Physical
SLM03	Stone bunds	Physical
SLM04	Sunken beds	Physical
SLM05	SALT	Physical
SLM06	Lateral drains	Physical
SLM07	Contour drains	Physical
SLM08	Lock and spill drains	Physical
SLM09	Integrated nutrient and pest management	Physical
SLM10	Rain water collection	Physical
SLM11	Minor irrigation Tanks/ Pathaha	Physical
SLM12	Micro irrigation systems	Physical
SLM13	Silt traps	Physical
SLM14	Percolation pits	Physical
SLM17	Live Terracing present	Biological
SLM18	Mulching	Biological
SLM19	Green manure crops	Biological
SLM20	Cover crops	Biological
SLM21	Ground cover management	Biological
SLM22	High density planting/relay intercropping	Biological
SLM24	Management of crop cover	Biological
SLM25	Soil rehabilitation (planting grasses)	Biological
SLM26	Multi-purpose tree species	Biological
SLM27	Hedge row planting	Biological
SLM28	Grass strips	Biological
SLM29	Wind belts	Biological

Number	SLM Practice	Category
SLM33	Contour planting	Behavioural
SLM34	Individual platform method of planting	Behavioural
SLM35	Crop rotation	Behavioural
SLM36	Intercropping with perennials on rain fed agriculture	Behavioural
SLM37	Bee-keeping	Behavioural
SLM38	Crop diversification	Behavioural
SLM39	Underutilized crops	Behavioural
SLM40	Multi-layered high-density planting arrangement	Behavioural
SLM41	Split application Fertilizer	Behavioural
SLM42	Dolomite application	Behavioural
SLM43	Reduction in the use of agrochemicals	Behavioural
SLM44	Organic fertilizer	Behavioural
SLM45	Burying pruned branches	Behavioural
SLM46	Maintaining plucking table	Behavioural
SLM47	Pruning and training of trees	Behavioural
SLM48	Shade management	Behavioural
SLM49	Site specific crop selection	Behavioural
SLM50	Leaf colour index cards	Behavioural
SLM51	Infilling of tea plants	Behavioural
SLM52	Envelop Forking	Behavioural
SLM53	Integrated Weed management	Behavioural
SLM55	Waste management	Behavioural
SLM56	Bee-keeping	Behavioural
SLM57	Sanitising animal husbandry	Behavioural
SLM63	Lateral and leader drains	Behavioural
SLM64	Eco-certification	Behavioural

Annex 2. Questionnaire for SLM assessment

මධ්‍යම කඳුකරයේ නුවර, බදුල්ල හා නුවර එළිය දිස්ත්‍රික්කවල තිරසාර ඉඩම් කළමනාකරණ රටා පිළිබඳ ප්‍රශ්නාවලිය
(ඉඩමේ හිමිකරු හමුවී මෙම ප්‍රශ්නාවලියට පිළිතුරු ලබාගන්න.)
Questionnaire on Sustainable Land Management Patterns in Central Hills Kandy, Badulla and Nuwara Eliya Districts
(Meet the landlord and get answers to this questionnaire)

කෘෂි ඉඩම් පරිහරණය (Agricultural land use type):

- ප්‍රශ්න අසන්නාගේ නම (Name of the questioner):
  ....
- ප්‍රශ්න අසන්නාගේ දු.අංකය (Questioner's telephone number):..
- දිස්ත්‍රික් සම්බන්ධීකාරක (District Coordinator):...
- දිස්ත්‍රික්කය (District)
  :..
- කුඩා ජල පෝෂක ප්‍රදේශය (Small watershed area):
  ....
- ග්‍රාම සේවා වසමේ නම (Name of the Grama Niladhari Division):..
- GPS කණ්ඩාංක (GPS Coordinates):
  ....
- ඉඩමේ විශාලත්වය (Extent of the land) : ....
- ආනතිය (Angle): less than 20% ☐ 20-40% ☐ 40-60% ☐ > 80% ☐
- ඉඩම් කළමනාකරණ රටාවේ තත්වය පිළිබඳ ඔබේ අදහස H ☐ M ☐ L ☐

- (Your opinion on the status of land management pattern)

- වගාව හා ඒ පළිබඳ විස්තරයක් (උදා. තේ සමග ගම්මිරස්), ප්‍රධාන හා අතුරු භෝග වෙන්කර හඳුන්වන්න (Introduce cultivation and its description (e.g. Tea with Pepper), major and by-products.)

....

....

....

....

....

1.0 පිළිතුරු දෙන්නගේ නම හා සමාජ-ආර්ථිකම දත්ත (Name and socio-economic data of the respondent)

1.1 පිළිතුරු දෙන්නාගේ නම (Name of the respondent):

1.2 පිළිතුරු දෙන්නාගේ ලිපිනය (Address of the respondent):

1.3 පිළිතුරු දෙන්නාගේ ජීවනෝපාය (The livelihood of the respondent):

1.4 ගෘහ සාමාජකයින් සංඛ්‍යාව (Number of House Members☺:

1.5 ගෘහවාසීගෙන් ශ්‍රමය සපයන පුද්ගලයින් පිළබඳ සංඛ්‍යාමය විස්තරයක් (A statistical description of the persons who provide labor from the household)

(පූර්ණ කාලින නම් (If full time) 1, අර්ධ කාලීනව නම් (If part-time) 0.5)

ගෘහමූලික (Householder)	
වෙනත් (other)	
වෙනත් (other)	
වෙනත් (other)	
වෙනත් (other)	

1.6 සේවකයින් හෝ වෙනත් ශ්‍රමය සපයන පුද්ගලයින් පිළබඳ සංඛ්‍යාමය විස්තරයක් (A statistical description of employees or other labor providers) (පූර්ණ කාලින නම් (If full time) 1, අර්ධ කාලීනව නම් (If part time) 0.5)

....	
....	
....	
....	

1.7 ගෘහයේ දළ ආදායම (Household Gross Income):

....

....

....

1.8 ඉඩම්හිමිකම (Land ownership) [11]:

	Category	Present/Absent	*Thattumaru*[2]	*Kattimaru*[3]	*Ande*[4]
1.8.1	Private Lands පුද්ගලික ඉඩම්				
1.8.2	Jayaboomi, which are lands given as state grants under certain conditions ඉඩම් සංවර්ධන ආඥා පනත යටතේ කොන්දේසි සහිත ලබා දෙන ලද ජයභූමි ඉඩම් ඔප්පු				
1.8.3	State lands (with permit) රජයේ ඉඩම් (බලපත්‍ර සහිත)				
1.8.5	Temple land විහාරගම් හා දේවාලගම්				
1.8.6	State leaseholds such as lands under the Land Development Ordinance (LDO) ඉඩම් සංවර්ධන ආඥා පනත යටතේ ගොවි ජනතාවට සහනයක් ලෙස රජයේ ඉඩම් සංවර්ධන ආඥා පනත මගින් රජයේ ඉඩම් බෙදාදීමේ වැඩපිළිවෙල යටතේ දීමනාපත්‍ර				
1.8.7	Encroachment අනවසර ඉඩම් පරිහරනය				
1.8.8	Other වෙනත්				

[11] http://www.fao.org/gender-landrights-database/country-profiles/countries-list/land-tenure-and-related-institutions/prevailing-systems-of-land-tenure/en/?country_iso3=LKA

[2] *Thattumaru*: the co-owners of a piece of land take turns in cultivating it. තට්ටු මාරු - එක් ඉඩමක සම අයිතිකරුවන් මාරුවෙන් මාරුව වගා කිරීම

[3] *Kattimaru*: land is subdivided into plots which are cultivated in rotation by co-owners.
කට්ටි මාරු - එක් ඉඩමක් උප කොටස් ලෙස වෙන් කර, එක් එක් කොටසෙහි අයිතිකරුවන් මාරුවෙන් මාරුව වගා කිරීම

[4] 'බාැථ a land owner who is not able to cultivate by himself land under paddy gets another person to help him and pays him with a share of the crop.
අඳේ - කුඹුරු ඉඩම් හිමිකරු තම ඉඩමේ ඔහු විසින්ම වගා නොකර, තවත් පුද්ගලයකුගේ සහය ඇතිව වගාකොට අස්වැන්නෙන් කොටසක් ඔහුට ලබා දෙනු ඇත

තිරසාර ගොවිකුම ගැන ප්‍රශ්න විමසන විට කරුණාකර නිදර්ශන සහිත පොත භාවිතා කරන්න (When questioning about sustainable farming, please use the illustrated book)

තිරසාර කෘෂිකාර්මික ක්‍රමවේදයන් පිළිබඳ විමසන ප්‍රශ්න සඳහා පහත සඳහන් සූචකය භාවිතා කරන්න (Use the index below to ask questions about sustainable agricultural practices.).

1: අදාළ නැත (Not applicable),
2: ක්‍රමවේදය පිළිබඳ අදහසක් නැත (No idea of methodology),
3: ක්‍රමවේදය ක්‍රියාත්මක කිරීමට දන්නේ නැත (Do not know how to implement the methodology),
4: ක්‍රියාත්මක කිරීමට වියදම් දැරීමට නොහැකිය (Can't afford to execute),
5: නුදුරු අනාගතයේ ක්‍රියාත්මක කිරීමට තීරණය කර ඇත (It has been decided to implement it in the near future).

මෙම පිළිතුරු (1-5) පිළිතුරු දෙන පුද්ගලයින්ට නොකියන්න, ප්‍රශ්නාවලියට ලැබෙන පිළිතුරු අනුව මෙම කොටසට පිළිතුරු ඔබම සටහන් කරන්න (Do not tell the person who answers this question (1-5), write your own answer to this section according to the answers to the questionnaire.).

2.1	**ගොවිපල තුළ (In the Farm)**														
2.1.1	**භෞතික (Physical)**	ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (**Reasons not in use)**						**භෞතික (Physical)**	ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (**Reasons not in use)**				
			1	2	3	4	5				1	2	3	4	5
2.1.1.1	හෙල් මළු බැඳීම/Terracing							**2.1.1.10**	වැහි ජල එකතු කිරීම/Rain water collection						
2.1.1.2	ගල්වැටි හෙල් මළු පිළියෙල කිරීම /Stone Terracing							**2.1.1.11**	Minor irrigation Tanks/Pathaha සුළු වාරිමාර්ග වැව් / පතහ						
2.1.1.3	ගල් වැටි/Stone bunds							**2.1.1.12**	ක්ෂුද්‍ර ජල පද්ධති/Micro irrigation systems						
2.1.1.4	Sunken beds (බක්කි පාත්ති)							**2.1.1.13**	Silt traps නැන්පතු උගුල්						
2.1.1.5	SALT							**2.1.1.14**	Percolation pits පෙරීම් වල්						
2.1.1.6	පාර්ශ්වික කාණු/Lateral drains							**2.1.1.15**	Other 1 වෙනත් 1						
2.1.1.7	සමෝච්ඡ කාණු/Contour drains							**2.1.1.16**	Other 2 වෙනත් 2						
2.1.1.8	කුට්ටි කාණු ක්‍රමය /Lock and spill drains							**2.1.1.17**	Other 3 වෙනත් 3						
2.1.1.9	ඒකාබද්ධ පෝෂක හා පළිබෝධක පාළනය/Integrated nutrient and pest management							**2.1.1.18**	Other 4 වෙනත් 4						

2.1.2	ජීවවිද්‍යාත්මක (Biological)	ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (Reasons not in use)						ජීවවිද්‍යාත්මක (Biological)	ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (Reasons not in use)				
2.1.2.1	Live Terracing							2.1.2.11	Hedge row planting හරිත පේළි රෝපණය						
2.1.2.2	වැස්ම/Mulching							2.1.2.12	තෘණ වැටි/Grass strips						
2.1.2.3	Green manure crops කොළ පොහොර බෝග							2.1.2.13	සුළං බාධක/Wind belts						
2.1.2.4	Cover crops ආවරණ බෝග							2.1.2.15	Other 2 වෙනත් 2						
2.1.2.5	බිම් වැස්ම කළමණාකරණය /Ground cover management							2.1.2.16	Other 3 වෙනත් 3						
2.1.2.6	ඉහල ඝනත්ව රෝපණ/ අතුරු වගාව High density planting/relay intercropping							2.1.2.17	Other 4 වෙනත් 4						
2.1.2.7	සෙවණ කලමනාකරණය/Shade management							2.1.2.18	Other 5 වෙනත් 5						
2.1.2.8	Management of crop cover බෝග ආවරණ කළමනාකරණය							2.1.2.19	Other 6 වෙනත් 6						
2.1.2.9	Soil rehabilitation (planting grasses) පාංශු පුනරුත්ථාපන (තෘණ රෝපණය)							2.1.2.20	Other 7 වෙනත් 7						
2.1.2.10	Multi-purpose tree species බහු කාර්යය ශාක විශේෂ														
2.1.3	**චර්යාත්මක (Behavioral)**	ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (**Reasons not in use**)						**චර්යාත්මක (Behavioral)**	ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (**Reasons not in use**)				
2.1.3.1	සමෝච්ඡ ක්‍රමයට වගාව/Contour planting							2.1.3.18	භූමියට සුදුසු වගාවන් තේරීම/Site specific crop selection						
2.1.3.2	Individual platform method of planting පැල සිටවීමේ තනි වේදිකා ක්‍රමය							2.1.3.19	Leaf colour index cards පත්‍ර වර්ණ සූචිය						
2.1.3.3	භෝග මාරුව (උදා. මඤ්ඤොක්කා හා කෙසෙල්)/Crop rotation (eg. cassava/banana and rice)							2.1.3.20	Infilling in seedling tea තේ බීජ පිරවීම						
2.1.3.4	Intercropping with perennials on rain fed agriculture වැසි සම්ප්‍රේෂණ කෘෂි වගාව							2.1.3.21	Envelop Forking						

	බහුවාර්ෂික අතුරුබෝග මගින්														
2.1.3.5	Intercropping and diversification with export crops/and fruits අතුරුබෝග සහ විවිධාන්ගීකර්ණය කිරීම අපනයන බෝග / පලතුරු සමග							**2.1.3.23**	Soil amelioration පාංශු වාතාශ්‍රය						
2.1.3.6	භෝග විවිධාංගිකරණය/ Crop diversification							**2.1.3.24**	ඒකාබද්ධ වල් මර්ධනය/Integrated Weed management						
2.1.3.7	Underutilized crops ඌන උපයෝගිතා බෝග							**2.1.3.25**	පාරිසරික සහතිකකරණය/Eco-certification						
2.1.3.8	Multi-layered high-density planting arrangement බහු ස්තර අධික ඝනත්ව සැලැස්ම							**2.1.3.26**	කසල කලමනාකරණය/ Waste management						
2.1.3.9	කොටස් වශයෙන් පොහොර යෙදීම/Split application Fertilizer							**2.1.3.27**							
2.1.3.10	ඩොලමයිට් එකතු කිරීම/Dolomite application							**2.1.3.28**	මී මැසි පාලණය/Bee-keeping						
2.1.3.11	පුළුල් වශයෙන් කෘෂි රසායන භාවිතය අඩු කිරීම/Reduction in the use of agrochemicals							**2.1.3.29**	සනීපාරක්ශිත සත්ත්ව පාළනය/Sanitising animal husbandry						
2.1.3.12	කාබනික (කොම්පෝස්ට්) පොහොර භාවිතය Organic fertilizer							**2.1.3.30**	Other 2 වෙනත් 2						
2.1.3.13	Good Agricultural Practices (GAP) යහපත් කෘෂිකාර්මික පිළිවෙත්							**2.1.3.31**	Other 3 වෙනත් 3						
2.1.3.14	කප්පාදු කළ අතු වළදැමීම/Burying pruned branches							**2.1.3.32**	Other 4 වෙනත් 4						
2.1.3.15	කප්පාදු කිරීම එකම මට්ටමට කිරීම /Maintaining plucking table							**2.1.3.33**	Other 5 වෙනත් 5						
2.1.3.16	Pruning and training of trees ගස් කප්පාදුව සහ පුහුණුව							**2.1.3.34**	Other 6 වෙනත් 6						
2.1.3.17	සෙවණ කලමනාකරණය/Shade management														

2.2	**ගොවිපලට පිටතින් (outside the farm)**	ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (**Reasons not in use)**							ඔව්/ නැත (Yes/No)	භාවිතයේ නැත්නම් හේතු (**Reasons not in use)**				
2.2.1	පාර්ශ්වික කාණු සම්බන්ධකොට ඇති ප්‍රධාන ජල වහන පද්ධති/Lateral and leader drains							**2.2.4**	Other 2 වෙනත් 2						
2.2.2	පාරිසරික සහතිකකරණය/Eco-certification							**2.2.5**	Other 3 වෙනත් 3						
2.2.3	Other 1 වෙනත් 1							**2.2.6**	Other 3 වෙනත් 3						

2.3 Have you observed filling up of paddy lands? If so, describe the extent?

කුඹුරු ගොඩකිරීම් ඔබ නිරීක්ෂණය කර තිබේද? එසේනම් විස්තර කරන්න

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3.0 ජල පහසුකම් වළට සම්බන්ධව (connected to water facilities)

3.1 වැසි ජලය හැර වනත් ප්‍රභව පිළිබඳ විස්තර සඳහා පහත වගුව භාවිතා කරන්න (Use the table below for details on sources other than rainwater)

	කෘෂිකර්මාන්තය සඳහා භාවිතා කරන ජල ප්‍රභවය (Source of water used for agriculture)	**දුර**	**Seasonal (if seasonal specify season)/Perennial** සෘතුව (සෘතුමය නම් කන්නයේ නම්) / බහු වාර්ෂික		**කෘෂිකර්මාන්තය සඳහා භාවිතා කරන ජල ප්‍රභවය (Source of water used for agriculture)**	**දුර**	**Seasonal (if seasonal specify season)/Perennial** සෘතුව (සෘතුමය නම් කන්නයේ නම්) / බහු වාර්ෂික
3.1.1	වැවකින් පොම්ප කිරීම/Directly from tank (pumped)			3.1.5	Other 1 වෙනත් 1		
3.1.2	දියපාරකින් ලබාගැනීම/Directly from stream			3.1.6	Other 2 වෙනත් 2		
3.1.3	ළිඳකින්/Well			3.1.7	Other 3 වෙනත් 3		
3.1.4	ජල සැපයුම් පද්ධති /Irrigation Canal			3.1.8	Other 4 වෙනත් 4		

3.2 ප්‍රධාන ජල සැපයුම වැසි ජලයෙන් නම්, ඒ පළිබඳ විස්තර කිරීමට, පහතින් එකක් තෝරන්න (If the main water supply is rainwater, select one below to describe it)

3.2.1	වර්ෂා ජලයෙන් එක් කන්නයක් (One season from rain water		**3.2.3**	එක්-කන්නයක් වාරි ජලයෙන් (one-season from irrigation water	

3.2.2	වර්ෂා ජලයෙන් කන්න දෙකක් (Two seasons from rain water		**3.2.4**	කන්න-දෙකක් වාරි ජලයෙන් (two-seasons from irrigation water	
			3.2.5	කන්න-තුනක් වාරි ජලයෙන් (three-seasons from irrigation water	

3.3 ළඟම ගංගා හෝ වෙනත් ජලවහන පද්ධති හෝ වෙනත් තෙත්බිම් වළට ඇති බලපෑම් (**Impacts on nearby rivers or other drainage systems or other wetlands)**

3.3.1 දැනට ඉඩමේ සිදුවන ක්‍රියාකාරකම් වළින් ඉඩමේ සිට ඊට පහළින් සෝදාපාළුව හෝ වෙනත් අනිසි පාරිසරික ප්‍රතිඵල සිදුවිය හැකිද? (Can erosion or other adverse environmental effects from existing activities occur below the land level?)

ඔව් (Yes) ☐ නැත (No) ☐

3.3.2 මෙම ඉඩමේ සිට ඊට පහතින් පිහිටි ළඟම ජලවහන පද්ධතිය හෝ වෙනත් තෙත්බිමකට ඇති දුර (Distance from this land to the nearest drainage system or other wetland below it)........................

3.3.3 ඉහළ සඳහන් ජලවහන පද්ධතිය හෝ වෙනත් තෙත්බිම හා මෙම ඉඩම අතර පහත සඳහන් කර ඇති ඉඩම් පරිභෝජන රටා කාණ්ඩ වලින් කුමන කාණ්ඩයද දැකිය හැක්කේ? (Which of the following land use patterns can be seen between the above drainage system or other wetland and this land?)

	Land use type ඉඩම් පරිහරණ වර්ගය	**Yes/No** ඔව්/නැත
3.3.3.1	ලඳු කැලෑ/Scrub	
3.3.3.2	මුඩු ඉඩම්/Bare land	
3.3.3.3	තිරසාර ලෙස කෙරෙන කෘෂිකාර්මික ඉඩම්/SLM Agricultural land	
3.3.3.4	ද්විතීක වනාන්තර/Secondary forest	
3.3.3.5	වෙනත්/Other	
3.3.3.6	වෙනත්/Other	

4.0 සටහන් (Notes)

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Annex 3. ES assessment data entry sheet

Data Sheet for Recording Ecosystem Services at Farm Lands

(Kandy, Badulla and Nuwara Eliya district)

Agricultural Land use type			**Sheet No**
District			
Name of the Small catchment			
Land Size (ha)			
GN			
GPS coordinate	**NL**	**EL**	
ES provider	**Individual Farmer/ Farmer Society/ Company**		
Name, Age, Gender			
Address			

Ecosystem Service		ES Observed?		Quantity (H/M/L or % or kg per ha or kg per month)	Period of ESs available (Day, week, month, seasonal, year)	ES Beneficiary	Scale of ES (Local, downstream, national, global)	Importance of the ES[1]	Comment No. (C1, C2 etc.)
		Yes/No	If No, why? (NA or identify disservices if any)						
Regulating	Soil retention								
	Water purification/quality								
	Water flow regulation								
	Pollination/ seed dispersal								
	Pest/weed control								
	Carbon sequestration								
	Habitat provision								
	Invasive species resistance/ prevention								
	Natural Hazard protection								
Provisioning	**Food**: *(list crops below while at field)*								

Ecosystem Service		ES Observed?		**Quantity** (H/M/L or % or kg per ha or kg per month)	**Period of ESs available** (Day, week, month, seasonal, year)	**ES Beneficiary**	**Scale of ES** (Local, downstream, national, global)	**Importance of the ES**[2]	**Comment number** (C1, C2 etc.)
		Yes/No	**If No, why? (NA or identify disservices if any)**						
Provisioning									
	Medicinal								
	Timber								
	Fuelwood								
	Fibre								
	Fodder								

Provisioning	**Fresh Water:**								
	Storage (pond/tank/well)								
	Supply for irrigation								
	Supply for drinking water and HH use								
	Consumption by domestic animals								
	Supply for commercial purposes								
Cultural	Aesthetics (landscape beauty, photography potential, natural features)								
	Educational (school field visit, technical trainings etc being conducted)								
	Cultural/heritage (historical or cultural link exists - Ruins/folklore)								
	Recreational (foreign and local tourist visits)								
	Religious/Spiritual significance (occurrence of festivals, blessings/ offerings)								

Annex 4. Chosen sites for ES assessment

ID	Name of Enumerator	District	Name of Watershed/ micro-watershed	Name of GN division	Slope	Sustainability of Land management	Land Use Type
SLMKDE9	GGSW Kumarathunga	Kandy	Naranhinna Micro catchment	Gonangoda	1	3	H
SLMKDE8	GGSW Kumarathunga	Kandy	Naranhinna Micro catchment	Gonangoda	1	3	H
SLMKDE26	GGSW Kumarathunga	Kandy	Naranhinna Micro catchment	Gonangoda	2	2	T
SLMKDE1	GGSW Kumarathunga	Kandy	Naranhinna Micro catchment	Gonangoda	2	2	T
SLMKDO26	GGSW Kumarathunga	Kandy	Pambadeniya Micro catchment	Pambadeniya	3	2	T
SLMKDE3	GGSW Kumarathunga	Kandy	Naranhinna Micro catchment	Gonangoda	3	2	T
SLMKDO3	TAH Dharmasiri	Kandy	Maligamalaya catchment	Pambadeniya	1	2	H
SLMKDO4	TAH Dharmasiri	Kandy	Maligamalaya micro catchment	Pambadeniya	1	2	H
SLMKDO15	TAH Dharmasiri	Kandy	Maligamalaya micro catchment	Pambadeniya	3	1	H
SLMKDO10	TAH Dharmasiri	Kandy	Maligamalaya micro catchment	Pambadeniya	3	2	T
SLMKDO20	TAH Dharmasiri	Kandy	Maligamalaya micro catchment	Pambadeniya	1	1	T
SLMKDE18	WBPK Karunarathne	Kandy	Naranhinna Micro catchment	Gonangoda	3	3	H
SLMKDE17	WBPK Karunarathne	Kandy	Naranhinna Micro catchment	Gonangoda	2	3	T

ID	Name of Enumerator	District	Name of Watershed/ micro-watershed	Name of GN division	Slope	Sustainability of Land management	Land Use Type
SLMKDE21	WBPK Karunarathne	Kandy	Naranhinna Micro catchment	Gonangoda	2	3	H
SLMNAK12	R.A.M.S. Ranasinghe	Nuwaraeliya	Raththiya Ulpatha	Alla Kumbura	3	3	T
SLMNAK26	R.A.M.S. Ranasinghe	Nuwaraeliya	Raththiya Ulpatha	Alla Kumbura	2	2	V
SLMNKU8	PR Dishakumbura	Nuwaraeliya	Kurawaththa	Konthodiya 534F	3	2	V
SLMNKU2	PR Dishakumbura	Nuwaraeliya	Kurawaththa	Konthodiya 534F	3	2	V
SLMNAK16	R.A.M.S. Ranasinghe	Nuwaraeliya	Raththiya Ulpatha	Alla Kumbura	1	1	T
SLMNAK22	R.A.M.S. Ranasinghe	Nuwaraeliya	Raththiya Ulpatha	Alla Kumbura	1	2	V
SLMNKU9	PR Dishakumbura	Nuwaraeliya	Kurawaththa	Konthodiya 534F	1	1	V
SLMBPE20	SMB Mullegama	Badulla	Galabidichcha Dowa	Perawella	3	2	H
SLMBMW01	S.M. Nandana Rathnasiri	Badulla	Sapugolla	Maligawaththa	3	3	H
SLMBPE28	SMB Mullegama	Badulla	Galabidichcha Dowa	Perawella	1	3	P
SLMBPE29	SMB Mullegama	Badulla	Galabidichcha Dowa	Perawella	1	0	P

ID	Name of Enumerator	District	Name of Watershed/ micro-watershed	Name of GN division	Slope	Sustainability of Land management	Land Use Type
SLMBWA30	KA Mangalika	Badulla	Sapugas ulpotha micro catchment	67F Watagamuwa	1	1	P
SLMBWA22	KA Mangalika	Badulla	Sapugas ulpotha micro catchment	67F Watagamuwa	1	1	P
SLMBMW27	S.M. Nandana Rathnasiri	Badulla	Sapugolla	Maligawaththa	3	2	P
SLMBMW36	S.M. Nandana Rathnasiri	Badulla	Sapugolla	Maligawaththa	3	3	P
SLMBMW30	S.M. Nandana Rathnasiri	Badulla	Sapugolla	Maligawaththa	3	3	P
SLMBMW33	S.M. Nandana Rathnasiri	Badulla	Sapugolla	Maligawaththa	3	3	P
SLMBPE9	SMB Mullegama	Badulla	Galabidichcha Dowa	Perawella	2	3	T
SLMBMW25	S.M. Nandana Rathnasiri	Badulla	Sapugolla	Maligawaththa	2	2	V
SLMBMW17	S.M. Nandana Rathnasiri	Badulla	Sapugolla	Maligawaththa	2	2	V
SLMBPE38	SMB Mullegama	Badulla	Galabidichcha Dowa	Perawella	2	3	V
SLMBWA10	KA Mangalika	Badulla	Sapugas ulpotha micro catchment	67F Watagamuwa	3	1	V
SLMBWA2	KA Mangalika	Badulla	Sapugas ulpotha micro catchment	67F Watagamuwa	3	2	V

ID	Name of Enumerator	District	Name of Watershed/ micro-watershed	Name of GN division	Slope	Sustainability of Land management	Land Use Type
SLMBWA12	KA Mangalika	Badulla	Sapugas ulpotha	Watagamuwa	2	1	H
SLMBPE35	SMB Mullegama	Badulla	Galabidichcha Dowa	Perawella	2	3	V

Annex 5. Biodiversity assessment methodology details and data

Table 1. Summary of sampling techniques for fauna

Group/ taxa	Method	Technique
Amphibians	Direct	Visual encounter survey within the ecosystem.
Reptiles	Direct	Visual encounter survey within the ecosystem. communication with farmers
Birds	Direct and indirect	Visual encounter survey within the ecosystem. (visual and auditory observations)
Mammals	Direct and indirect	Visual encounter survey within the ecosystem. (including presence indicated by tracks, faecal matter, feeding signs, carnivore scat analysis and calls); communication with farmers
Butterflies and dragonflies	Direct	Visual encounter survey within the ecosystem. communication with farmers

Table 2. Sources used for the identification and classification of flora

Subject	Source
Taxonomic identification	Ashton *et al.* (1997); Dassanayake and Fosberg (1980 - 1991); Dassanayake *et al.* (1994 - 1995); Dassanayake and Clayton (1996 - 1999); de Vlas & Jong (2008)
Invasive species	BDS, MMD&E, (2016)
Ecosystem and Species Nomenclature and Conservation status	MoMD&E (2016); MOE (2012); Global Red List (2019) (https://www.iucnredlist.org/)

Table 3. Sources used for the identification and classification of fauna

Purpose	Group	Source
Taxonomic identification	Dragonflies	Bedjanic *et al*. (2007)
	Butterflies	van de Poorten and van der Poorten, (2018)
	Amphibians	Manamendra-arachchi & Pethiyagoda (2006)
	Reptiles	Somaweera (2006); Somaweera & Somaweera (2009)
	Birds	Grimmett *et al.* (2016)
	Mammals	Kotagama & Goonatilake (2017)

Quantification of Observations

Fauna

Species richness, endemicity, and the number of threatened species, pollinators, pests, and pest controllers were calculated for each agricultural land use type and individual counts with percentage values were given respect to each faunal or floral sections (lowland or highland). Scoring system was made to identify the higher to lower values (low, mid, high) for above each groups as well as identify each group (1 to 5) for ecosystem services. The classified scoring which used for faunal groups is given in table 4.

Table 4. Scoring used for diversity assessment

SPECIES RICHNESS	LOWLAND													
% Value	11	13	17	20	21	22	23	24	27	28	30	36		
Qualitative value	LOW				LOW				HIGH					
Value for ES	1	2			3			4			5			
SPECIES RICHNESS	**HIGHLAND**													
% Value	10	12	15	17	20	21	23	25	26	27	28	32	33	38
Qualitative value	LOW					MID						HIGH		
Value for ES	1			2			3			4			5	
ENDEMIC SPECIES	**LOWLAND**													
% Value	14	21	29	36										
Qualitative value	LOW	MID		HIGH										
Value for ES	2	3	4	5										
ENDEMIC SPECIES	**HIGHLAND**													
% Value	0	8	17	25	33	42	50							
Qualitative value	LOW			MID		HIGH								
Value for ES	1		2		3	4	5							
THREATENED SPECIES	**LOWLAND**													

% Value	0	25	50											
Qualitative value	LOW	MID	HIGH											
Value for ES	1	3	5											
THREATENED SPECIES	**HIGHLAND**													
% Value	0	8	17	25	33	42	50							
Qualitative value	LOW		MID			HIGH								
Value for ES	1		2		3	4	5							
POLINATOR	**LOWLAND**													
% Value	6	9	12	15	18	18	21	26	32	35	47			
Qualitative value	LOW				MID			HIGH						
Value for ES	1		2		3		4		5					
POLINATOR	**HIGHLAND**													
% Value	0	7	14	21	29	43								
Qualitative value	LOW		MID		HIGH									
Value for ES	1	2	3	4		5								
PESTS	**LOWLAND**													
% Value	17	25	29	33	38	42	50							
Qualitative value	LOW		MID		HIGH									
Value for ES	5	4	3		2		1							
PESTS	**HIGHLAND**													
% Value	10	14	24	31	34	38	41	45	66					
Qualitative value	LOW		MID				HIGH							
Value for ES	5		4		3		2		1					

PEST CONTROLLERS	**LOWLAND**													
% Value	8	14	17	19	22	31	33	42						
Qualitative value	LOW				MID			HIGH						
Value for ES	1	2		3		4		5						
PEST CONTROLLERS	**HIGHLAND**													
% Value	10	13	15	18	21	23	26	28	31	33	38			
Qualitative value	LOW				MID				HIGH					
Value for ES	1	2		3			4			5				

Flora

All agricultural land use types were separated in to two main clusters by a cluster analysis (using Minitab 17 Statistical Software) based on the frequency of flora species presence in each agricultural land use types. All the land use types in Doluwa, Deltota, Walapane and Kurawatta were clustered together (Cluster1) while all the land use types in Bindunuwewa, Etampitiya and Uva Paranagama separated in to other cluster (Cluster 2). Species richness of total flora, native, endemic, threatened (Nationally and globally), medicinal, timber, crop, plants used in spiritual purposes and invasive alien species (IAS) were calculated for each agricultural land use type separately, and their percentages were calculated with respect to the total plant richness in the relevant cluster. Scoring system was made to identify the higher to lower values (low, mid, high) for each of the above groups, as well as identify each group (1 to 5) for ecosystem services. The classified scoring which used for faunal groups is given in Table 5.

Table 5. Scoring for cluster 01- flora diversity assessment

Species richness	Cluster 01																			
Total Species %	2.1	12.0		12.8	15.3			16.5	17.8	18.2	18.6		#	19.4		21.9	26.0		27.3	28.5
Qualitative value	L	M														H				
Value for ES	1	2		3						4										
Native species %	0.4	1.7	2.1	2.5		2.9		3.7	4.1	4.5	5.0			5.4		5.8			7.0	
Qualitative value	L					M					H									
Value for ES	1		2					3		4	4					5				
Endemic species %	0						0.4						0.8					1.2		3.3
Qualitative value	L																	M		H
Value for ES	1												2					2		5
Nationally threatened %	0						0.4							0.8				1.2	1.7	2.1
Qualitative value	L													M					H	
Value for ES	1						2							3				4	4	5
Gobally threatened %	0																		0.4	
Qualitative value	L																		H	
Value for ES	1																		5	
Medicinal %	0.4	2.1	2.5			3.3		3.7	4.1			4.5			5.0			6.2	6.6	7.0
Qualitative value	L					M									H					
Value for ES	1	2				3						4			4			5		1
Timber %	0		0.8		1.2	1.7			2.1		2.5	2.9		3.3		3.7		4.1	5.0	6.2
Qualitative value	L								M										H	
Value for ES	1				2				2		3					4			4	5
Crop %	0.0	1.7	4.1		5.4	5.8	6.6			7.4	7.9	8.3		9.5	9.9	10.3	13.6		16.9	19.4
Qualitative value	L						M										H			
Value for ES	1		2				2				3						4		5	
Spiritual %	0			0.4	0.8		1.2									1.7				
Qualitative value	L				M											H				
Value for ES	1			2	3		4									4				5
IAS %	0.0	0.4		0.8		1.2			1.7		2.1						2.5			2.9
Qualitative value	L					M					H									
Value for ES	5			4		3					2						1			

Table 6. Scoring for cluster 02- flora diversity assessment

<table>
<tr><th>Species richness</th><th colspan="18">Cluster 02</th></tr>
<tr><td>Total Species %</td><td>10.8</td><td>11.4</td><td>12.0</td><td colspan="2">12.7</td><td>13.3</td><td>13.9</td><td>15.2</td><td colspan="2">17.1</td><td>17.7</td><td>18.4</td><td>19.6</td><td>20.9</td><td>24.1</td><td>24.7</td><td>27.8</td><td>39.2</td></tr>
<tr><td>Qualitative value</td><td colspan="13">L</td><td colspan="4">M</td><td>H</td></tr>
<tr><td>Value for ES</td><td colspan="8">1</td><td colspan="5">2</td><td>2</td><td colspan="3">3</td><td>5</td></tr>
<tr><td>Native species %</td><td>2.5</td><td colspan="2">3.2</td><td colspan="2">3.8</td><td colspan="3">4.4</td><td colspan="4">5.7</td><td colspan="3">7.0</td><td colspan="2">7.6</td><td>9.5</td></tr>
<tr><td>Qualitative value</td><td colspan="8">L</td><td colspan="7">M</td><td colspan="3">H</td></tr>
<tr><td>Value for ES</td><td colspan="5">1</td><td colspan="3">2</td><td colspan="4">3</td><td colspan="3">4</td><td colspan="2">4</td><td>5</td></tr>
<tr><td>Endemic species %</td><td colspan="15">0</td><td colspan="3">0.6</td></tr>
<tr><td>Qualitative value</td><td colspan="15">L</td><td colspan="3">H</td></tr>
<tr><td>Value for ES</td><td colspan="15">1</td><td colspan="3">5</td></tr>
<tr><td>Nationally threatened %</td><td colspan="14">0</td><td colspan="4">0.6</td></tr>
<tr><td>Qualitative value</td><td colspan="14">L</td><td colspan="4">H</td></tr>
<tr><td>Value for ES</td><td colspan="14">1</td><td colspan="4">5</td></tr>
<tr><td>Gobally threatened %</td><td colspan="18">0</td></tr>
<tr><td>Qualitative value</td><td colspan="18">L</td></tr>
<tr><td>Value for ES</td><td colspan="18">1</td></tr>
<tr><td>Medicinal %</td><td>2.5</td><td colspan="3">3.2</td><td colspan="5">3.8</td><td colspan="2">4.4</td><td colspan="3">5.1</td><td colspan="2">5.7</td><td>7.6</td><td>10.1</td></tr>
<tr><td>Qualitative value</td><td colspan="11">L</td><td colspan="6">M</td><td>H</td></tr>
<tr><td>Value for ES</td><td colspan="9">1</td><td colspan="2">2</td><td colspan="3">2</td><td colspan="2">3</td><td>4</td><td>5</td></tr>
<tr><td>Timber %</td><td colspan="7">0</td><td colspan="5">0.6</td><td colspan="2">1.3</td><td colspan="2">1.9</td><td>3.2</td><td>4.4</td></tr>
<tr><td>Qualitative value</td><td colspan="14">L</td><td colspan="2">M</td><td colspan="2">H</td></tr>
<tr><td>Value for ES</td><td colspan="12">1</td><td colspan="2">2</td><td colspan="2">3</td><td>4</td><td>5</td></tr>
<tr><td>Crop %</td><td colspan="2">1.9</td><td colspan="2">2.5</td><td colspan="2">3.2</td><td>3.8</td><td>4.4</td><td colspan="2">5.1</td><td>7.0</td><td>7.6</td><td colspan="2">8.2</td><td>12.0</td><td>12.7</td><td>13.3</td><td>23.4</td></tr>
<tr><td>Qualitative value</td><td colspan="14">L</td><td colspan="3">M</td><td>H</td></tr>
<tr><td>Value for ES</td><td colspan="10">1</td><td colspan="4">2</td><td colspan="3">3</td><td>5</td></tr>
<tr><td>Spiritual %</td><td colspan="5">0</td><td colspan="8">0.6</td><td colspan="3">1.3</td><td>1.9</td><td>2.5</td></tr>
<tr><td>Qualitative value</td><td colspan="13">L</td><td colspan="3">M</td><td colspan="2">H</td></tr>
<tr><td>Value for ES</td><td colspan="5">1</td><td colspan="8">2</td><td>3</td><td></td><td></td><td>4</td><td>5</td></tr>
<tr><td>IAS %</td><td>0.6</td><td colspan="5">1.3</td><td colspan="9">1.9</td><td colspan="3">2.5</td></tr>
<tr><td>Qualitative value</td><td>L</td><td colspan="14">M</td><td colspan="3">H</td></tr>
<tr><td>Value for ES</td><td>5</td><td colspan="5">4</td><td colspan="9">2</td><td colspan="3">1</td></tr>
</table>

Annex 6. Observed ecosystem services data

Number and percentage of sites of each agricultural land type that have observed ES:

Ecosystem service		ES observed							
		HG		P		T		V	
		Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites
Regulating	Soil retention	6	60	8	100	9	90	10	100
	Water purification/quality	2	20	0	0	0	0	0	0
	Water flow regulation	2	20	8	100	9	90	10	100
	Pollination/ seed dispersal	10	100	7	88	6	60	10	100
	Pest/weed control	9	90	8	100	9	90	10	100
	Carbon sequestration	10	100	7	88	6	60	3	30
	Habitat provision	10	100	7	88	10	100	10	100
	Invasive species resistance/ prevention	4	40	8	100	6	60	8	80
	Natural Hazard protection	3	30	0	0	1	10	1	10
Provisioning	Medicinal	10	100	8	100	10	100	10	100
	Timber	7	70	2	25	9	90	6	60
	Fuelwood	7	70	0	0	8	80	1	10

	Ecosystem service	ES observed							
		HG		P		T		V	
		Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites
	Fibre	1	10	0	0	0	0	0	0
	Fodder	0	0	0	0	0	0	0	0
	Fresh water Storage (pond/tank/well)	4	40	2	25	1	10	7	70
	Fresh water Supply for irrigation	3	30	4	50	2	20	7	70
	Fresh water Supply for drinking water and HH use	2	20	0	0	1	10	2	20
	Fresh water consumption by domestic animals	1	10	0	0	0	0	0	0
	Fresh water supply for commercial purposes	0	0	0	0	0	0	0	0
Cultural	Aesthetics	5	50	7	88	7	70	8	80
	Educational	5	50	6	75	3	30	6	60
	Cultural/heritage	0	0	0	0	0	0	0	0
	Recreational	1	10	0	0	0	0	0	0
	Religious/Spiritual significance	7	70	7	88	6	60	8	80

Number and percentage of sites of each agricultural land type where ES is not observed:

Ecosystem service		ES NOT observed							
		HG		P		T		V	
		Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites
Regulating	Soil retention	3	30	0	0	1	10	0	0
	Water purification/quality	5	50	8	100	10	100	10	100
	Water flow regulation	6	60	0	0	1	10	0	0
	Pollination/ seed dispersal	0	0	1	13	4	40	0	0
	Pest/weed control	1	10	0	0	1	10	0	0
	Carbon sequestration	0	0	1	13	4	40	7	70
	Habitat provision	0	0	1	13	0	0	0	0
	Invasive species resistance/ prevention	4	40	0	0	1	10	1	10
	Natural Hazard protection	4	40	7	88	7	70	5	50
Provisioning	Medicinal	0	0	0	0	0	0	0	0
	Timber	3	30	6	75	1	10	4	40
	Fuelwood	2	20	6	75	2	20	8	80
	Fibre	8	80	8	100	10	100	10	100

	Ecosystem service	ES NOT observed							
		HG		P		T		V	
		Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites
	Fodder	9	90	8	100	10	100	10	100
	Fresh water Storage (pond/tank/well)	6	60	6	75	9	90	3	30
	Fresh water Supply for irrigation	2	20	0	0	0	0	2	20
	Fresh water Supply for drinking water and HH use	3	30	2	25	0	0	6	60
	Fresh water consumption by domestic animals	1	10	2	25	1	10	7	70
	Fresh water supply for commercial purposes	3	30	2	25	1	10	7	70
Cultural	Aesthetics	5	50	0	0	3	30	2	20
	Educational	5	50	1	13	7	70	4	40
	Cultural/heritage	10	100	8	100	10	100	10	100
	Recreational	9	90	8	100	10	100	10	100
	Religious/Spiritual significance	2	20	0	0	4	40	2	20

Number and percentage of sites of each agricultural land type where ES is not applicable:

Ecosystem service		ES Not applicable							
		HG		P		T		V	
		Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites
Regulating	Soil retention	1	10	0	0	0	0	0	0
	Water purification/quality	3	30	0	0	0	0	0	0
	Water flow regulation	2	20	0	0	0	0	0	0
	Pollination/ seed dispersal	0	0	0	0	0	0	0	0
	Pest/weed control	0	0	0	0	0	0	0	0
	Carbon sequestration	0	0	0	0	0	0	0	0
	Habitat provision	0	0	0	0	0	0	0	0
	Invasive species resistance/ prevention	0	0	0	0	0	0	0	0
	Natural Hazard protection	3	30	1	13	2	20	3	30
Provisioning	Medicinal	0	0	0	0	0	0	0	0
	Timber	0	0	0	0	0	0	0	0
	Fuelwood	0	0	2	25	0	0	1	10
	Fibre	0	0	0	0	0	0	0	0

	Ecosystem service	ES Not applicable							
		HG		P		T		V	
		Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites	Number of sites	% of sites
	Fodder	0	0	0	0	0	0	0	0
	Fresh water Storage (pond/tank/well)	0	0	0	0	0	0	0	0
	Fresh water Supply for irrigation	5	50	4	50	8	80	1	10
	Fresh water Supply for drinking water and HH use	5	50	6	75	9	90	2	20
	Fresh water consumption by domestic animals	8	80	6	75	9	90	3	30
	Fresh water supply for commercial purposes	7	70	6	75	9	90	3	30
Cultural	Aesthetics	0	0	0	0	0	0	0	0
	Educational	0	0	0	0	0	0	0	0
	Cultural/heritage	0	0	0	0	0	0	0	0
	Recreational	0	0	0	0	0	0	0	0
	Religious/Spiritual significance	0	0	0	0	0	0	0	0

Number of sites of each agricultural land type where data is missing:

Ecosystem service		Missing data			
		HG Number of sites	P Number of sites	T Number of sites	V Number of sites
Regulating	Soil retention				
	Water purification/quality				
	Water flow regulation				
	Pollination/ seed dispersal				
	Pest/weed control				
	Carbon sequestration				
	Habitat provision				
	Invasive species resistance/ prevention	2		3	1
	Natural Hazard protection				1
Provisioning	Medicinal				
	Timber				
	Fuelwood	1			
	Fibre	1			
	Fodder	1			
	Fresh water Storage (pond/tank/well)				
	Fresh water Supply for irrigation				
	Fresh water Supply for drinking water and HH use				
	Fresh water consumption by domestic animals				
	Fresh water supply for commercial purposes				

	Ecosystem service	Missing data			
		HG Number of sites	P Number of sites	T Number of sites	V Number of sites
Cultural	Aesthetics		1		
	Educational		1		
	Cultural/heritage				
	Recreational				
	Religious/Spiritual significance	1	1		

Annex 7. Comparison of ecosystem services in well-managed and poorly-managed lands

Table 1. Comparison of ES by Land Type and Quality of SLM Practices (Each cell represents the average values for multiple sites identified as good/poor)

Ecosystem Service	Homegarden-Poor	Homegarden-Good	Paddy-Poor	Paddy-Good	Tea-Poor	Tea-Good	Vegetable-Poor	Vegetable-Good	All-Poor	All-Good
Soil retention-Observed Y/N	0.60	0.75	1.00	1.00	0.80	1.00	1.00	1.00	0.85	0.94
Soil retention-Quantity (H/M/L)	0.80	1.00	2.33	2.75	1.40	2.00	2.00	1.40	1.63	1.79
Water purification/quality-Observed Y/N	0.20	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.13
Water flow regulation-Observed Y/N	0.00	0.67	1.00	1.00	0.80	1.00	1.00	1.00	0.70	0.92
Water flow regulation-Quantity (H/M/L)	0.00	0.67	2.33	2.75	1.20	2.00	1.75	1.40	1.32	1.70
Pollination/Seed Dispersal-Fauna-Pollinator (%)	14.96	25.71	26.19	8.93	10.84	18.82	10.71	22.10	15.68	18.89
Pollination/Seed Dispersal - Fauna-Quantity (H/M/l	1.60	2.40	1.75	1.50	1.20	1.80	1.50	2.40	1.51	2.03
Habitat Provision-Fauna-Species richness %	20.21	26.00	33.33	21.60	21.82	20.22	21.60	26.64	24.24	23.62
Habitat Provision-Fauna-Endemic (%)	22.62	24.05	25.00	25.00	26.19	21.43	25.00	26.19	24.70	24.17
Habitat Provision-Fauna-Threatened (%)	16.67	35.00	5.56	33.33	21.67	20.00	33.33	6.67	19.31	23.75
Habitat Provision - Flora-Total	45.00	59.80	25.75	23.00	38.40	44.00	22.75	25.80	32.98	38.15
Habitat Provision - Flora-Species richness %	20.26	29.15	16.30	14.56	17.05	18.18	10.94	14.44	16.14	19.08
Food-Number of Crop plants	18.20	35.60	8.75	6.50	12.40	19.80	8.50	11.00	11.96	18.23
Food-% crop plants	8.36	17.22	5.54	4.11	5.26	8.18	3.68	6.08	5.71	8.90
Medicinal -Medicinal plants - number	9.80	12.60	6.00	6.75	9.00	10.40	5.75	6.80	7.64	9.14
Medicinal -% medicinal plants	4.45	6.17	3.80	4.27	4.07	4.30	2.87	3.78	3.80	4.63
Timber-Timber - number of plants	4.80	5.40	1.00	0.75	7.60	8.40	1.00	1.00	3.60	3.89
Timber-%	2.20	2.67	0.63	0.47	3.14	3.47	0.52	0.55	1.62	1.79
Fuel wood-Observed Y/N	0.75	0.80	0.00	0.00	0.80	0.80	0.00	0.20	0.39	0.45
Aesthetics-Observed Y/N	0.40	0.60	1.00	1.00	0.40	1.00	0.75	0.80	0.64	0.85
Educational-Observed Y/N	0.40	0.60	1.00	0.67	0.20	0.40	0.25	0.80	0.46	0.62
Religious/Spiritual -Observed Y/N	0.75	0.80	1.00	1.00	0.60	0.60	0.50	1.00	0.71	0.85

Table 2. Comparison of Fauna by Landscape Type and Quality of SLM Practices (Each cell represents the average values for multiple sites identified as good/poor)

Ecosystem Service/Indicator	Homegarden-Poor	Homegarden-Good	Paddy-Poor	Paddy-Good	Tea-Poor	Tea-Good	Vegetable-Poor	Vegetable-Good	All-Poor	All-Good
FAUNA-Species Richness	18.00	23.00	27.00	17.50	22.25	18.60	17.50	24.75	21.19	20.96
FAUNA-Species Richness (%)	20.21	26.00	33.33	21.60	24.18	20.22	21.60	29.60	24.83	24.36
FAUNA-Species Richness Quantity (H/M/L)	1.60	2.40	2.67	1.50	2.25	1.60	1.75	2.50	2.07	2.00
FAUNA-Importance of the ES (1 to 5)	2.60	3.60	4.67	2.50	3.75	2.80	2.25	4.00	3.32	3.23
FAUNA-Endemic	3.00	3.20	3.00	3.00	4.00	3.00	3.00	3.75	3.25	3.24
FAUNA-Endemic (%)	22.62	24.05	25.00	25.00	28.57	21.43	25.00	30.65	25.30	25.28
FAUNA-Endemic Quantity (HM/L)	1.80	2.00	1.67	2.00	2.25	1.60	1.75	2.00	1.87	1.90
FAUNA-Importance of the ES (1 to 5)	2.80	3.20	2.33	2.25	3.75	3.00	2.25	3.00	2.78	2.86
FAUNA-Threatened	0.80	1.60	0.33	2.00	0.75	0.80	2.00	0.25	0.97	1.16
FAUNA-Threatened (%)	16.67	35.00	5.56	33.33	18.75	20.00	33.33	4.17	18.58	23.13
FAUNA-Threatened species (H/M/L)	1.60	2.40	1.33	2.00	1.75	1.80	2.25	1.25	1.73	1.86
FAUNA-Importance of the ES (1 to 5)	2.20	3.60	1.33	3.00	2.50	2.60	3.25	1.25	2.32	2.61
FAUNA-Pollinator	4.80	7.60	3.67	1.25	4.00	6.40	1.50	4.50	3.49	4.94
FAUNA-Pollinator (%)	14.96	25.71	26.19	8.93	11.76	18.82	10.71	25.84	15.91	19.83
FAUNA-Pollinator Quantity (H/M/L)	1.60	2.40	2.33	1.50	1.25	1.80	1.50	2.75	1.67	2.11
FAUNA-Importance of the ES (1 to 5)	2.80	3.80	4.00	2.25	2.00	2.80	2.50	3.75	2.83	3.15
FAUNA-Pests	8.00	8.00	12.33	9.50	9.50	8.20	10.25	11.75	10.02	9.36
FAUNA-Pests (%)	31.47	31.32	42.53	32.76	39.58	34.17	35.34	42.31	37.23	35.14
FAUNA-Pests quantity (H/M/L)	2.00	1.80	1.33	1.75	1.25	2.00	1.75	1.50	1.58	1.76
FAUNA-Importance of the ES (1 to 5)	3.20	3.00	2.33	3.25	2.00	2.80	3.00	2.75	2.63	2.95
FAUNA-Pest controller	7.00	8.60	13.33	8.75	10.50	5.20	6.75	11.00	9.40	8.39
FAUNA-Pest controller (%)	18.97	23.12	34.19	22.44	29.17	14.44	17.31	28.85	24.91	22.21
FAUNA-Pest controllers quantity(H/M/L)	1.40	1.60	3.00	2.00	2.25	1.00	1.25	2.25	1.98	1.71
FAUNA-Importance of the ES (1 to 5)	2.60	3.40	4.67	3.25	3.75	2.00	2.50	3.75	3.38	3.10

Table 3. Comparison of Flora by Landscape Type and Quality of SLM Practices (Each cell represents the average values for multiple sites identified as good/poor)

Ecosystem Service/Indicator	Homegarden-Poor	Homegarden-Good	Paddy-Poor	Paddy-Good	Tea-Poor	Tea-Good	Vegetable-Poor	Vegetable-Good	All-Poor	All-Good
FLORA -Total	45.00	59.80	25.75	23.00	41.25	44.00	22.75	27.00	33.69	38.45
FLORA -%	20.26	29.15	16.30	14.56	17.05	18.18	10.94	14.73	16.14	19.15
FLORA -Native	10.80	12.00	9.50	9.75	12.50	8.20	6.00	7.00	9.70	9.24
FLORA -%	4.77	5.84	6.01	6.17	5.17	3.39	3.08	3.72	4.76	4.78
FLORA -Endemic	2.60	1.00	0.00	0.00	1.50	1.40	0.25	0.00	1.09	0.60
FLORA -%	1.12	0.41	0.00	0.00	0.62	0.58	0.16	0.00	0.47	0.25
FLORA -Threatened (national)	1.80	2.20	0.25	0.00	1.00	1.00	0.00	0.00	0.76	0.80
FLORA -%	0.74	1.00	0.16	0.00	0.41	0.41	0.00	0.00	0.33	0.35
FLORA -Threatened (Global)	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
FLORA -%	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
FLORA -Medicinal	9.80	12.60	6.00	6.75	9.25	10.40	5.75	7.00	7.70	9.19
FLORA -%	4.45	6.17	3.80	4.27	3.82	4.30	2.87	3.77	3.73	4.63
FLORA -Timber	4.80	5.40	1.00	0.75	9.50	8.40	1.00	1.00	4.08	3.89
FLORA -%	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00
FLORA -Crop	18.20	35.60	8.75	6.50	14.75	19.80	8.50	11.75	12.55	18.41
FLORA -%	8.36	17.22	5.54	4.11	6.10	8.18	3.68	6.34	5.92	8.96
FLORA -Spiritual	3.00	3.20	0.75	1.75	2.25	2.60	0.50	1.75	1.63	2.33
FLORA -%	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
FLORA -IAS	4.60	3.80	2.50	3.25	4.75	4.00	1.25	2.25	3.28	3.33
FLORA -%	1.99	1.79	1.58	2.06	1.96	1.65	0.68	1.31	1.55	1.70

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