Agroforest Syst
https://doi.org/10.1007/s10457-020-00564-9

Forest gardens increase the financial viability of farming enterprises in Sri Lanka

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Received: 6 January 2020 / Accepted: 26 October 2020

Abstract Forest gardens (FGs) are tree-dominant land uses in Sri Lankan farming enterprises. Although FG financial performance has been described, their overall contributions to farming enterprises remain unclear. This information is critical given the global quest for financially viable, sustainable agricultural models. Farming enterprises include On-farm (land uses: FGs, paddy, cash crops, plantations, swidden/*chena* plots, livestock), Off-farm (employment, trading, grants, welfare) and household components. Forest garden financial performance was compared with other enterprise components in short-(reference year, 2012–2013) and long-terms (beyond 2013). Financial data were collected for 85 farming enterprises in nine locations of the Intermediate zone using Household Income and Expenditure surveys and quantified using accounting procedures. In the short-term, 49% of On-farm income was the value of household consumption while 54% of On-farm expense the value of household contributions. FGs contributed 29% to food and fuelwood self-sufficiency, generated the highest profit, were the most financially efficient land use, and average FG profit (Current assets) was greater than enterprise profit. In the long-term, FGs had the highest number of timber and fuelwood species (biological assets). Their average net realisable value (NRV) was 90% of total NRV for biological assets from all land uses. Since FGs occupied 68% of the study area, their substantial biological and land assets had high Non-Current asset values. Average FG Non-Current asset values accounted for 79% of Total Equity and were farmers' core ownership interest in enterprises. Forest gardens increase the financial viability of farming enterprises. Their financial contributions warrant recognition in national economic performance assessments.

Keywords Forest gardens · Farming enterprises · Sri Lanka

Bronwyn Myers: Deceased.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10457-020-00564-9) contains supplementary material, which is available to authorized users.

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Published online: 04 December 2020

Introduction

The quest is ongoing for financially viable agricultural models that increase food production and improve farmers' livelihoods (HLPE 2019) in the face of multiple stressors including climate variability (Esham et al. 2018), limited natural resources, such as land and water (Food and Agriculture Organisation and Earthscan 2011), and increasing impacts of animal and insect pests (Horgan and Kudavidanage 2020). Tree-dominated, agrobiodiverse forest gardens (FGs) are a likely choice because they have prevailed for millennia (Kumar and Nair 2006) and dominate small farming enterprises in Sri Lanka (Melvani et al. 2020) and other tropical countries (McConnell et al. 2003).

Diverse accounting and economic methods have been used to evaluate FG financial performance. Accounting methods such as Gross Margin Analysis determined FG profitability between agroforestry systems (de Souza et al. 2012), while the Income-to-Cost ratio compared financial efficiency (Cardozo et al. 2015). Standard accounting procedures (Profit and Loss statements and Reports of Financial Position) were used to assess financial performance in large-scale forestry and farming enterprises, but may not have valued FGs (Merlo and Boschetti 2001). Several authors have used economic valuation methods (Batagalle et al. 1996; Lindara et al. 2006; Molua 2005; Ramirez et al. 2001; Wise and Cacho 2011), of which Investment Project Appraisal or Financial Analysis is the most popular (Mercer and Miller 1998). Financial Analysis determines the impact that an incremental activity will have on the net cash flows of a firm and its financial performance over time (Harrison and Herbohn 2016). This method has been used to assess the: economic potential of agroforestry compared to swidden farming in Indonesia (Rahman et al. 2017) and Bangladesh (Rahman et al. 2007; Rasul and Thapa 2006); inclusion of tree crops in seasonal agricultural systems (Rahman et al. 2016); financial values of FGs in Kerala, India (Mohan et al. 2006), and the financial viability of diverse agroforestry practices in Africa (Franzel 2005).

Nevertheless, financial benefits that farmers gain from FGs compared to other On- and Off-farm livelihood strategies in farming enterprises are not fully understood, and knowledge gaps remain (Arnold 1987; Mercer and Miller 1998; Molua 2005; Torquebiau and Penot 2006). For example, contributions that households receive from (food, medicine, fuelwood and timber) and provide (labour and other inputs) to FGs are rarely considered with respect to their monetary value (Scherr 1992), in short- and long-terms, and especially from farmers' perspectives (Arnold and Dewees 1998; Franzel and Scherr 2002). In addition, current and realisable financial contributions from numerous long-term timber and fuelwood species may not have been included in the overall financial evaluation of tree-dominant farming enterprises (Anyonge and Roshetko 2003). There is also the need to assess impacts of concurrent multiple stressors on farming enterprises, what farmers do to adapt, and how this is reflected in their overall financial performance. Further, effects of increased household cash needs as a consequence of economic liberalization (Hettige 1995) and other ongoing rural transformations (Wiersum 2006), would not have been considered when FG financial performance was assessed.

This study addresses most of the above knowledge gaps. Using standard accounting methods, it assesses the overall financial performance of tree-dominated farming enterprises in short- and long-terms to determine the financial importance of FGs to farmers. This knowledge is critical since farmers will only adopt and maintain an agricultural land use if it is profitable (Banyal et al. 2015; Hosier 1989). Outcomes of this research have positive implications for development planning in Sri Lanka and other tropical countries that seek to enhance farmers' livelihoods in the face of increasing climate variability, insect and animal pests, and dwindling land and water resources.

Methods

Farming enterprise

A typical Sri Lankan farming enterprise in the Intermediate agroecological zone (IZ) consists of On-farm, Off-farm and household components—*Online resource 1* (OR1). The On-farm component is comprised of land uses in farmers' landholdings including FG, paddy, *chena* (swidden plot), cash crop plot, plantation and livestock management interspersed with forest remnants, streams and other water bodies on the landscape mosaic. The Off-farm component refers to livelihood strategies not undertaken On-farm. Household includes the farmer's family.

Forest gardens are tree-dominated, have multiple strata and high floristic diversity including annual, semi-perennial and perennial crops. The majority of FGs in this study had secure tenure since they were ancestral lands, that were on average, 35 years old (Melvani et al. 2020). Paddy (*Oryza sativa*) is a wetland crop, the cultivation of this and other annual crops involves agrochemical use, hired labour, mechanical tilling, harvesting, threshing and irrigation. *Chena* crops include maize (*Zea mays*), finger millet (*Eleusine coracana*), banana varieties (*Musa spp*.) and vegetables that are seasonally cultivated. Although subsistence agriculture was practiced in traditional *chenas*, farmers in this study engaged in commercial cultivation. Cash crops encompass annual (vegetables, purple yam—*Dioscorea alata*, sweet potato—*Ipomea batatas*, groundnut—*Arachis hypogaea*), semi-perennial (turmeric, *Cucurma longa*), and perennial crops (cinnamon, *Cinnamonum verum*). Plantations include monocultures of tea (*Camellia sinensis*), rubber (*Hevea brasiliensis*), coconut (*Cocos nucifera*), timber (mainly teak, *Tectona grandis*) and pineapple (*Ananas comosus*). Livestock management incorporates poultry, goats and cattle that either graze on common land or are stall-fed.

Each land use in the On-farm component generated income and incurred expenditure in short- and long-terms. Short-term is the reference year (October 2012 to September 2013), which includes the *Maha* (October 2012–January 2013) and *Yala* (April–July 2013) cultivation seasons. The long-term encompasses the 100-year period following October 2013, during which long-term or tree crops will be harvested. The reference and preceding years (October 2011 to September 2012) experienced climatic (rainfall) variability and extreme climatic events including droughts and floods (Melvani et al. 2020). Recurrent droughts in both *Yala* seasons (2011–2012 and 2012–2013), and major floods during the *Maha* (2012–2013) were attributed to an *El Niño* Southern Oscillation (ENSO) event that impacted Sri Lanka in 2012–2013 (Herath et al. 2012; Perera 2012; Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) 2013).The Off-farm component generated income and incurred expenditure only in the short-term. Families generated income from On- or Off-farm sources, or both (OR1), but incurred household expenses independent of them. Short- and long-term transactions in farming enterprises are shown in OR2.

Short-term, On-farm income includes revenue from sales (S), and the monetary value of crops and products households consumed (HC). On-farm expenditure incorporates cultivation costs (C) for hired labour, seed, fertiliser, biocides, irrigation, transporting goods to markets, renting livestock for draught energy, and the monetary value of household contributions (HI) of labour, seed, suckers, straw and trellis poles. Households earned Off-farm income from employment, leasing equipment or livestock, trading natural forest and non-agricultural products, receipts of grants, remittances, insurance, lease and welfare payments. They expended cash on some food (e.g. meat) and non-food items (e.g. children's education). Long-term, On-farm income refers to the Net Realisable value (NRV) that will be earned when biological assets such as trees and woody shrubs are consumed as timber and fuelwood, or sold. This value refers to the "net amount that an entity expects to realise from the sale of inventory in the ordinary course of business" (Australian Accounting Standards Board 2015).

Undertaken from 2013 to 2018, this study investigated 85 farming enterprises in villages (V) located across nine Divisional Secretariat areas (DS) in the IZ. Sampling locations are listed as DS (V) and included Moneragala (Maragalakanda comprised of Aliyawatte, Wedikumbura and Kawdawa in the upper reaches, and Kolonwinna, Thenagallanda and Kaludiya Ella in the lower reaches), Polpithigama (Thimbiriyawa), Kundasale (Narampanawa and Gomagoda), Badalkumbura (Punsisigama), Pallama (Siyambalagaswewa), Uva Paranagama (Rahupola and Deeyakola), Weligepola (Hatangala), Naula (Bowatennawatta), and Hakmana (Denagama), Fig. 1, and OR3, which includes socioeconomic and biophysical information for locations.

Data collection

Data were collected in two phases under Charles Darwin University Human Ethics application reference no. H13026. The first phase spanned 2013–2014 and engaged with all 85 farming enterprises, including ten each at Moneragala, Polpithigama, Badalkumbura, Pallama, Weligepola, Naula and Hakmana, nine in Kundasale, and six in Uva Paranagama. Land uses in

85 landholdings comprised 85 FGs, 44 paddy fields, 13 cash crop plots, 12 plantations and four *chenas* (Melvani et al. 2020). Household Income and Expenditure surveys were used to collect financial data for On-farm, Off-farm, and household components in farming enterprises. See example of Income and Expenditure statement for On-farm component (OR4). Farmers arrived at a consensus on unit land value for each land use in locations (OR5). This was the benchmark value since Sri Lanka's Valuation Department does not have data for different land uses at the regional level. Farmers offered values for other assets (built-up property, machinery and livestock) including interest received on fixed deposits that is treated as income in accounting. They detailed their Current liabilities (balances on enterprise expenditure incurred in the reference year including bank loan instalment and interest payable) and Non-Current liabilities (bank loan amount remaining and interest due). Farmers accurately recalled yields, costs and income for the past year. Data were credible because they answered with certainty, and the information provided was consistent when addressed in different lines of questioning.

The second phase of data collection occurred in 2015–2016 when farmers estimated a potential cash value (NRV) for harvestable timber and fuelwood from trees and woody shrubs in each land use beyond the reference year, (described in OR6) using the Transactions method. Net Realisable Value is based on "recent transaction prices, market prices… for the biological asset or agricultural product in its present condition" (Leech and Ferguson 2012). This method estimates a 'fair value' or "the amount for which an asset could be exchanged, or a liability settled, between knowledgeable, willing parties in an arm's length transaction (Australian Accounting Standards Board, AASB 141:8). The fair value of an asset is

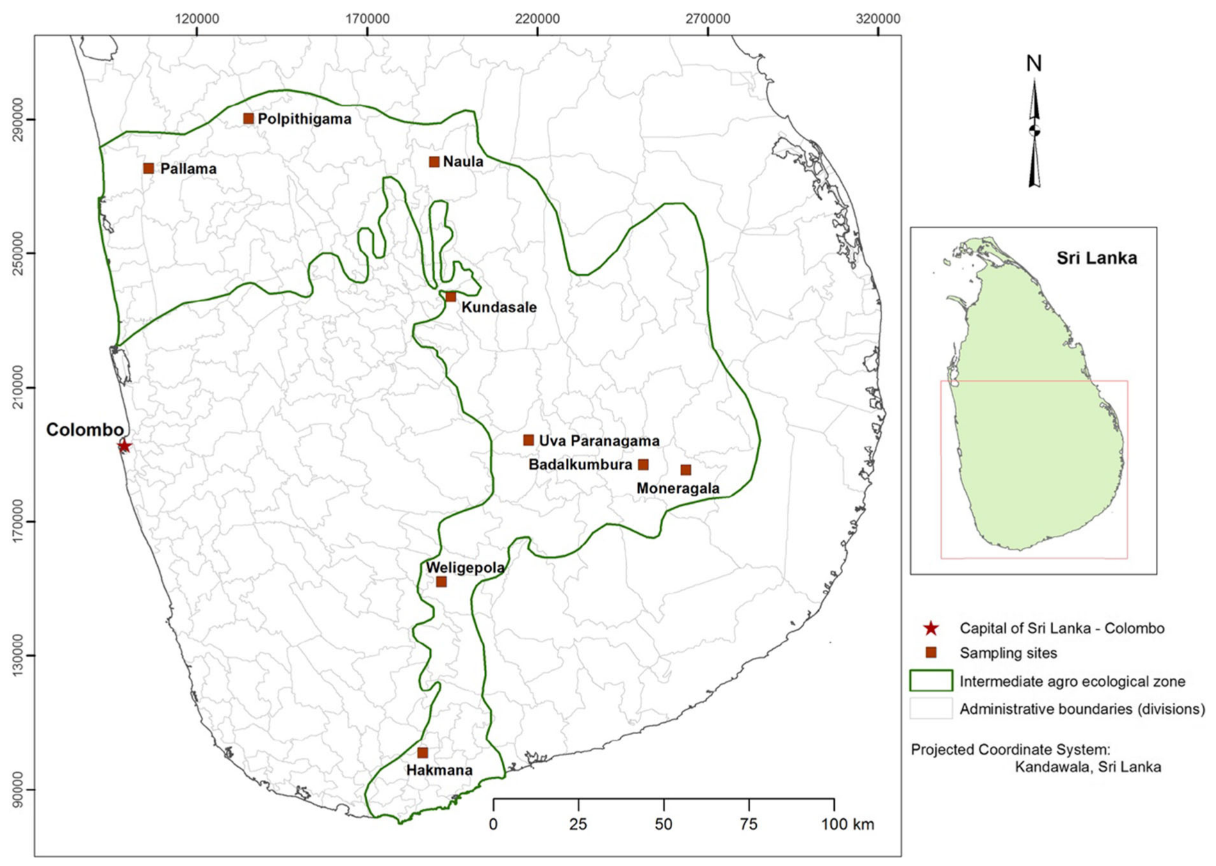


Fig. 1 Map displaying sampling locations in the Intermediate agroecological zone in Sri Lanka (Melvani et al. 2020). (Color figure online)

based on its current location and condition (AASB 141:9)" (Leech and Ferguson 2012). Estimations were made for every harvestable tree or woody shrub in landholdings of previously interviewed farmers who volunteered to participate. Five estimations were made per location and in a total of 45 farming enterprises including 45 FGs, 12 paddy fields, four cash crop plots, eight plantations and four *chenas*. Trees bearing fruits and nuts during the survey were not valued as timber or fuelwood.

Non-financial data had been collected in a previous, parallel study (Melvani et al. 2020) which investigated: water availability, climate variability, farmer gender, age and educational status in locations; tenure, age, plant and crop species richness and diversity per land use, and mapped area in all land uses and landholdings across locations.

Financial and non-financial variables used in short- and long-term financial analyses of farming enterprises are described in Table 1. Financial data were converted to US$ as at 31.10.2013 when US$1 = LKR 130.90 (https://www.xe.com/currencytables/?from=USD&date=2013-10-31). Data compilation and processing are described in OR7.

Statistical analyses

Statistical analyses to assess the short- and long-term financial performance of farming enterprises were undertaken separately using multivariate and univariate PERMANOVAs (Permutational Multivariate Analysis of Variance, PRIMER-E v7, Plymouth UK). The multivariate PERMANOVA determined whether significant differences existed between location and land use factors and the *composite* of financial and non-financial response variables. In contrast, univariate PERMANOVAs indicated significant differences between factors with respect to *each* financial variable.

Experimental designs for both, short- and long-term financial analyses were unbalanced owing to different sample numbers in groups of locations, land uses and landholdings. Moreover, data contained outliers with skewed distributions. Hence the PERMANOVA approach with Type III sums of squares and 999 permutations was chosen because it is free of assumptions of multivariate normality and robust to unbalanced designs (Anderson et al. 2008).

A three-factor hierarchical experimental design was utilised in both, univariate and multivariate PERMANOVAs. Location and land use were fixed factors, and farmer landholding a random factor nested in location. The land use factor had five levels: FG, paddy, cash crops, plantation and *chena*. Livestock was excluded from the statistical analysis because it did not have values for area and thus profitability could not be calculated. Location had nine levels or sampling locations. The random factor landholding had 85 levels or landholdings in the short-term analysis, and 45 levels in the long-term analysis.

Financial and non-financial response variables differed between short- and long-term analyses. Profit, profitability and financial efficiency were financial response variables in the short-term analysis while non-financial response variables included numbers of plant species, numbers of crop species, plant diversity, crop diversity and area. Crops differ from plants because they are deliberately cultivated. Non-financial variables were included to ascertain whether financial performance was contingent on them. Net Realisable value and numbers of timber and fuelwood (TFW) crop species were financial response variables in the long-term analysis, while area the single non-financial response variable.

Financial data in this study were highly variable and contained negative values that were not removed. Only financial response variables (profit, profitability) with negative values (losses) were converted to positive values by adding a constant (the maximum difference) to all samples (profit + $333; profit/m^2 + $0.42). This enabled fourth root transformation and compressed overly large values (e.g. for profit) (Norman and Streiner 2008). Thereafter, data were normalised to standardize differences in the range and size of units of different variables.

Principal Coordinates Analyses (PCO) (Gower 1966) visualized the Euclidean dissimilarity matrix in 2-dimensional space (Anderson et al. 2008). The PCOs were fitted in Primer-E v7 (Plymouth, UK) based on a Euclidean distance matrix of transformed and normalized variables in short- (number of plant species, number of crop species, plant diversity, crop diversity, area, profit, profit/m^2 and financial efficiency) and long-terms (number of TFW species, NRV and area). Vectors in PCO ordinations represent the magnitude and direction of correlations between response variables and the first two PCO axes.

Table 1 Financial and non-financial variables, and index of terms

Variable	Acronym	Description
Non-financial variables used only in statistical analysis		
Area		Covered by land use, m^2
Floristic diversity		Species richness and diversity of floral vegetation
Plant species richness		Number of plant species in land uses
Crop species richness		(a) Number of crop species in land uses
		(b) Number of timber and fuelwood crop species in land uses
Plant diversity		Number of plant species per unit land use, m^2
Crop diversity		Number of crop species per unit land use, m^2
Financial variables, all values in US$		
SHORT-TERM		
Income	I	Value generated when food, products or services are sold or consumed
Sales	S	Value of food, products or services sold
Household consumption	HC	Value of food, products and services consumed/used by households
Expense	E	Value of inputs purchased or contributed by households
External inputs	C	Value of external inputs purchased with cash
Household inputs	HI	Value of household contributions of family labour and other inputs
Profit	P	Income–expense (I–E)
Productivity	P/kg	Profit per unit kilogram
Profitability	Profit/m^2	Profit per unit land use area = profit/land use area
Financial or Operating efficiency ratio	OER	Total expense/Gross income from land use
Self-sufficiency ratio for landholdings	SSR	Value of food and fuelwood produced in landholding % total consumed
Self-sufficiency ratio for FGs	SSR_{FG}	Value of food and fuelwood produced in FG % total consumed
Off-farm income		Income generated from Off-farm livelihood strategies
Off-farm expense		Expense incurred during Off-farm livelihood strategies
Household expense		Expense on food and non-food items purchased by households
LONG-TERM		
Net realisable value	NRV	Potential value of timber and fuelwood at and after October 2013
Biological assets		Living trees and shrubs that will provide timber and fuelwood
Current assets		Short-term profit or Cash-in-hand
Non-Current assets		Land, biological and livestock assets, or long-term assets
Total assets		Current + Non-Current assets, or short and long-term assets
Current liabilities		Expenditure balances including bank loan instalments and interest payable
Non-Current liabilities		Balances on bank loans payable over time and interest due
Total liabilities		Current + Non-Current liabilities, or short and long-term liabilities
Owner's Equity		Total assets − Total liabilities

If the PERMANOVA resulted in negative estimates of components of variation for a factor, then that factor was pooled (Anderson et al. 2008). In case of a significant PERMANOVA result ($p < 0.05$), a test of homogeneity of multivariate dispersions (PermDISP) was carried out to assess the homogeneity of multivariate dispersions among groups/levels within each factor. This allowed for better interpretation of PERMANOVA results since these tests are sensitive to differences in data dispersion between groups.

Pairwise PERMANOVAs were undertaken subsequently for factors with more than two levels if the main test in either multivariate or univariate PERMANOVAs showed significant effects of this factor on response variables. For example, if the land use factor had a significant influence on profit (univariate PERMANOVA), then pairwise comparisons were undertaken to determine profit differences between land uses. *p* values for pairwise comparisons were not adjusted for multiple testing but interpreted with caution accounting for the increased risk of *Type I* errors. Pairwise comparisons that had < 100 permutations were attributed to low sample numbers in *chena*, cash crops and plantations. These results were disregarded because they did not have the statistical power to generate conclusive outcomes. Box and whisker plots using untransformed data visualised the median and data range for each response variable across land use levels or locations.

Drivers of short- and long-term financial performance in FGs and landholdings were identified using Microsoft Excel. Both, individual and aggregated FG data were log transformed to homogenise variance. Pearson's correlations and linear regressions were undertaken in the short-term analysis between (1) profit, HC and HI, and numbers of plant and crop species, (2) Off-farm income and landholding food and fuelwood self-sufficiency (SSR), and FG food and fuelwood self-sufficiency (SSR_{FG}); and in the long-term analysis, between (1) NRV of landholdings and total number of TFW crop species, (2) FG NRV with FG TFW crop species and area. Scatter plots with lines of best fit were generated to check results for outliers, and only significant results are reported ($p < 0.05$). One-way ANOVAS determined effects of FG age on profit, profitability and financial efficiency, followed by t-tests (assuming unequal variances) to identify groups with differing means.

Results

Short-term results (income, expenditure, food and fuelwood self-sufficiency, profit, productivity, profitability and financial efficiency) are described for the On-farm component, and then for the farming enterprise (income, expenditure and profit). Long-term results follow for the On-farm component and FGs. Results are synthesised for the overall (short- and long-term) financial performance in farming enterprises thereafter. Contributions from FGs to equities in farming enterprises are described last.

Short-term financial performance of the On-farm component

On-farm income and expenditure

Total On-farm income from land uses in landholdings included the HC value of food, fuelwood and timber, and revenue from sales (Table 2, Part A). Average HC as a proportion of total On-farm income in landholdings was nearly equal (49%) to sales income (51%). Total On-farm income in landholdings across locations ($190,390) was three-fold greater than total expenditure ($56,423). The average value of produce consumed by households was highest from paddy fields (69%) plantations (56%) and FGs (52%), and higher than that sold from these land uses. Households obtained their staple rice and vegetables from paddy fields, while plantations provided coconut (another staple) and timber used in house and furniture construction. Forest gardens contributed fruit, spices, nuts, oil seed, timber and fuelwood. Household consumption was lowest from *chenas* (19%) cash crops (32%) and livestock (30%) since these crops/services (draught power) were mainly sold. Household consumption in FGs strongly increased with increasing numbers of crop species (R^2: 0.53, $p < 0.001$). Total FG income was 73% of total On-farm income, and highest of all land uses across locations (Fig. 2a).

On-farm expenditure included both, the HI value of labour, seeds, suckers, straw and trellis poles, and cost of external inputs (Table 2, Part B). Expense items used in the cultivation of dominant crops are shown in OR8. Household input value as a proportion of total expense (54%) was higher than expenditure incurred on external inputs (46%). Household inputs accounted for the highest proportion of expenses in FGs (69%), plantations (55%) and livestock management (55%), since family members harvested fruit and maintained FG crops, plucked tea, de-husked coconut, and managed livestock. Household inputs were lower for seasonal crops including paddy (31%), cash crops (38%) and *chena* (39%) which used greater hired labour and external inputs (agrochemicals and mechanisation). Farmers also used hired labour to harvest pepper, cloves and coconuts in FGs since these tasks required skill, and because they experienced labour shortages when their

Table 2 Average household consumption, HC (Part A) and household inputs, HI (Part B) as a proportion (%) of total On-farm income and expense in land uses respectively, and average total On-farm income and expense in landholdings at locations in US$

Location	FG	Paddy	Cash crops	Plantation	*Chena*	Live stock		US$
Part A: HC % of total On-farm income in land use							Total HC % total On-farm income	Average total On-farm income in landholdings at locations
Moneragala	34	65	25	100	18	37	34	54,913
Polpithigama	79	63		100	22		69	13,420
Kundasale	26	48				61	28	24,712
Badalkumbura	41	80				51	43	15,749
Pallama	48	100	57	100		17	37	16,620
Uva Paranagama	51	36	47			4	46	10,032
Weligepola	51	100	100	31			52	31,593
Naula	73	77				37	66	9489
Hakmana	64	100	1	21			60	13,863
Average per land use %	52	69	32	56	19	30	49	
								190,390
Part B: HI % of total On-farm expense in land use							Total HI % total On-farm expense	Average total On-farm expense in landholdings at locations
Moneragala	56	32	36		32	58	48	12,068
Polpithigama	68	17		100	60		28	5838
Kundasale	59	56				66	57	7137
Badalkumbura	62	4				67	57	3631
Pallama	81	23	95	46		51	64	7475
Uva Paranagama	78	41	65			63	65	3789
Weligepola	64	36	30	45			60	5054
Naula	81	38				50	69	5498
Hakmana	70	21	5	64			43	5933
Average per land use %	69	31	38	55	39	55	54	
								56,422

children migrated to towns for employment. Most farmers spent little on transport because produce was sold at village fairs or to middlemen. Household inputs in FGs increased with increasing numbers of crop ($R^2 = 0.42$, $p < 0.001$) and plant species ($R^2 = 0.23$, $p < 0.001$). Total FG expenditure was 58% of total On-farm expenditure (Fig. 2b), highest of all land uses and attributed to elevated HI values. Contrarily, expenditure in paddy was 25% of the total owing to the high cost of external inputs.

Food and fuelwood Self-sufficiency

Average SSR accounted for more than a third (38%), and average SSR_{FG} to more than one quarter (29%) of the total average annual value of food and fuelwood consumed by households ($1448) (OR9). Forest gardens were integral to household food and fuelwood self-sufficiency because their contributions were higher than all other land uses in landholdings.

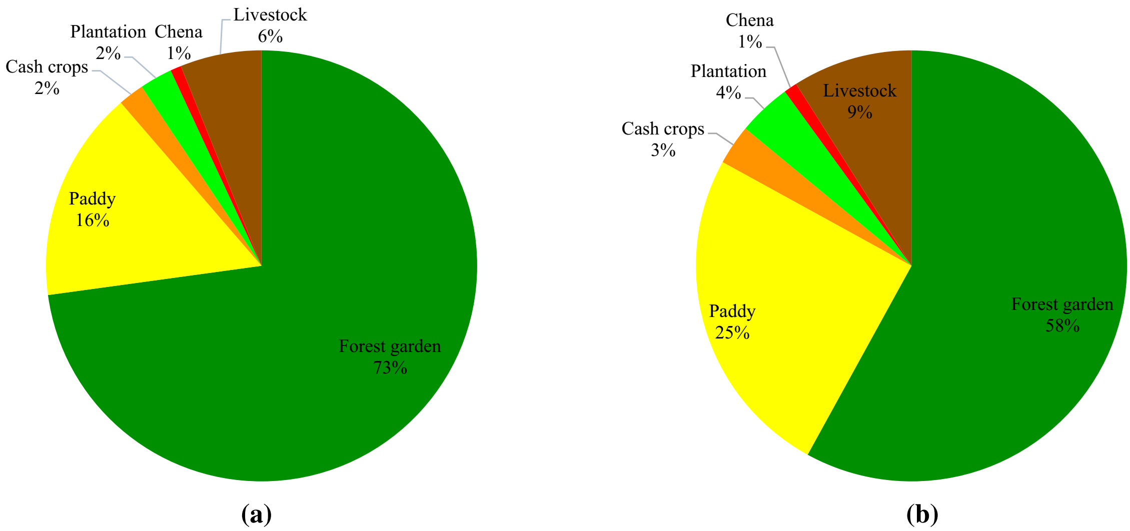


Fig. 2 **a** Average total income from land uses as a proportion (%) of total On-farm (all land uses) income across locations. Higher values indicate higher income. **b** Average total expenditure in land uses as a proportion (%) of total On-farm (all land uses) expenditure across locations. Higher values indicate higher expenditure. (Color figure online)

Profit, productivity, profitability and financial efficiency

The multivariate PERMANOVA revealed that only land use significantly impacted the composite of financial (profit, profitability and financial efficiency) and non-financial response variables (area, numbers of plant and crop species, plant and crop diversity) ($Pseudo\text{-}F_{(4,157)} = 14.61$; $p = 0.001$). Results from pairwise comparisons and the Principal Coordinates Analysis (PCO) (Fig. 3) showed that FGs were significantly different to all land uses with respect to all response variables. Results from univariate PERMANOVAs follow.

Profit was influenced by land use and did not significantly differ between locations ($Pseudo\text{-}F_{(4,157)} = 11.60$; $p = 0.002$). Forest gardens generated higher average profit than all other land uses (\$1311 ± 345) (OR10), and profits earned by *chena* were 49%, cash crops 32%, paddy 18%, plantations 18% and livestock management 8% of FG profit value. The box and whisker plot (OR11) indicated that FGs earned the highest profits while paddy, plantations and cash crops suffered losses. Extraordinary FG profits were mainly from the sale of timber, pepper and coconut, and elevated HC values. Forest garden profits increased with self-sufficiency ($R^2 = 0.23$, $p < 0.001$), and as also shown in the PCO (Fig. 3), with numbers of plant ($R^2 = 0.15, p < 0.001$) and crop species ($R^2 = 0.12, p < 0.001$).

Paddy and vegetable cash crops suffered losses due to rainfall variability and recurrent *Yala* drought. However, cash crops such as purple yam generated profits despite high costs of seed and maintenance because exporters paid premium prices. Plantations earned profits (irrespective of drought impacts on pineapple) owing to the elevated HC and sales values of coconut and timber. Tea and rubber plantations generated profit from the sale of inter-planted timber. *Chenas* generated high profits because farmers had plentiful rainfall during the *Maha* 2012–2013 although low sample numbers resulted in high variability of profits (OR10). The poultry farming aspect of livestock management made greater profits than cattle rearing, which used large amounts of HI. Forest gardens accounted for nearly half (45%) of average total profit in the On-farm component, followed by *chenas* (22%) and cash crops (14%) (Fig. 4a).

Crop *productivity* differed with the agroecological characteristics of locations (OR3). The most productive (P/kg) crops were from FGs including pepper (\$4/kg ± 0.31) and cashew (\$1.34/kg ± 0.11) (OR12). Paddy displayed an overall average negative productivity (\$-0.02/kg ± 0.04) owing to rainfall variability in all locations except Moneragala, where farmers had access to stream water (OR3). Even though yield

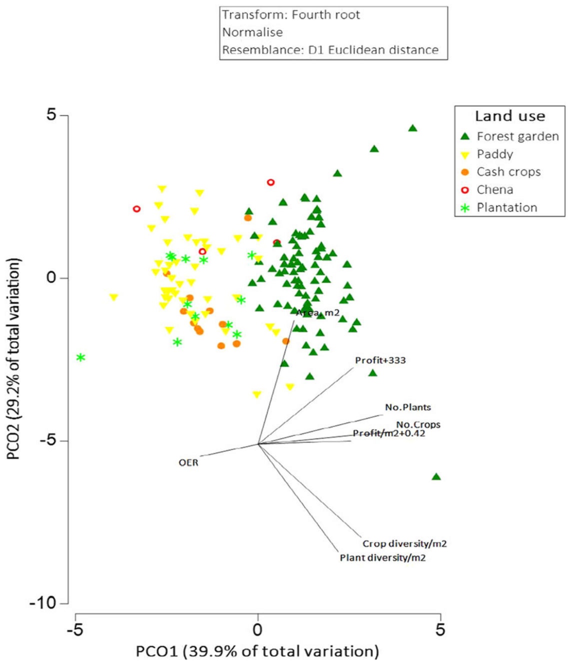


Fig. 3 The PCO explains similarity and dissimilarity between land uses including FGs, paddy, cash crops, *chenas* and plantations for response variables: area,m^2, profit (Profit + 333), number of plant species (No. Plants), number of crop species (No. Crops), profitability (Profit/m^2 + 0.42), crop diversity/m^2, plant diversity/m^2 and OER. Closely clustered samples are similar. The first 2 axes explained 69.1% of the cumulative variance. FGs are separated from other samples along the first axis explaining 39.9% of the variance. The second axis explained 29.2% of the variance, separating paddy from cash crop and plantation samples. The graph shows correlations between, (a) area, profit, numbers of plant and crop species, and (b) plant diversity and crop diversity. Outlying samples include three very large FGs (three black triangles) in the upper centre, one very small FG (black triangle) and plantation (white circle) in the lower right and upper left side of the graph respectively. (Color figure online)

losses caused by animal pests were not quantified, their impacts were reflected on the productivity and profitability of land uses, and on the farming enterprise as a whole. Giant squirrels (*Ratufa macroura*), Toque Macaques (*Macaca sinica sinica, Macaca sinica aurifrons*), grey langurs (*Semnopithecus priam thersites*), wild boar (*Sus scrofa*) and porcupines (*Hystrix indica*) devoured fruit, coconut and vegetables, and were the worst offenders. Farmers cultivated many fruit trees, but animals ate nearly all the harvest leaving little for HC or sale. Elephants (*Elephas maximus maximus*) and peacocks (*Pavo cristatus*) damaged paddy and vegetable crops, which also suffered excessive insect pest damage that farmers attributed to the increased frequency of extreme climatic events (Melvani et al. 2020). Although conventional (e.g. making noises, lighting firecrackers) and traditional (*kem*) pest control methods were used, these did not eliminate the problem. Consequently, farmers cultivated greater numbers of tree/perennial crops (e.g. tea, rubber, cashew, timber, nutmeg and pepper that are 'unattractive' to wild animals) and were disinclined to grow vegetables.

Profitability (Profit/m^2) was only influenced by land use ($Pseudo\text{-}F_{(4,157)} = 4.51$; $p = 0.02$). Forest garden profitability ($0.21/m^2 ± 0.03) was similar to cash crops ($0.18/m^2 ± 0.10) and *chena* ($0.04/m^2 ± 0.01), but significantly different to paddy ($0.08/m^2 ± 0.03), and plantations ($0.02/m^2 ± 0.08) (OR13). However, this result is inconclusive because there were only four *chena* samples in the analysis. Differences in profitability are shown in box and whisker plot (OR14), where data for paddy, cash crops and plantations lie below the X-axis signifying negative values or low profitability. Although overall differences in Profit/m^2 were not statistically significant between locations, small, intensively cultivated FGs and landholdings in Weligepola were more profitable than large FGs and landholdings in Polpithigama, since this metric is based on area. Average FG profitability was 39% of average total profitability of the On-farm component followed by *chenas* (34%) and cash crops (14%) (Fig. 4b). Forest garden profitability increased with SSR ($R^2 = 0.17$, $p < 0.001$), and there were significant differences between FGs of varying age: ($F_{(3,150)} = 4.39$, $p = 0.005$). Profitability was higher in age groups '26–50' years (*M*: 1.71, *SD*: 0.16) than '11–25' years (*M*: 1.55, *SD*: 0.09): ($t_{(112)} = 2.42$, $p < 0.008$) and '50+' years (*M*: 1.47, *SD*: 0.02): ($t_{(85)} = 2.96$, $p < 0.002$) because this was when most timber trees were felled and generated high returns. Profitability was also reflected in farmer ascribed, unit land values that differed within and between land uses across locations (OR5). High average values were given to cash crop plots ($3.3/m^2 ± 0.6), FGs ($3.2/m^2 ± 0.3) and plantations ($1.9/m^2 ± 0.3). Paddy lands had relatively low values ($1.3/m^2 ± 0.2), and those in Weligepola (subject to traditional agrarian, *Viharagam Devalagam* laws), and Badalkumbura (only two paddy farmers) were ascribed very low values. *Chena* lands carried the lowest value ($1.1/

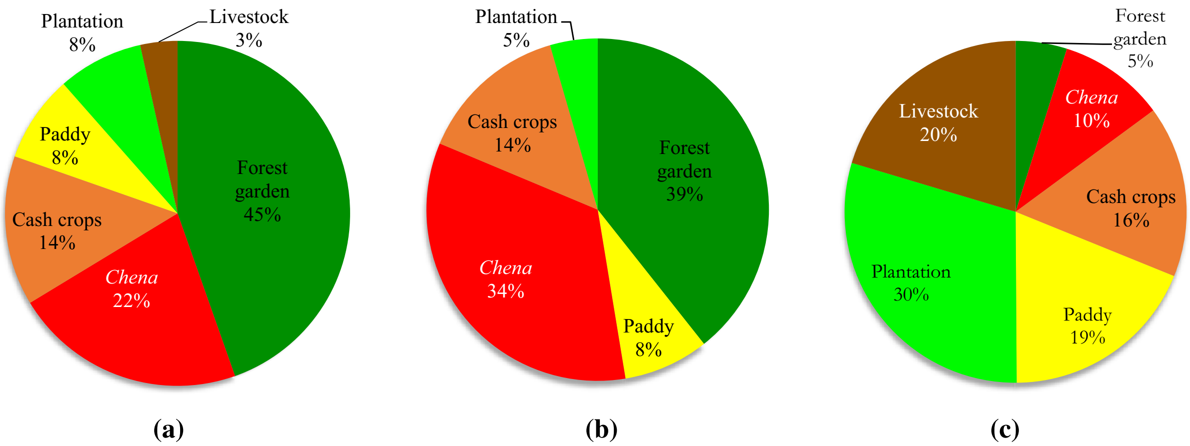


Fig. 4 **a** Average total profit of land uses as a proportion (%) of total profit for the On-farm component across locations. **b** Average total Profit/m^2 of land uses as a proportion of total Profit/m^2 for the On-farm component across locations. **c** Average Operating Expense Ratio, OER (indicates financial efficiency) of land uses as a proportion % of total OER for the On-farm component across locations. Lower values indicate higher efficiency. (Color figure online)

m^2 ± 0.7) because these were encroached upon and had insecure tenure.

Financial efficiency was assessed using the Operating Efficiency ratio (OER) and only influenced by land use (Pseudo-$F_{(4,157)}$ = 8.74; p = 0.001). Forest gardens were the most financially efficient land use because average OER (0.23 ± 0.01) was lower than *chenas* (0.48 ± 0.14), cash crops (0.78 ± 0.19), paddy (0.90 ± 0.10), livestock (0.98 ± 0.30) and plantations (0.1.42 ± 1.04) (OR15 and OR16). Average FG financial efficiency was 5% of the average total for the On-farm component, whereas *chenas* were 10%, cash crops, 16%, paddy, 19%, livestock, 20% and plantations, 30% (Fig. 4c). Although OER increased in FGs when expensive skilled labour was used to harvest pepper, coconuts, cloves and cashew, cultivate banana, and fell timber trees, high gross profits from elevated HC values ensured financial efficiency. In contrast, pineapple plantations, paddy and cash crops were less financially efficient owing to excessive production costs and low gross profits from unfavourable climatic conditions, insect and animal stress. Livestock management (cattle rearing) was not financially efficient owing to high household labour costs and low milk yields. Financial efficiency significantly differed between FGs of varying age: ($F_{(3,150)}$ = 4.02, p = 0.008). Those < 10 years of age (M: 0.10, SD: 0.003) had a higher OER and were less financially efficient than FGs in the '11–25' years (M: 0.07, SD: 0.003) ($t_{(65)}$ = 1.89, p < 0.03), and '26–50' years age groups (M: 0.08, SD: 0.01): ($t_{(62)}$ = 1.75, p < 0.04). These results make sense because the period < 10 years is the establishment phase in FGs when initial costs are high but reduce with vegetation maturity.

Short-term financial performance of farming enterprises

Following the financial performance of the On-farm component, we describe household expenditure, Off-farm income and the overall short-term financial performance of farming enterprises.

Household expenditure

Households purchased several foods (meat, fish, sugar, wheat flour, spices, oil) and paid cash for non-food items including energy for cooking and lighting, pipe-borne water, toiletries, health care, medicine, telephone bills, finance for vehicle leases, textiles, children's education, travel, transport, fuel and other items (entertainment, liquor). Monthly household expenses (OR17) differed from those incurred in On- and Off-farm components. Households incurred over half ($120 ± 14) of average total monthly expenditure ($193 ± 15) to purchase non-food items and bought food for nearly one third ($72 ± 4) of this value. The average value of food produced On-farm ($48 ± 4) was equivalent to one quarter of average total monthly expenditure. Although children's education, travel, fuel, transport, and other items incurred the highest costs, households spent little on cooking energy and only a few paid for pipe-borne water. Average monthly household expenditure in this study ($193 ± 15) was far less than the national average for rural households ($292) in 2012–2013 (Department of Census and Statistics 2015). However, it exceeded average monthly On-farm ($131 ± 33) and enterprise ($96 ± 35) profit. This compelled family members to seek Off-farm income that increased with decreasing enterprise profit ($r = 0.41$, $n = 85$, $p = 0.05$).

Off-farm income

Farming households generated Off-farm income from many sources. Seventy nine percent of households obtained remuneration from employment, 51% received government welfare payments, pensions and endowments, 44% operated small businesses, 13% traded natural forest products, 13% leased land, 13% were awarded grants, insurance payments and compensation, while 2% earned bank interest and received local and foreign remittances. Highest Off-farm income values were from employment, trading and welfare that accounted for 62%, 24% and 7% respectively of total Off-farm income ($243,005) earned in 2012–2013 (OR18).

Overall short-term financial performance of farming enterprises

In the short-term, Off-farm income was a greater proportion (56%) of total farming enterprise income than On-farm income (44% including all land uses) (Fig. 5a). Forest gardens generated the highest proportion of On-farm income (31%) followed by paddy (6%), livestock (3%), plantation (2%), cash crops (1%) and *chena* (0.4%).

In contrast, Off-farm expenses were a very small proportion (7%) of total short-term expenditure in farming enterprises, (Fig. 5b). Total On-farm (all land uses) expenditure was ~ 17% of total short-term expenditure of which, FGs accounted for only 7%. Household expenditure was 76% of average total short-term expenditure ($3948 ± 307) and highest in farming enterprises.

Average total enterprise and FG profit differed between and within locations (Fig. 6). Short-term, average total FG profit ($1312 ± 345) was higher than average total enterprise profit ($1150 ± 415) across all locations, and at Polpithigama, Badalkumbura, Uva Paranagama and Hakmana.

Long-term financial performance of the On-farm component

Results are described with respect to numbers of timber and fuelwood (TFW) crop species, their Net Realisable Value (NRV) and biological assets. The composite of long-term response variables including numbers of TFW crop species, their NRV and area cultivated were investigated between land use and location factors. The multivariate PERMANOVA revealed that the long-term financial performance of farming enterprises significantly differed only between land uses (Pseudo-$F_{(8,72)} = 11.34$; $p = 0.002$). The PCO demonstrated that the long-term financial performance of FGs differed from all other land uses with respect to all response variables (OR19). Results from univariate PERMANOVAs follow.

Numbers of timber and fuelwood (TFW) crop species

Only land use influenced the number of TFW crop species in landholdings (Pseudo-$F_{(8,72)} = 25.37$; $p = 0.001$). Forest gardens had the greatest average number of TFW crop species (18 ± 1), followed by plantations (6 ± 2), cash crops (4 ± 2), *chenas* (4 ± 2) and paddy (2 ± 1) (OR20 and OR21). Numbers of TFW crop species in FGs increased with area ($R^2 = 0.23$, $p < 0.001$), and explained why large FGs had greater numbers than small FGs. Fifty eight tree species that farmers estimated NRV for were expensive timbers, of which 7% were Super Luxury class, 9% Luxury Class, 14% Special Class Upper, 3% Special class, 26% Class 1, 24% Class 11, and 17% Class 111 (State Timber Corporation 2019) (OR22).

Net realisable value (NRV) of timber and fuelwood crop species

Net Realisable Value differed between land uses (*Pseudo*-$F_{(8,72)} = 21.17$; $p = 0.001$) and was influenced by the interaction term *land use x location*

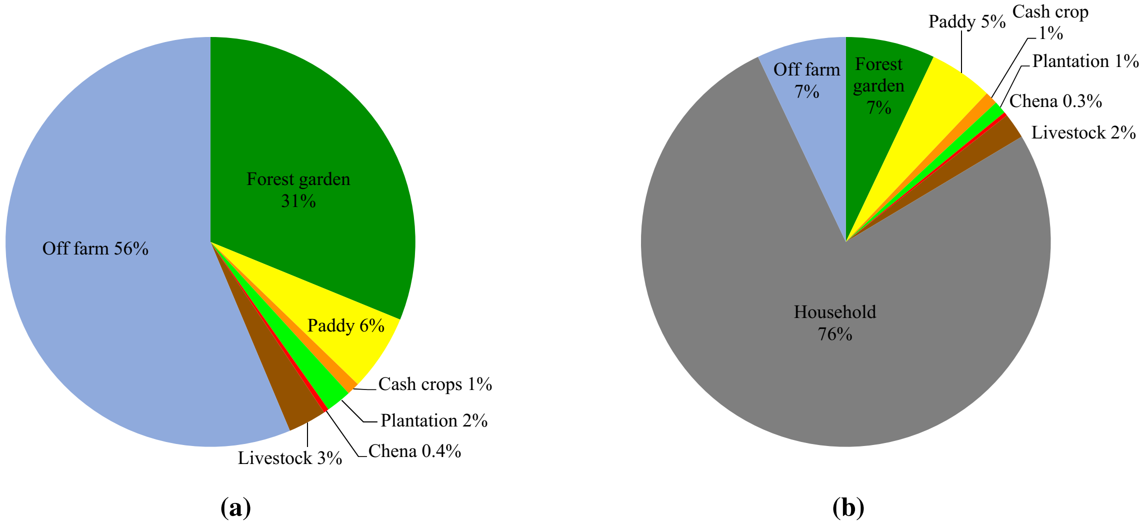
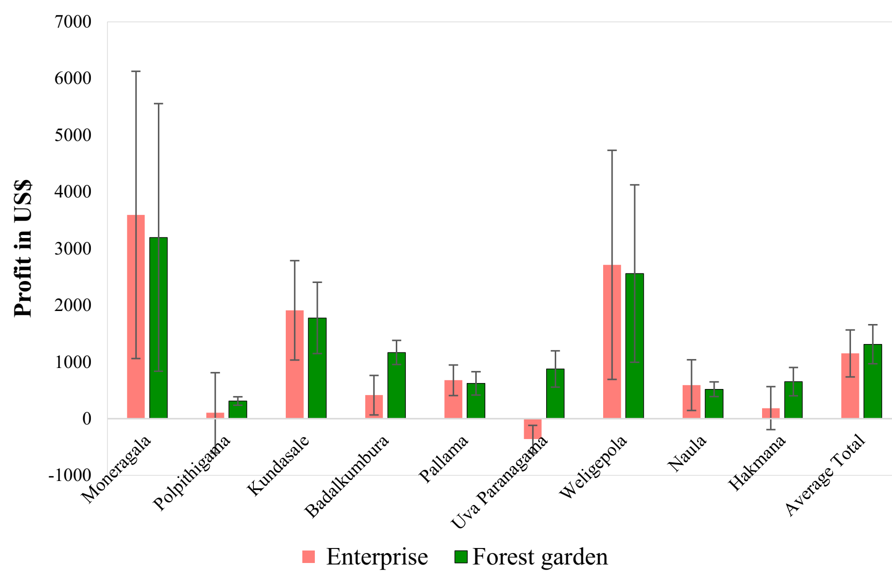


Fig. 5 **a** On-farm (forest garden, paddy, cash crops, plantation, *chena* and livestock) and Off-farm income as proportions (%) of total short-term income in farming enterprises. **b** On-farm (forest garden, paddy, cash crops, plantation, *chena* and livestock), Off-farm and household expenditure as proportions (%) of total short-term expenditure in farming enterprises. (Color figure online)

Fig. 6 Average (± SE) total profit from farming enterprises and FGs across locations in US$. (Color figure online)



($Pseudo\text{-}F_{(8,72)}$ = 3.16; p = 0.03). The effect of the interaction term was pronounced because different valuation methods were used in locations (OR6). Forest gardens had the highest average NRV (\$3349 ± 606), followed by plantations (\$1738 ± 788), *chenas* (\$668 ± 574), paddy (\$141 ± 56) and cash crops (\$146 ± 70) (OR23 and OR24). Forest garden NRV increased with increasing numbers of TFW crop species (R^2 = 0.33, $p < 0.001$), and area ($R^2 = 0.10$, $p < 0.001$).

Biological assets

The NRV of all TFW crop species in land uses and landholdings is equivalent to the total value of biological assets in farming enterprises, which in this study was \$ 170,676 across locations. Forest gardens were the main repositories for biological assets in farming enterprises because their average total NRV was 90% of the total value of biological assets from all land uses in landholdings across locations (OR25). The total number of TFW crop species was positively correlated with the total value of biological assets in landholdings ($R^2 = 0.42$, $p < 0.001$).

Overall financial performance in farming enterprises

We synthesise results of short- and long-term financial analyses and evaluate the overall financial performance of farming enterprises in the context of their Current (cash-in-hand or short-term profit in the reference year) and Non-Current assets (biological, land and livestock, or long-term assets), and Current and Non-Current Liabilities.

Non-Current assets in farming enterprises

Values of biological, land and livestock assets in farming enterprises accounted for 12%, 87% and 1% respectively of the total value of Non-Current assets ($1,377,154) across locations. Land was the farmer's largest asset and livestock the smallest. Total Non-Current asset values varied in locations owing to differences in land values (OR5), or area.

Total assets in farming enterprises

Total assets comprised Current and Non-Current assets. In 2012–2013, the average total value of Non-Current assets ($30,603 ± 5815) was ~ 96% of average total asset values ($31,726 ± 6305) in farming enterprises, and this varied in and between locations (OR26). On average, land assets had the greatest value ($26,545 ± 5578) followed by biological ($3793 ± 648), Current ($1122 ± 620) and livestock assets ($265 ± 99).

Current and Non-Current liabilities in farming enterprises

Current liabilities in farming enterprises comprised balances on enterprise expenditure incurred in the reference year including bank loan instalments and interest payable. These liabilities were either settled and adjusted in Profit and Loss statements for 2012–2013 or brought forward as Current losses into Reports of Financial position. Balances and the interest due on bank loans taken for house and building construction, purchase of vehicles, machinery or livestock were considered as Non-Current liabilities and payable over the long-term. Farming enterprises were not heavily burdened with debt since average Total liabilities (Total Current + Non-Current liabilities) across locations amounted to $291 ± 140.

Forest garden contributions to farmers' equities in enterprises

Equity is a farmer's ownership interest in the farming enterprise (Bragg 2017), and a good indicator of its financial health (Murphy 2020). Total Equity (Total assets - Total liabilities) was $1,414,577 while average Total Equity $31,435 ± 6312. The average value of FG Non-Current assets was 79% of Total Equity (OR27), attributed to elevated values of biological (OR20, 23 and 25) and land assets since FGs covered 68% of the study area (Melvani et al. 2020).

Discussion

The results of this study confirm that land use and specifically FGs determined the financial performance of farming enterprises. Although farmers maintained a portfolio of On- and Off-farm livelihood strategies, FGs were valued most because they sustained households, ensured financial wellbeing, coped with adversity, provided insurance, and made for resilient farming enterprises.

Sustaining households

Farmers concurrently adopted several On-farm livelihood strategies to sustain households. Paddy made short-term food contributions, plantations provided food and timber, while agrobiodiverse FGs with greater numbers of long-term crops provided food, fuelwood and timber across time in this and other studies (Gautam et al. 2009; Wezel and Bender 2003). Household consumption values negated cost on purchases leaving cash in family coffers as income saved. Similar experiences are described in the Philippines (Neal 2007), and Indonesia, where food expenses reduced by ∼ 10% (Arifin et al. 2012). Elevated HC values, the division of landholdings into different land uses or food production units (Wickramasinghe 1992) with high plant and crop diversity (Melvani et al. 2020) enabled greater food and fuelwood self-sufficiency in these landholdings (38%) compared to others (26%) in Sri Lanka (Landreth and Saito 2014). Nevertheless, contributions from tree-dominated, agricultural landholdings to household economies go unrecognised at the national level because HC values are not included in the calculation of Gross Domestic Product (GDP) (Grishin et al. 2019).

Similarly, the considerable time and energy that family members invest in their agricultural landholdings are usually unaccounted for in GDP calculations (Messac 2018; Sidh and Basu 2011). Households in this study were motivated because their lands had secure ancestral tenure (*paraveni*) (Melvani et al. 2020) and they desired to sustain ancestral traditions (*paramparawa*) (Melvani et al., in preparation). In the bigger picture, substantial household involvement and higher returns to labour gave FGs the competitive edge (Lipton 2005) over commercial land uses (cash crop plots and *chenas*) that used greater hired labour and external inputs, and incurred higher costs. Family farming traditions and the combination of diverse land uses, forest remnants and water bodies in the landscape mosaic, increased: agroecosystem resilience (Scherr and McNeely 2008), livelihood opportunities, and the financial well-being of farming enterprises.

Financial well-being

Forest gardens were fundamental to the financial well-being of farming enterprises. They earned the highest profits of all land uses owing to: elevated HC values, high sales income from diverse crops, and the dominance of tree crops which required minimal maintenance and incurred low expenditure. Timber sales generated extraordinary profits in FGs and served household needs for immediate and large outlays of cash (Anyonge and Roshetko 2003). In contrast, paddy cultivation was impacted by the 2012–2013 ENSO event during which alternating drought and flood events caused low yields and revenue losses compounded by high external input costs and a low market price (Dissanayake and Wipulasena 2014). Nevertheless, farmers continued to cultivate paddy because rice is a staple food.

Profits from cash crops depended on crop type and location. Purple yam was lucrative because it carried a premium export price despite high costs of seed and maintenance. Vegetable cash crops suffered price fluctuations owing to market saturation experienced when all farmers in a location cultivated the same crops each season. Although cinnamon commanded a high export price, traditional profit-sharing arrangements with cinnamon peelers reduced profits (Caron 1995). Notwithstanding these risks, farmers cultivated cash crops in anticipation of immediate and extra cash to overcome mounting household expenses. Plantations generated profit mainly from the sales and HC of coconut and timber. Although traditional *chena*s are subsistence-oriented and crop diverse (Gunasena and Pushpakumara 2015), *chena* farmers in this and other studies (Sandika and Withana 2012) cultivated commercial monocultures of maize, chillies or vegetables. Livestock management was not widespread here as in Indonesia and Vietnam (Arifin et al. 2012; Trinh et al. 2003) because cattle rearing needed space and incurred high labour costs. Conversely, poultry farming generated profits owing to low labour inputs and short turn-around times.

In this study FGs were more profitable than all land uses except cash crops because the latter had greater cultivation intensity (inputs, cultivation cycles, and space optimisation). Similarly, in Amazonia, Brazil, gross income/ha from FGs was greater than slash and burn agriculture (*chena*), commercial agroforestry (plantation), enriched woody fallows and pastures (Cardozo et al. 2015). Small FGs were more profitable (Profit/m^2) than large FGs because farmers intensified cultivation out of necessity in these and other IZ locations (Sivarajah and Wickremasinghe 2016). Profitability gauged through farmer-ascribed, monetary values for land could, according to Awasthi (2014), be influenced by productivity, income and scale of investment. This may explain why FGs, cash crops and plantations enjoyed high land values while paddy and *chenas* had low land values.

Financial efficiency in cash crops and paddy was impacted by high costs of hired labour and expensive external inputs in this and Thiruchelvam (2010) studies, whereas livestock management and plantations suffered elevated household labour values. In contrast, high gross income and low expenditure gave FGs the highest financial efficiency here and in Brazil (Cardozo et al. 2015). Financial efficiency in farming enterprises also reduced when labour was hired. This situation arose when farmers' children migrated to towns for Off-farm employment as in Kerala (Guillerme et al. 2011). Additionally, other stressors including climatic variability, animal pests and increasing household expenditure impacted the financial performance of farming enterprises.

Coping with adversity

Farmers used diverse strategies to cope with stress (Melvani et al. 2020). They adapted to climatic variability by maintaining FGs because tree crops are more resilient to drought (Bayala and Prieto 2020) and water-logging (Dimitriou et al. 2009) than annual and semi-perennial crops cultivated in paddy, cash crop plots and *chenas*. Farmers practiced diverse pest-control methods also common in other parts of Sri Lanka (Horgan and Kudavidanage 2020). Nonetheless, animal pest problems were irresolvable because human-animal conflict is an ancient and complex issue in densely populated Sri Lanka, where forest destruction and land use change have resulted in the loss of habitat and natural food abundance (Bandara and Tisdell 2002; Nahallage et al. 2008). Consequently, tree-dominant agricultural landholdings have become attractive refugia for biodiversity in this and other studies (Kudavidanage et al. 2012; Yashmita-Ulman and Kumar 2018).

The biggest issue in farming enterprises however, was mounting household expenditure on a consumer-oriented lifestyle, children's education and diverse 'non-food' items that other studies have also recognised (Esham et al. 2018; Rigg 2006). Since On-farm profit was insufficient to cover household expenses, farmers were compelled to adopt a portfolio of On- and Off-farm livelihood strategies to survive (Hoang et al. 2014; Thorlakson et al. 2012). Consequently, Off-farm income became a major contributor to enterprise income in this (56%) and other Sri Lankan studies (61%) (Landreth and Saito 2014). Although remuneration from employment offset some household expenses, income from other Off-farm sources was inadequate. For example, revenue from grants was minuscule in this study and that generated from trading natural forest products less than what farmers in Sri Lanka's Knuckles forest buffer zone earned (Gunatilake et al. 1993).

Farmers' On-farm response to stressors was to cultivate diverse short- and long-term crops in different land uses. Short-term crop choices were made in immediate response to water availability, market demand or household needs, and varied with cultivation season (Melvani et al. 2020). Farmers exhibited great skill in crop selection and land management. These skills were either inherited from ancestors and embedded in farmers' social-ecological memories (Calvet-Mir et al. 2015), or acquired through local experience. This wealth of traditional knowledge and experience (Altieri and Nicholls 2017) gave farmers the ability to cope with stress and reduce risk (Barthel et al. 2010; Nykvist and von Heland 2014). Risk mitigation, however, was not the farmer's only aim. Intermediate zone farmers in this study diversified land into cash crops because of high market demand, premium prices, and immediate returns as did Dry zone farmers (Kumari et al. 2011). Nevertheless, only farmers with access to adequate capital could cultivate cash crops as in Indonesia (Abdoellah et al. 2006). Land availability and tenure determined investments made (Kurukulasuriya and Ajwad 2007), crop selection, and how land was managed. Large landholdings diversified land use, whereas small landholdings divided land into crop micro zones as in Ethiopia and Nicaragua (Mellisse et al. 2017; Méndez et al. 2001).

Insurance

While farmers juggled with multiple issues related to their short-term livelihood portfolios, they were cognisant of the untapped wealth that timber trees in FGs represented and their importance in sustaining long-term livelihoods (Arnold and Dewees 1998). Extreme competence in tree valuation demonstrated that farmers had extensive knowledge of timber values, and skill in wealth management. Farmers in this study planted or retained diverse TFW crop species as long-term investments, similar to those in Indonesia and India (Ichwandi et al. 2007; Mohan 2004). Although large landholdings had more TFW crop species than small landholdings, it was not the number but the class of timber species that carried a premium value. Farmers knew the value of different timbers and is why they planted mixtures of e.g. *Super Luxury Class* ebony (*Diospyros ebeneum*), *Luxury Class* satinwood (*Chloroxylon swietenia*) and *Class 11*

Melia dubia trees in their youth that were converted to cash in an emergency or at old age, as in India (Chambers and Leach 1987). Similarly, in an Amazonian farmer's life-cycle, seasonal crops provide income when the family is young, while perennial crops are converted to cash at old age (Walker et al. 2002).

Forest garden timber and fuelwood species provided insurance to farmers in this study. Their NRV provided collateral for loans because most farmers were asset-rich (trees and land) albeit cash-poor, and did not sell land or pawn jewelry as easily as is undertaken in India and Bangladesh (Conroy 1992; Mohammad et al. 1992). Farmers opined here, as in Indonesia (Ichwandi et al. 2007), that biological assets were durable, easily converted to cash, and their value increased with time. Even when farming enterprises incurred short-term losses (as reflected in their Current asset values), households enjoyed long-term financial security from the biological assets and land in FGs.

Resilient farming enterprises

Forest garden contributions to enterprise income in this study (31%) were higher than intensively cultivated household enterprises in Java (20.9%) (Arifin et al. 2012). They generated the highest On-farm, short-term profits or Current assets, and the average value of FG Non-Current or long-term assets amounted to 79% of Total Equity. Forest gardens were farmers' core ownership interest, and the financial contributions they made underpinned the resilience of family farming enterprises.

Conclusion and recommendations

Forest gardens were financially important to IZ farmers in Sri Lanka because they sustained short- and long-term livelihoods despite concurrent impacts of multiple stressors. This study recommends that FG financial contributions to national economies be considered at an enterprise scale and not merely as random revenues generated by a few commercially important FG crops. Household consumption and contribution values from FGs warrant inclusion in agricultures' contribution to GDP, food self-sufficiency, and food security metrics in Sri Lanka and other tropical countries. We recommend that remnant forest patches be conserved as integral components of the agricultural landscape mosaic in Sri Lanka and other densely populated tropical countries because they provide habitat for animal pests who would otherwise continue to disturb crops and lower the financial performance of agricultural landholdings.

Acknowledgements This research was supported by an Australian Postgraduate Award and operational funds provided by Charles Darwin University. Farmer respondents gave generously of their time and knowledge to this study. Special thanks to Associate Professor Natasha Stacey of Charles Darwin University, and Dr. Nigel Turvey. We extend our gratitude to the Future In Our Hands Organisation, Weligepola Womens Society, and Sri Lanka: Forest, Export Agriculture and Census and Statistics Departments for facilitating this study. Field assistance provided by Mr. Muditha Kularatne is gratefully acknowledged. This study would not have been possible without the technical support of Mrs. Damayanthi Kodikara, the late Mrs. Rohini Perera, and Ms. Dilukshi Theswa of the Neo Synthesis Research Centre, and Mr. Gopal Iyer. Sincere thanks also to Dr. C.R. Panabokke, Mr. Leopold Amerasinghe, Prof. Lisa McManus, Dr. Keith McGuiness, Dr. Muditha Heenkenda, Ms. Bernadette Royal, Ms. Jeevani Perumbuli, Mr. V.R. Perera, Ms. Parveen Dassanaike and Mr. Feisal Mansoor for their contributions.

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