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Influence of labour availability on smallholder cropping systems in two Agro Climatic Zones of Sri Lanka

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Abstract
The overall aim of this study was to determine how the availability of labour influences smallholder cropping systems in four selected villages representing two different agro-climatic zones of Sri Lanka. Four villages were selected and stratified random sampling was used to derive a representative sample of 92 households from each village. Chi-square test and General Linier Models were used to analyse parametric and non-parametric data collected through semi-structured interviews, direct observations, farmer recorded data and Rapid Rural Appraisal. This study found that no marked variation in farmer knowledge was observed for most of the selected crops, but knowledge did vary significantly between villages and in relation to cultivation activities of rubber. Also, farmer knowledge of nursery management was strongly dependent on the length of experience in cultivation of rubber, e quality of extension services and knowledge received from outside areas. Study ascertained that an increase in the level of farmer knowledge resulted in an increase in the survival rate of rubber plants in the nurseries and vice versa. Further, when land size was large with a labour intensive crop, farmers tended to use hired labour, but when land size was small (< 1 ha), family labour was predominantly used. Significant gender divisions in labour activities were observed for tea, rubber, paddy and chena crops compared with homegarden crops and banana. More manual labouring activities were undertaken by women than men and high-income smallholders were found to prefer female hired labour because women work more effectively and for lower wages than men. Low-income female-headed families, consisting of only female members were limited in their ability to choose chena crops, paddy, rubber and tea, due to the lack of male labour for slashing and burning and for protecting chena crops at night, ploughing and harrowing of paddy land and land preparation of tea and rubber. The findings derived from this study will be useful for agricultural policy makers and on-farm researchers in helping to identify the most important issues for raising smallholder agricultural productivity.

Keywords: labour availability, farmer knowledge, seasonality of labour, gender, smallholdings

Introduction

Labour availability is dictated by number of people in an area and their skills as well as the seasonality of labour, supply and demand. Although the number of people may be sufficient, farmers may face problems with a scarcity of skilled labour. Many harvesting activities in different crops, including tapping rubber (*Hevea brasiliensis*), plucking tea (*Camellia sinensis*), tapping coconut (*Cocos nucifera*) and peeling cinnamon (*Cinnamomum zelanicum*) require a degree of skilled labour (FAO, 1992). Therefore, the limitation on some crops in particular regions can be seen in Sri Lanka due to the scarcity of skilled labour. Particularly, cultivation of cinnamon is largely concentrated in the Southern regions of Sri Lanka, where skilled labour can still be found to peel the cinnamon bark (Jayasuriya, 1977). Availability of skilled labour not only limits what crops are grown where but it may also affect the quality and amount of production, as yield is strongly related to farmer knowledge and experience (Levi and Havinden, 1982) [31]. Also, in the case of labour, specific times are required for different operational activities in different crops, particularly for seasonal crops compared with permanent crops. Consequently, seasonality in labour costs occurs due to interactions between demand and supply of labour (Gunesekara, 1980; Muqtada and Alam, 1986) [17, 32, 34]. Permanent crops are sometimes attractive because of their low labour costs compared with seasonal crops. Consequently, permanent crops are more prevalent where wages are high and labour is in short supply (NRI, 1993) [36]. Harwood (1979) [23] suggested that an increase in labour leads to better weed control, more planting and complete harvesting. The personal characteristics of farmers in the labour force have great relevance to the pattern of agriculture (Hill and Ray, 1987) [24], returns of the farms (Levi and Havinden, 1982) [31] and the choice of the actual cropping systems (Wiersum, 1982). Farmers tend to adopt new technologies and farming methods based on profitability, risk, contribution to food supply and labour requirement (Carter, 1995) [10]. Also, relationships between land size, labour use patterns and land productivity indicate that small farms with access to a higher proportion of family labour, take better care of the land, and increase the cropping intensity, which all result in an increase in land productivity over that on large or medium sized farms (Ahmed, 1981; Hirashima and Muqtada, 1986; Stirling *et al.*, 2002) [3, 17, 32, 34, 46].

Despite its importance, there has been limited in-depth research on the effects of labour availability on decision-making in smallholder cropping systems in Sri Lanka. Most research has mainly focused on environmental and socio economic status of rubber-based cropping systems at the estate and smallholder levels (Gunarathne and Wesumperuma, 1984; Sinnathamby and Wickramasekara, 1984, Edirisinghe *et al.*, 2005; Rodrigo, 2001; Rodrigo *et al.*, 2001; Dissanayake *et* *al.*, 2005a; Dissanayake *et al.*, 2005b; Dissanayake *et al.*, 2010; Dissanayake *et al.*, 2012) [16, 42, 43, 12, 13, 14, 15, 16] and paddy cultivation, with little known regarding the effects of labour availability on homegardens in Sri Lanka, other than Kandyan homegardens and chena cultivation. The overall aim of this study was to determine how the availability of labour influences smallholder cropping systems in two different agro-climatic zones of Sri Lanka (Wet and Intermediate). The specific objectives were to gain a better understanding of (i) differences in the number of people and their skills between villages and for specific crops, (ii) the labour requirements and seasonal changes in labour demand for different crops and (iii) the combined influence of labour amount, seasonality of demand, skill and gender on cropping systems.

Materials and methods

Four villages, two from the Intermediate Zone (*Pallekiruwa* and *Bookandayaya*) and two from the Wet Zone (*Kobawaka* and *Pannila*), were selected for comparison in this study, because of the important differences shown in land use systems, development, crops grown, social structure, history of the communities and type the extent to which family, hired and shared labour were used (Jayasundera, 1998; Thennakoon, 1998) [29. 48]. Specific crops were chosen for case studies, these included two permanent crops: rubber and tea, two homegarden crops: pepper and arecanut, seasonal crops including paddy and millet grown under chena cultivation and banana (*Musa spp*.). These were chosen in order to compare issues relating to labour such as labour skills, labour inputs, gender divisions of labour and labour type used on-farm activities. Stratified random sampling was used to derive a representative sample of households for the present study. Thereafter, 24 households, including a minimum of 3 households for each crop, were selected as a representative sample from each village.

Data collection

Four different forms of analyses were undertaken at the village-level relating to; (i) labour requirements of selected crops, (ii) seasonal changes in labour demand, (iii) the survival rate of banana plants with labour availability and (v) survival rate of rubber with labour skills. To achieve this, several different methods were used including; population studies, documentation of seasonal calendars, semi-structured interviews, direct observations of farmer practice, collection of farmer recorded data and Rapid Rural Appraisal (RRA) (Thennakoon, 2002) [46, 49].

Farmers were interviewed on major key areas of rubber cultivation such as land preparation (including lining and pegging, digging holes and soil conservation), raising seedlings in polybag nurseries, fertiliser application, pest and disease control and tapping of rubber. Dependent on the information collected on these key aspects, labour skills were categorised as high, medium, low and very low for analysis of differences in labour skills between villages and for different cultivation activities across the villages.

Whilst collecting the ethnographic data, marked differences were observed between villages in the survival rate of rubber in the nurseries. Therefore, it was assumed that different skill levels in nursery management might be responsible for differences in survival rate of rubber between the selected villages. Farmer knowledge on nursery management was reflected in activities such as selection and storage of soil for packing plants, pruning the budded stumps provided by rubber extension officers, filling the polythene bags as recommended by Rubber development officer, planting of budded stumps in the bags, selection of the place for storage of rubber plants, maintenance of nurseries, watering, and identifying and controlling diseases. Taking the level of knowledge in these areas of nursery management into account, the level of farmer knowledge was categorised as high, medium, low and very low. Association between the level of farmer knowledge and the survival rate of rubber plants were also tested. Farmer knowledge was dependent upon many socio-economic factors such as quality of the extension services, measured in terms of the number of visits made to an individual nursery by rubber extension officers and the number of training programs attended by household members, experience in cultivation of rubber (years) and knowledge received from the previous generation (yes/no) and outside friends (yes/no). Data relating to the aforementioned variables were also collected in order to test associations between farmer knowledge and these socio-economic factors. Percentage survival of the 225 rubber plants issued per nursery was recorded over a period of 10 months for 56 rubber nurseries in the four selected villages.

Assumptions were made regarding gender divisions of labour for different cultivation activities and crops. Gender groups for labour were classified into male, female and mixed including children in some cases. Data for the analysis of gender divisions of labour were collected using semi-structured interviews and direct observations. However, because it is rare to find a particular activity allocated to a particular gender in the cultivation of homegarden crops, data were collected only for tea, rubber, paddy and chena crops.

Data for the type of labour used were collected based on crop activities, because for the same crop some activities depend on family labour, whilst others depend on hired labour. Labour inputs for cultivation activities such as land cleaning, digging holes, and establishing drains and terraces, planting and weeding in rubber, tea, homegarden crops and banana were collected separately from the seasonal paddy and chena crops. Data for total labour inputs for each cultivation activity and for each crop were collected in terms of labour days. The term labour day is controversial, because different countries have identified the units of labour input per day differently. For example, India considers a labour day equal to 8 hours work, whilst China and Taiwan denote 10 hours (Ishikawa, 1978). However, in this study a labour day was taken as 8 hours.

The analysis of seasonal labour demand was considered only for seasonal crops (paddy and chena crops) that have a marked seasonal variation in labour requirement. Data for the analysis of seasonal labour demand were collected using semi-structured interviews, direct observations and seasonal calendars drawn up by farmers in small groups. As a first step, specific times required for each activity were determined by interviewing individual farmers within the sample. Also, direct observations further helped to confirm the reliability of the data collected from the above method. Furthermore, small group meetings involving both men and women together and separately were conducted in each selected village towards the end of the ethnographic study in order to gain a representative view of the seasonal labour demand. Although, time of starting farming activities differs between agro-climatic zones, there are no marked differences in labour demand for activities (Thilakarathne *et al.*, 1997) [51]. Therefore, a single diagram for seasonal labour demand is presented in this study, with data normalised for time within the cropping cycle rather than relation to time of year.

Relationship between survival rate of banana and level of weeding and family labour availability was known by researcher-led on-farm trials on rubber/banana intercropping which were established by the Rubber Research Institute of Sri Lanka (RRISL) in each of the four selected villages involving a total of 18 farms (Senevirathna, 2001) [45] and ran concurrently with the ethnographic studies. Banana plants were established in each field with survival rates differing widely between smallholdings. It was important to identify the reason (s) for such large differences in survival rate of banana and one assumption was that the rate of survival of banana was strongly dependent on the level of weeding and hence labour availability. In order to test this hypothesis, the number of banana plants were recorded at two stages of growth; at establishment and at 8 months after planting. The % survival rate for each farm was then calculated. At the same time the level of weeding was recorded several times during the first 8 months after planting and each farm was categorised according to the frequency of weeding; frequent (once per month), less frequent (once per two months) and seldom (two times per 8 months). In addition, the availability of labour for weeding was categorised as high, medium and low.

Data analysis

The series of associations between i) level of labour skills for rubber and socio economic indices such as number of visits made to a particular smallholding by extension officers within a year, experience in cultivation, knowledge received from the previous generation and outside friends in relation to rubber, were analysed using two-way chi-square tables (non-parametric data). Likewise, chi-square analysis was used to test if there were any significant associations between (a) cultivation activities and gender, labour type and labour skills. General Linear Models (Proc. GLM) were used to analyse the relationship between survival rate of banana and level of weeding and the availability of labour (parametric data). Also, survival rate of rubber plants in the nurseries and village location, knowledge on nursery management and socio-economic indices were tested using similar models as for survival rate of banana. Labour inputs per cultivation activity were analysed in terms of the average labour inputs per activity from 96 households. Summary statistics including chi-square value, degree of freedom and p value with absolute counts were presented for chi-square tests, whilst GLM results were presented in terms of LSMEANS, R square (r^2) and the corresponding p value.

Results

Association between cultivation activities, labour skills, labour type and gender

The level of labouring skills for rubber cultivation differed significantly between villages X^2 (N = 484, df = 9) = 180.59, p≤0.001, with the most marked effect being the low skill levels of households in the Intermediate Zone (*Bookandayaya* and *Pallekiruwa*). In contrast, no households in the Wet Zone were categorised as very low in terms of labouring skills, with the majority classified with high or medium skill levels (Fig. 1).

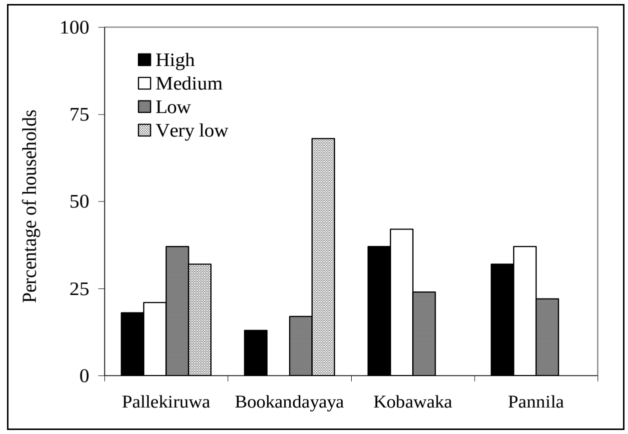

Fig 1: Comparison of villages in terms of the level of labouring skills for rubber cultivation. A total of 22, 10, 21 and 20 households (rubber grown) were interviewed in *Pallekiruwa, Bookandayaya, Kobawaka* and *Pannila*, respectively.

Comparison of labour skills between crop activities in rubber cultivation are summarised in Figure 2. The level of labouring skills was strongly dependent upon the particular cultivation activity undertaken for rubber, X^2 (N = 484, df = 15) = 566.12, p≤0.001. The level of skill in weeding was high across all four villages, whilst there were no households with either high or very low skill levels when it came to raising polybagged rubber (Fig. 2). Skill levels varied quite widely in activities such as land preparation, fertiliser and pesticide application and tapping. Approximately 50% of households had high labouring skills in land preparation (including lining, pegging, digging holes and establishing terraces and drains), whilst the majority of households had very low tapping skills, with a further 8% and 38% of households categorised with high and medium skill levels.

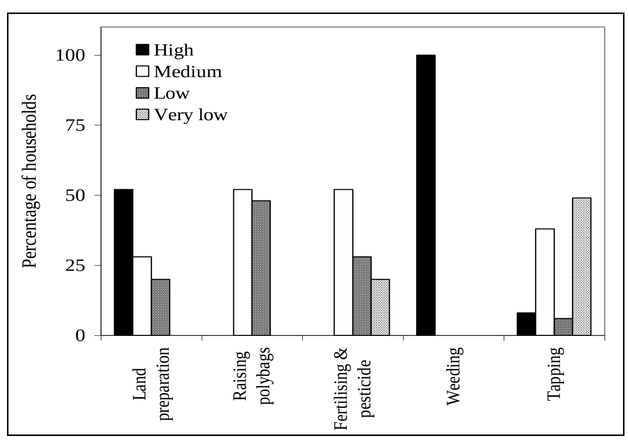

Fig 2: Comparison of labouring skills according to rubber cultivation activities across all four villages of *Pallekiruwa, Bookandayaya, Kobawaka* and *Pannila*. Data are shown as a % of the total of 73 households (rubber grown) interviewed in four villages.

Spatial variation in survival rate of rubber plants

Table 1 summarises the average survival rate of rubber plants in the nurseries in different villages. Survival rate differed significantly between villages (p≤0.001). Both Wet Zone villages recorded the highest average survival rate (*ca.* 92%) whilst *Bookandayaya* had the lowest (54%). *Pallekiruwa* performed better (73%) survival rate compared to *Bookandayaya* in the same agro-climatic zone.

Table 1: Summary of GLM analysis comparing villages in terms of the average survival rate of rubber plants where values represented the average number of plants per nursery (%) with a total of 56 nurseries ± SEM together with the p value and degrees of freedom.

Villages	Average survival rate of rubber plants (%)
Pallekiruwa	73 ± 4.6
Bookandayaya	54 ± 7.3
Kobawaka	93 ± 12.5
Pannila	92 ± 9.0
P value	≤0.001
Degrees of freedom	55

Association between survival rate of rubber and farmer knowledge

The relationship between different levels of farmer knowledge on nursery management and the average survival rate of rubber plants is summarised for a total of 56 rubber nurseries in Table 2. Survival rate of rubber plants was significantly dependent on the level of farmer knowledge (p≤0.001). When farmers' knowledge was categorised as high, survival rate of rubber was the highest (89%) and with very low farmer knowledge, survival rate was extremely low (3%).

Factors influencing level of farmer knowledge

Table 3 summarises the factors determining the level of farmer knowledge on nursery management across the four selected villages, with chi-square test indicating that farmer knowledge was strongly dependent on the information and advice received from outside friends, X^2 (N = 56, df = 3) = 37.35, p≤0.001 and the number of visits made to a particular nursery by rubber extension officer within a year, X^2 (N = 56, df = 24) = 48.76, p≤0.002. There was no association between experience in cultivation of rubber or level of farmer knowledge, whilst information and advice handed down from previous generations had little influence on farmer knowledge (p≤0.012). Similar analysis done for the individual villages showed that farmer knowledge was significantly associated with the experience in cultivation of rubber in the villages of the Wet Zone and the number of extension visits and knowledge received from outside friends in *Pallekiruwa* and *Bookandayaya* (data not shown).

Table 2: Summary of GLM analysis of the relationship between the level of farmer knowledge specifically for nursery management of rubber and average survival rate of rubber plants where values represented the average number of plants (%) per nursery for a total of 56 nurseries ± SEM together with the p value and degrees of freedom.

Farmer knowledge	Average survival rate of rubber plants (%)
High	89 ± 0.9
Medium	68 ± 1.9
Low	38 ± 2.1
Very low	3 ± 2.8
P value	≤0.001
Degrees of freedom	55

Table 3: Summary of chi-square analysis of the relationship between the level of farmer knowledge specifically for nursery management of rubber and a range of socio-economic indices. Data are pooled for all four villages showing the chi-square values, p value and degrees of freedom (DF). A two-way chi-square analysis was performed using the null hypothesis that there was no association between farmer knowledge and the socio-economic indices.

Relationship	Chi- square value	DF	P value
Farmer knowledge: Number of extension visits	48.76	24	≤0.002
Experience in cultivation of rubber	31.48	36	0.684
Knowledge from previous generation	10.95	3	≤0.012
Knowledge from outside friends	37.35	3	≤0.001

Gender division in labouring activities

Allocation of labouring activities was strongly dependent upon gender in four crops; rubber, tea, paddy and millet, p≤0.001 (Fig. 3). In the case of rubber, land preparation was undertaken by males in *ca.* 77% of households, or by both men and women in *ca.* 23 % of households (Fig. 3a). In contrast, harvesting (tapping) was predominantly a female (50% of households) or mixed (men and women) activity. All other activities such as raising of polybags, planting, fertiliser and pesticide application and weeding were undertaken mainly by both men and women (Fig. 3a). Gender division in labouring activities for tea was similar to that of rubber in terms of land preparation, raising of polybags and planting. However, women in the majority of households were responsible for harvesting tea leaves (100% of households), weeding (95% of household) and fertilising (65% of households), respectively, whilst the majority of men engaged in land preparation (Fig. 3b).

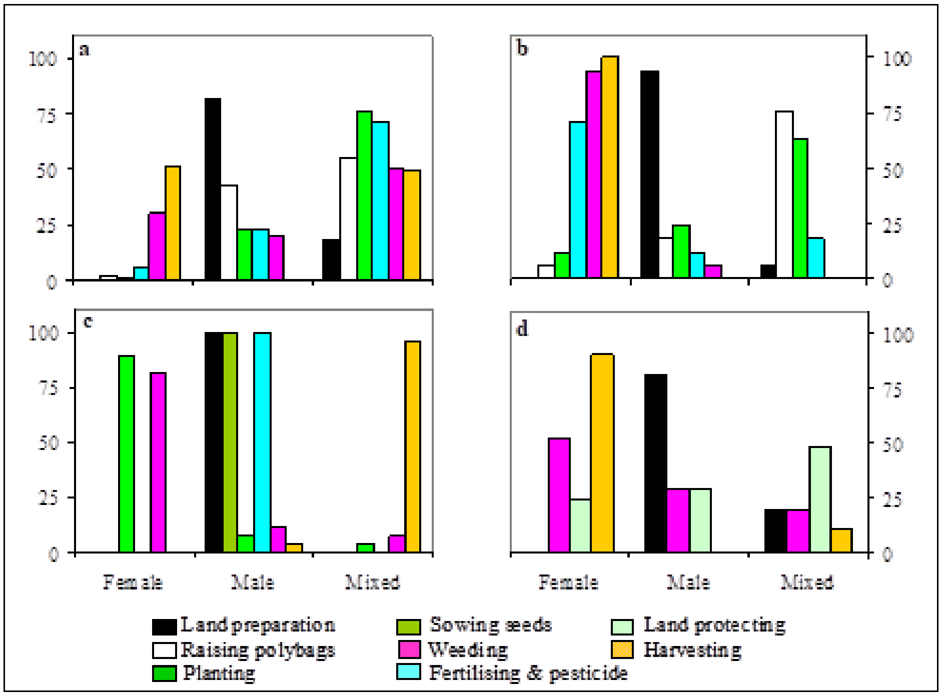

Fig 3: Comparison of gender divisions according to cultivation activity for the crops; (**a)** rubber, **(b)** tea, **(c)** paddy and **(d)** millet. Data are pooled for all four villages and values represent the % of the total of 73, 19, 55 and 40 households grown rubber, tea, paddy and millet, respectively.

Paddy cultivation activities were predominantly undertaken by men, with males in 100% of households being responsible for land preparation, sowing and application of fertiliser and pesticide (Fig. 3c). The majority of females *ca*. 98% and 89% undertook transplanting and manual weeding activities, respectively. In all households, both men and women harvest the rice crop. In the case of chena cultivation, manual weeding and land protection were the responsibility of either solely men or women, or a mixture of both, whilst harvesting and land preparation were predominantly female and male tasks, respectively (Fig. 3d).

Type of labour used for different crop activities

The type of labour used in cultivation of millet, paddy and rubber across all four selected villages is summarised in Figure 4. Summary statistics indicate that the type of labour used was strongly dependent on the cropping activity for all three crops ($p \leq 0.001$). In the case of rubber, the majority of households (60%) used hired labour for initial land preparation, whilst the same percentage of households used family labour for raising polybagged plants and fertilising. Family and hired labour contributed a significant component of the labour in all rubber cultivation activities, whilst a combination of family and hired labour was also used across the broad spectrum of cultivation activities, albeit in fewer households. Shared labour was not used for activities such as fertiliser and pesticide application, weeding or tapping. Family labour was the dominant source of labour for chena crop cultivation such as millet (Fig. 4b), with as many as 99% of households having used family labour for planting or sowing seeds. Only in the case of slashing/burning and harvesting was family labour outnumbered by shared labour. Hired labour was seldom used in millet cultivation, with at most 19% of households using hired labour for slashing/burning (Fig. 4b). Family labour was again a dominant source of labour in most activities of paddy cultivation, apart from land preparation, transplanting, weeding and harvesting where shared labour or hired labour predominated (Fig. 4c).

Labour demand

Average labour days per hectare for different activities such as land preparation, transplanting, sowing seeds, weeding, fertilising and harvesting in paddy cultivation are summarised in Figure 5a. Harvesting of paddy required the highest labour days (95) followed by transplanting (60) and land preparation (35). Sowing seeds, manual weeding and transplanting and chemical weeding involved medium labour. As might be expected, lot of farmers (42%) practised the method that required the smallest labour days while fewer farmers (12%) adopted the most labour intensive method. Labour inputs for new plantings of tea and rubber are presented in two forms, either according to cropping activity or growth stage of the crop. The most labour demanding activities are harvesting (54% and 52% of the total labour days) followed by establishment (34% and 36% of the total labour days) and maintenance (12% and 12% of the total labour days) in both tea and rubber, respectively.

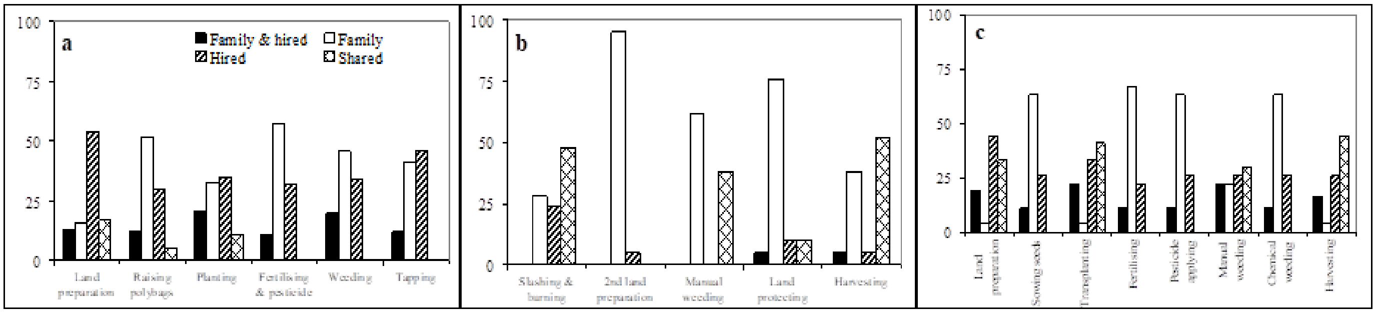

Fig 4: Type of labour used for different cultivation activities of **(a)** rubber, **(b)** millet and **(c)** paddy. Data are pooled for the four villages (*Pallekiruwa*, *Bookandayaya*, *Kobawaka* and *Pannila*) and values represent the % of the total of 73, 55 and 40 households grown rubber, paddy and millet, respectively.

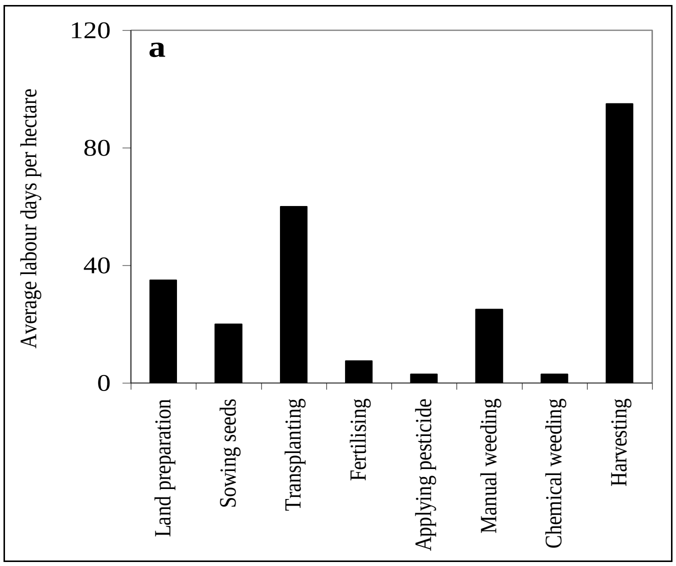

Fig 5a: Summary of the average labour days for different cultivation activities in paddy. Data are pooled for the villages of *Pallekiruwa* and *Kobawaka*.

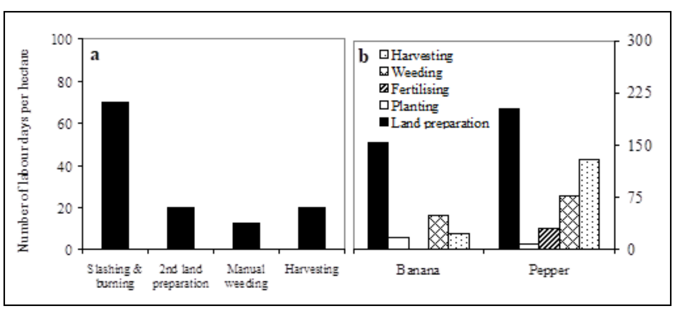

Fig 6: The average number of labour days per hectare for different cultivation activities in **(a)** millet and **(b)** banana and pepper. In the case of banana, the average labour days for all four banana varieties (*Embule, Embune, Rath kesel* and *Kolikuttu*) are shown.

Seasonality of labour demand

The seasonal cycle in labour demand over the two paddy growing seasons of *Maha* and *Yala* is shown in Figure 7. The *Maha* season lasts for approximately 24 weeks from mid October to the beginning of March and within this period three main activities; land preparation and transplanting, harvesting and other activities including fertilising, weeding and irrigation are undertaken. The peak seasons in labour demand in *Maha* and *Yala* seasons are October to December, February to March, March to mid June, and August to September where the main operational activities are undertaken (Fig. 7).

Comparing the allocation of time to different farming activities between seasons indicates that the *Maha* season is more flexible than the *Yala* season. Land preparation and transplanting in the *Maha* season takes *ca.* 8 week whereas in the *Yala* season the same activity is done within only 6 weeks. In the case of paddy farming in *Kobawaka*, the major reason for these differences in allocation of time is because of the timing of rainfall that affects the requirement for labour to tap rubber, which is not done when it is raining. In the *Yala* season, farmers have to struggle to complete their paddy farming activities more than that in the *Maha* season, because there is more restricted release of farm labour (Fig. 8).

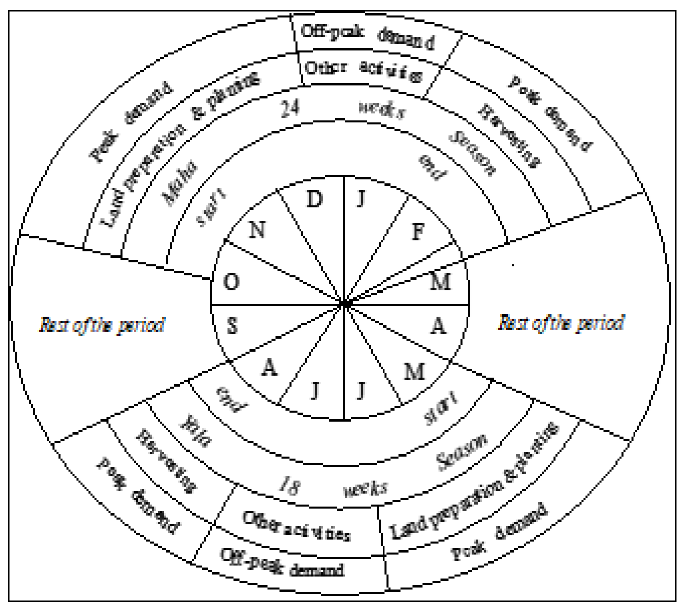

Fig 7: Seasonal changes in labour demand associated with different cropping activities in paddy cultivation. The two main paddy growing seasons known in Sinhala as *Maha* and *Yala* are shown (*ca.* 24 and 18 weeks duration, respectively) with rest periods in between when labour is allocated to other on-farm and off-farm activities. Activities taking place during peak and off-peak periods in labour demand are shown, with “other activities” referring to weeding, fertiliser and irrigation. Months of the year are indicated in the centre of the diagram.

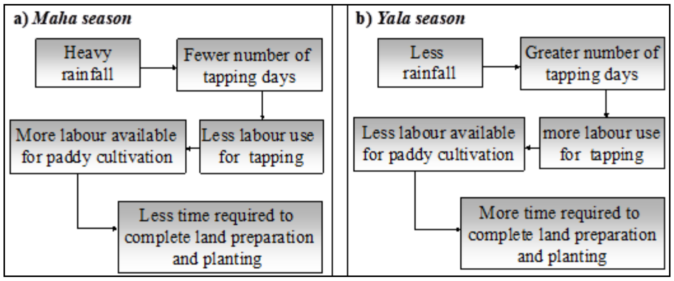

Fig 8: Schematic diagram showing the relationship between rainfall, tapping days, labour and time available for paddy cultivation. Qualitative relationships are shown for the *Maha* (October-March) and *Yala* (March-June) seasons in the villages of the Wet Zone of Sri Lanka.

The seasonal labour demand for different cropping activities in chena cultivation is shown for the *Maha* and *Yala* seasons in Figure 9. The *Maha* season lasts *ca.* 20 weeks compared to 18 weeks for the *Yala* season. Within each season, different types of activities; initial land preparation (including slashing/burning *etc.*) and planting or sowing seeds, harvesting and other activities such as weeding, protecting lands from wild animals are carried out. The peak seasons in labour demand during the *Maha* and *Yala* seasons are August to mid October, end of March to June, December to mid January and June to July where the main operational activities of land preparation and planting or sowing seeds and harvesting are undertaken (Fig. 9).

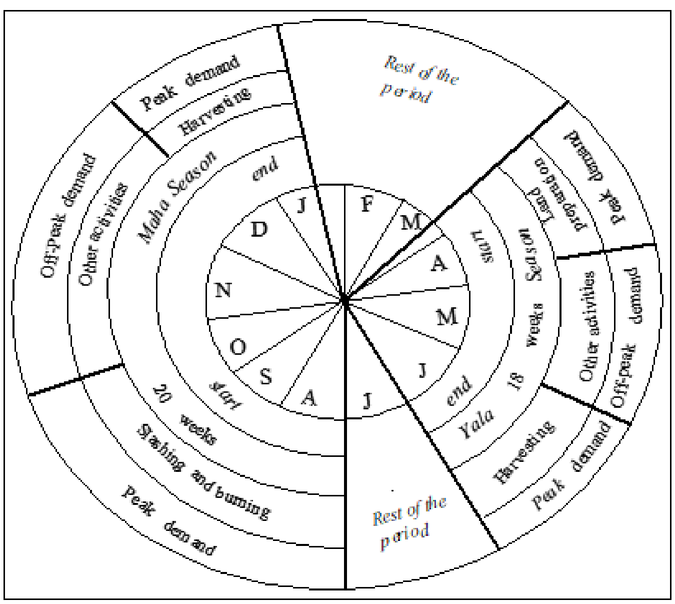

Fig 9: Seasonal changes in labour demand associated with different cropping activities in chena cultivation. The two main chena crops cultivating seasons known in Sinhala as *Maha* and *Yala* are shown (*ca.* 20 and 18 weeks duration, respectively) with rest periods in between when labour is allocated to other on-farm and off-farm activities. Activities taking place during peak and off-peak periods in labour demand are shown, with "other activities" referring to weeding and protecting from wild animals. Months of the year are indicated in the centre of the diagram.

A case study of Banana

Overall, over 60% of growers ranked flexibility of labour requirements for growing banana, because there is no seasonal labour demand for completing activities, as the most important reason for cultivating the crop (Table 5.7).

Table 4: Summary of how banana growers prioritise the different reasons for cultivating banana, with data presented as the % of the total banana growers (*i.e.* 353) that gave 1st 2nd and 3rd priority to each of the four reasons.

Reasons for growing banana	Priorities		
	1st	2nd	3rd
Flexibility of labour or no seasonal labour demand for doing activities	61	20	4
Less production cost	5	3	1
Good market is available	1	2	1
Knowledge of banana cultivation	2	-	-

Factors determining the survival rate of banana plants

Survival rate of banana was closely related to the level of weeding (p≤0.001) and labour availability (p≤0.001). Survival rate was highest for those fields that were frequently weeded, with a survival rate of 65%, whereas survival rate was less than 1% in fields that were rarely weeded. On the other hand, for households where labour availability was high, the survival rate of banana plants was correspondingly high (71%), whilst the rate was less than 1% in households with low labour availability (Fig. 5.18). Finally, as might be expected, the level of weeding was found to be highly dependent upon labour availability, X^2 (N =18, df = 4) = 30.273, p≤0.001(Appendix 5.3).

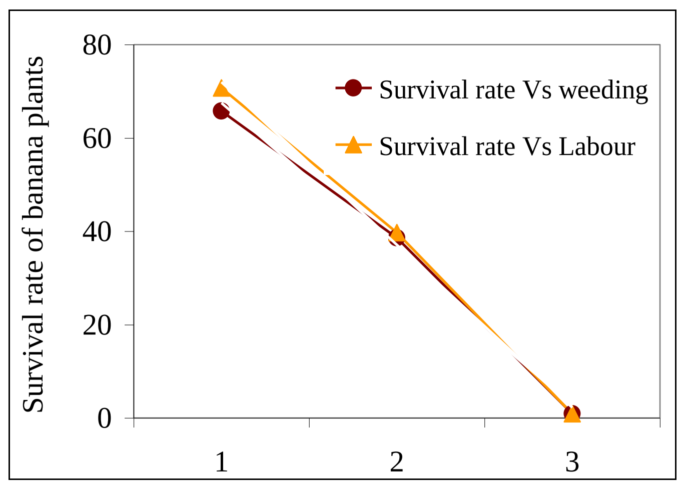

Fig 10: Regression analysis of the relationship between survival rate of banana plants and (i) level of weeding (r^2 = 0.652, p≤0.0004) and (ii) labour availability (r^2 = 0.664, p≤0.0003). Data were collected from 18 families in the selected four villages (*i.e. Pallekiruwa, Bookandayaya, Pannila* and *Kobawaka*). The x-axis refers to the ranking of the quality of weeding and labour availability (*i.e.* 1=frequent and high, 2=less frequent and medium and 3=seldom and low). Survival rate of banana are presented in terms of the Least Square Mean (LSM) for two stages of growth; at establishment and 8 months after planting.

Discussion

No marked variation in farmer knowledge was observed for most of the selected crops, but knowledge did vary significantly between villages and in relation to cultivation activities of rubber ($p<0.001$), (Figs. 1and 2), as was previously described by Raedeke and Rikoon (1997; Nathalie, 2015) [35, 37]. The lower level of knowledge in the Intermediate than Wet Zone most probably reflected the lack of long-term experience of farmers in the cultivation of rubber, which had only recently been introduced at the smallholder level. In particular, farmer knowledge of nursery management was strongly dependent on the length of experience in cultivation of rubber in *Kobawaka* and *Pannila,* and on the quality of extension services and knowledge received from outside areas, in *Pallekiruwa* and *Bookandayaya*. These findings are consistent with the observations made by Talgaswatte (1995) [47] on rubber smallholdings in Sri Lanka and Arega *et al.* (2005) [6] on alternative cropping systems in Ethiopia.

Land preparation required more labour input than other activities, except for paddy, rubber and tea where labour inputs were greatest for harvesting (Figs. 5a and 6), which resulted in the hiring of labour in combination with shared labour (Fig. 4). This is broadly consistent with other studies in Sri Lanka (Chinnappa and Silva, 1977; Jayasena and Herath, 1984; Talgaswatte, 1995) [47]. Application of fertiliser and pesticide, sowing seeds and chemical weeding were all less labour intensive than land preparation, harvesting, transplanting and manual weeding and depended mainly on family labour (Fig. 4) as has been previously noted (Talgaswatte, 1995; Gastao *et al.*, 2007; Thomas, 2010) [47, 52]. Cultivation of pepper, arecanut and banana depended mainly on family labour as has been generally suggested for these crops in Sri Lanka (Jayasena and Herath, 1986a; Jacob and Alles, 1987; FAO, 1992; Rodrigo, 2001) [17, 32, 34, 42, 43, 28], but it is noteworthy that other labour sources were required for the establishment of terraces in pepper and digging holes to plant banana. Ahmed (1981) [3] and Elahi and Khan (1986) [17] observed that the type of labour used depended on the size of land allocated to different crops, so that smallholders used different types of labour on different occasions, for example, when land size was large with a labour intensive crop, farmers tended to use hired labour, but when land size was small (< 1 ha), family labour was predominantly used.

As was previously investigated by Mendez *et al.*, (2001) [33] elsewhere, significant gender divisions in labour activities were observed for tea, rubber, paddy and chena crops compared with homegarden crops and banana (Fig. 3), with strong variation in the labour requirement of different crops (Figs.5 and 6). Activities such as ploughing, harrowing of paddy land and slashing and burning of chena land were mainly undertaken by men (Berger, 1992), whilst transplanting, weeding and harvesting of chena crops such as millet were undertaken by women (Fig. 3), in accordance with the findings of previous studies (Atapattu, 1997; FAO, 1996; as cited in Huvio, 1998; Abhayarathna, 2001) [7, 25, 1]. However, the situation differed between villages where different techniques were used for land preparation through to harvesting and threshing. For example, farmers use water buffalo in *Pallekiruwa* and therefore male labour was still predominant, but in *Kobawaka* people use machinery such as tractors and combined harvesters. Similar contrasts in gender roles across sites in Sri Lanka have been noted by Thilakarathne *et al.* (1997) [51]. As Tiffen and Mortimore (1990) [53] and Talgaswatte (1995) [47] stated, there were no clear gender divisions in labour used for cultivation of permanent crops (tea and rubber), except tea plucking (Fig. 3) which in any case, is mostly done by women. Consistent with previous studies of Chinnappa and Silva (1977), NRI (1993) [36], Fafchamps and Qusumbing (1999) [19] and Abhayarathna (2001) [1] more manual labouring activities were undertaken by women than men and high-income smallholders were found to prefer female hired labour because women work more effectively and for lower wages than men.

Gender divisions of labour in cultivation activities had a significant influence on the selection of cropping system as has been found more generally (Adesina *et al.*, 2000; Erick *et al.*, 2017) [2, 18], and is consistent with the majority of activities in chena, paddy, rubber and tea crops being differentiated according to gender (Fig. 3). As a result low-income female-headed families, consisting of only female members were limited in their ability to choose chena crops, paddy, rubber and tea, due to the lack of male labour for slashing and burning and for protecting chena crops at night, ploughing and harrowing of paddy land and land preparation of tea and rubber. These findings are in accordance with the study of Makintosh (1989). In *Pallekiruwa* and *Bookandayaya*, these low-income female-headed households solved their labour problems by sharing labour with other families (Olenja, 1991) [37]. However, paddy and tea crops were unable to be grown by low-income female-headed families in *Kobawaka* and *Pannila*, where households had little access to shared labour. In the case of rubber, *ca.* 50% of total costs are covered under the subsidy provided by RDD (Thennakoon, 2002) [46, 49] and this would, in part, account for the fact that approximately 80% of low-income female-headed families cultivated rubber in *Pannila* and *Kobawaka.*

Seasonality of labour demand is generally higher for annual than permanent crops (NRI, 1993) [36]. Consistent with previous studies (Chinnappa and Silva, 1977; Muqtada and Alam, 1986; Balakrishnan, 1991) [34, 17, 32, 34, 8], labour shortages were observed during peak periods of labour demand, associated with land preparation and harvesting (Figs. 7 and 9). In general, a cyclical pattern of labour demand develops with peaks for paddy and chena crops off-set but the greater dependency on rain water than irrigation in the Intermediate Zone, resulted in farmers trying to establish both cropping systems before the end of the rainy season (Figs. 7 and 9) accentuating peak demand, as has been found in other research (Gunasekara, 1980; Luechai *et al.*, 1986; Thilakarathne *et al.*, 1997) [22, 5, 32, 51]. Under these circumstances, unless a farmer has sufficient labour to establish cultivation activities on time, yield losses can be incurred due to the higher risk of crop damage by pests and disease. Although labour shortages occurred during the peak season, more farmers in *Pallekiruwa* than in other villages managed to complete seasonal cultivation activities by using a combination of shared labour and family labour.

Farmers tend to select crops or cropping practices taking into account the different labour and gender requirements, availability of labour, and farmer knowledge (Roder, 1997; Osugiri *et al.*, 2012; Wilson *et al.*, 2015; Erick *et al.*, 2017; Angiro *et al.*, N.D) [18, 38, 54]. In the case of paddy, there were two methods of weeding; manual and chemical, that required a different amount of labour input. However, the majority of farmers practised chemical weeding which required less labour and material costs, because as Thilakarathne *et al.* (1997) [51] examined, it was time saving rather than because it provided long-term profits (Fig. 5). Although manual weeding required more labour inputs (Gastao *et al.*, 2007) than chemical methods in this study (Fig. 5a), as has been found more generally (Luechai *et al.*, 1986; Rajendran, 1993) [22, 32, 40], farmers stated that there were an additional benefits through loosening of the soil and physical contact with the crop plants. Also, planting of paddy involves sowing seeds or transplanting, the former being less labour intensive than the latter (Rajendran, 1993) [40]. It is evident from farmer interviews that yield of rice is higher for transplanted material than sown seeds, because establishment rates are generally higher for transplanted material thereby leading to an improved crop stand, consistent with the studies of Thilakarathne *et al.* (1997) [51] and Islam *et al.* (2002) [27]. The majority of farmers in all four selected villages sowed rice seed rather than transplanting (Fig. 5b), mainly because of lack of labour at planting time. There are many activities that need to be completed at planting time, such as establishing and maintenance of nurseries, land preparation, uprooting plants and transporting materials (Wickramasekara, 1984; Konchan and Kono, 1996) [30]. These findings are consistent with the results of the studies done by Yamauchil and Biswas (2002) [55] and Islam *et al.* (2002) [27] at various locations in Asian countries. Nevertheless, due to the availability of shared labour in *Pallekiruwa*, more farmers practised transplanting there than in *Kobawaka*. However, the higher labour demand of practices such as transplanting means that despite the related increase in rice yield many smallholders tend to opt for less labour demanding methods (Fig. 5b) often at the expense of yield. Particularly in the villages of the Wet Zone, farmers prefer not to allocate hired labour for paddy cultivation because it is mainly a subsistence crop and so labour inputs would be too costly (Barker *et al.*, 1985; Elahi and Khan, 1986; NRI, 1993; Thilakarathne, *et al.*, 1997) [36, 51, 17].

It was evident from the previous study of Thennakoon (2002) [46, 49] that farmers' selected cropping systems depending on the production cost, including labour and materials. However, as several authors observed (Gunesekara, 1980; Jayasena and Herath, 1984; Yogaratnam *et al.*, 1995 and Samarappuli *et al.*, 1997) [57, 44] the majority of crops at the smallholder level involve costs mainly in terms of labour rather than for materials and smallholders prefer crops that involve less labour input. Tea is a more labour intensive (1 184 total Labour Day's ha^{-1}) permanent crop than rubber (458 Labour Day's ha^{-1}) consistent with the results of Tiffen and Mortimore (1990) [53] and NRI (1993) [36]. The majority of farmers selected rubber rather than tea in the Wet Zone villages because of its lower labour requirement. However, where households have sufficient family labour, they are able to cultivate labour intensive crops (Harwood, 1979) [23] and even where little family labour is available but income is sufficient to obtain hired labour and materials, farmers will consider cultivating tea (Thennakoon, 2002) [46, 49]. Consistent with several other studies, the labour requirement for banana was lower than that of pepper for all activities, except planting (Fig. 6; Gray, 1997; NRI, 1993; Rodrigo *et al.*, 2001a) [22, 36]. As a result, smallholders prefer to grow more bananas rather than pepper, as an intercrop with rubber or as a monocrop or in mixtures in the homegardens. Since there is no particular seasonal labour demand for banana, it is a highly flexible crop in terms of labour which adds to its popularity amongst smallholders (Table 4; Gray, 1997; Stirling *et al.*, 2002) [21, 46]. More land area was cultivated with banana in the villages of the Intermediate Zone (Thennakoon, 2002) [46, 49], where fewer smallholders were dependent on hired labour than in the Wet Zone. In addition, although high income farmers are able to hire outside labour (Palmer, 1991; as cited in NRI, 1993) [36], they prefer not to allocate hired labour for banana, because of the fact that there were no well-connected markets in the Wet Zone villages, compromising any profits that could be made (Thennakoon, 2017) [50].

Harwood (1979) [23] and Angiro (N.D.) observed that the greater the amount of labour available the higher the yield of the smallholder cropping system. In particular, an increase in available family labour resulted in an increase in frequency of weeding (Wilson *et al.*, 2015) [54], which in turn increased the survival rate of banana and *vice versa* (Fig. 10). Timely weeding was required for the success of banana, but this was greatly influenced by the availability of family labour consistent with the study of Thomas (2010) [52]. Manual weeding with hired labour and chemical weeding were considered to be expensive and shared labour was not generally used for the day-to-day upkeep of banana. Even in the cases where expenses for hired labour could be borne, supervision of labour was necessary and could be problematic if family members were not available. Hence in the absence of sufficient family labour, crops suffered from weed infestation, which as has been generally established is likely to decrease the survival rate of banana (Stirling *et al.*, 2002; Thomas, 2010; Wilson *et al.*, 2015) [46, 52, 54].

Labouring skills were the most important element in terms of labour availability, because although a household or a region may have sufficient number of people in the labour force, if skills were lacking in certain cultivation activities this would result in labour shortages. Average survival rate of rubber plants in the nurseries was higher in the villages of the Wet Zone compared to the Intermediate Zone (Table 1), due to significant variation in farmer knowledge (Fig. 1). An increase in the level of farmer knowledge resulted in an increase in the survival rate of rubber plants in the nurseries and *vice versa* (Table 2), confirming assertions of other authors that such a link would likely (Jayasena and Herath, 1986a). Consistent with the results of Anwar *et al.* (1997) [5] and Adesina *et al.* (2000) [2], this study asserted that the level of farmer knowledge was significantly dependent on the quality of the extension services (Arega *et al.*, 2005) [6] and knowledge received from the previous generation or outside the villages (Table 3), but not on the experience in cultivation. Farmer knowledge was significantly dependent on the long-term experience of growing rubber in both villages of the Wet Zone ($p<0.001$), but no such association was observed for data pooled across all four selected villages (Table 3).

Farmer knowledge depended on the quality of the extension services and the knowledge received from outside areas and from a few training programmes in *Pallekiruwa* and *Bookandayaya*. However, the survival rate was higher in *Pallekiruwa* than in *Bookandayaya* (Table 1) and farmer knowledge of rubber was higher for all activities in *Pallekiruwa* than *Bookandayaya* (Fig. 1). This reflected the poor quality of extension services in *Bookandayaya*, for example, the extension officer visited none of the rubber smallholdings other than those belonging to his friends or relatives. Consequently, the majority of farmers abandoned their rubber plants in the nurseries and even rubber already planted on the smallholding as has been found more generally in Sri Lanka where extension has been inadequate (Stirling *et al.*, 2002) [46]. It was evident that the area of rubber cultivated depended on the quality of the extension services in the Intermediate Zone villages. However, survival rate of rubber was a little lower in *Pallekiruwa* compared to villages in the Wet Zone, due to the relative inexperience of farmers in rubber cultivation and less information being passed on from previous generations. Nevertheless, growth rate of rubber in the smallholdings (after planting) was similar to the Wet Zone villages (Stirling *et al.*, 2002) [46] and this could be because the level of weeding and maintenance was higher in the smallholdings in *Pallekiruwa* because more labour was available.

Although farmers in the villages of the Wet Zone had sufficient knowledge of rubber cultivation, due to their long experience of growing the crop and knowledge passed down through generations, shortages in skilled labour were still evident, particularly with respect to tapping of rubber (Fig. 2). Previous studies (Tiffen and Mortimore, 1990; Sanker and Samarakoon, 1998) [53] suggest that the major reason for the above results could be that although knowledge was received from the previous generation, the offspring preferred not to get involved in rubber tapping. However, middle-aged household members still chose to work on rubber land if wages were sufficiently attractive, as has been mentioned elsewhere (Dei, 1992; as cited in NRI, 1993) [36]. Smallholders who depend mainly on hired labour suffered labour shortages with respect to tapping, due to the long term decline in the pool of skilled labour and the fact that the skilled labour that did exist preferred work that was better paid. Consequently, some mature rubber land in the villages of the Wet Zone, in particular in *Kobawaka* where labour availability was less than in *Pannila*, was abandoned without tapping, as was evidence in previous studies (Herath and Naranpanawa, 1998).

Labour skills for harvesting are very important, because this directly affects yield. For example, when tappers are trained, less damage is caused to the cambium of the rubber tree, which directly relates to yield and profitability (Talgaswatte, 1995) [47]. The highest labour requirement was for tea plucking and rubber tapping, accounting for as much as 90% of total labour inputs during the mature phase and being far more intensive than for other crops since harvesting is done at more frequent intervals. Despite this, tea has recently been introduced to both villages of the Wet Zone, with differences evident in the number of holdings adopting in the two villages (Thennakoon, 2002) [46, 49]. The number of tea holdings was higher in *Pannila* than *Kobawaka* and this was partially due to a readily available market in *Pannila* for tea leaves (Thennakoon, 2017) [50]. In addition, farmer knowledge on tea cultivation was poor in *Kobawaka*, due to limited channels along which knowledge could be passed, apart from a few tea growers who received knowledge from relatives and friends in outside areas. However, farmers in *Pannila* received knowledge from the estates surrounding the village, where the majority worked as casual labourers. Due to available skilled labour, harvesting of tea was not a problem for smallholders in *Pannila*, whilst in *Kobawaka* smallholders hired labour from distant areas.

There was no marked difference between villages in labouring skills for homegarden crops (pepper and arecanut), chena crops, paddy and banana. The reason was that farmers have long-term experience in cultivating these crops which contrast with tea and rubber, that have been introduced to the smallholder sector relatively recently. However, availability of skilled labour required for peeling cinnamon bark was higher in *Bookandayaya* than other locations and hence a lot of farmers in this village cultivated cinnamon in their homegardens and as a monocrop (see Thennakoon, 2002) [46, 49]. This is in marked contrast to unskilled farmers in *Pallekiruwa* who abandoned cinnamon bushes in the homegardens, although a few farmers continued to utilise wild cinnamon from forest areas. These findings are generally similar with observations made by Jayasuriya (1977) and FAO (1992). Thus, although an area or a household may have a sufficient number of labourers, if they are unskilled for specific activities, this may create the problems of labour shortages, which in turn influences the success and selection of different cropping systems (Iqbal *et al.*, 2005; Wilson *et al.*, 2015) [57, 54].

Conclusions

The overall aim of this study was to determine how the availability of labour influences smallholder cropping systems in four selected villages representing two different agro-climatic zones of Sri Lanka (Wet and Intermediate). This study clearly shows how type of labour used and labouring skills vary amongst villages, crops and cropping activities and how farmers allocate labour to different cultivation activities. It has also shown the importance of farmer knowledge and skill levels of the labour pool in determining cropping decisions. Farmers' knowledge varied significantly between the Wet and Intermediate Zone for rubber but not other crops, due to the fact that farmers in the Wet Zone had many years of experience in rubber cultivation but it was relatively new crop in the Intermediate Zone. Both the lack of farmer knowledge of rubber and the poor extension services have limited the extent of rubber cultivation in the Intermediate Zone. Farmers mostly preferred to select crops (*e.g.* banana rather than pepper, rubber rather than tea) and cultivation activities (*e.g.* sowing rather than transplanting; chemical weeding rather than manual weeding) that made fewer demands in terms of labour inputs, even where labour demanding activities (*e.g.* transplanting) provided higher returns, particularly in paddy cultivation. Labour demanding activities (land preparation, weeding and harvesting) required a mixture of hired and family labour, whilst family labour was predominant for less labour consuming activities. There were clear gender divisions in terms of labour inputs for chena, rubber and paddy cultivation and low-income households where only one sex was present tended to avoid such crops.

References

1. Abhayarathna MDC. Agricultural Innovation and Marginalization of the Rural Poor in Sri Lanka. In: Karunanayake MM ed. People, Space and Resources: Perspectives on Development Issues in Rural Sri Lanka. SIDA/SAREC Research Cooperation Project, Department of Geography, University of Sri Jayewardenepura, 2001, 55-74.
2. Adesina AA, Mbila D, Nkamleu GB, Endamana D. Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. Agriculture, Ecosystems and Environment, 2000; 80:255-265.
3. Ahmed I. Farm size and labour use; some alternative explanations. Oxford Bulletin of Economics and Statistics, Special Issue, 1981, 73-111.
4. Anyiro CO, Emerole CO, Osondu CK, Udah SC, Ugorji SE ND. Labour-use Efficiency by Smallholder Yam Farmers in Abia State, International Journal of Food and Agricultural Economics, 1, 151-163.
5. Anwar C, Suryaningtyas H, Nancy C. Factors related to the transfer of technology to the smallholders. Paper presented in the Seminar on Modernising Rubber Smallholding Sector. Indonesian Rubber Research Institute. Sembawa. Indonesia, 1997.
6. Arega D, Alene, Rashid M Hussan. Total Factor Productivity and resource use efficiency of alternative cropping systems in two agro-climatic zones of eastern Ethiopia. Agricultural Economic Review, 2005, 32-46.
7. Atapattu JP. Sustainable farming systems and the role of change agents: Monaragala District, Sri Lanka. PhD Thesis. Silsoe Collage, Cranfield University. UK, 1997.
8. Balakrishnan V. Labour use pattern for rice farms in Tamil Nadu. Manpower Journal. 1991; 27(1):27-32.
9. Barker R, Herdt R, Rose B. The Rice Economy of Asia, A book from Resources for the future, Johns Hopkins University press. London, 1985.
10. Carter J. Alley farming have resource-poor farmers benefited? Natural Resource Perspectives, ODI, 1995, 3.
11. Chandrabose AS ND. Labour Force in the Small Tea holdings: A case study of Ratnapura and Kotapola Divisional Secretariats in Sri Lanka. http://digital.lib.ou.ac.lk/, 2017.
12. Dissanayake DMAP, Wijesuriya W, Edirisinghe JC. Smallholder Rubber Sector in the Moneragala District: Potentials and Constraints. Bulletin of Rubber Research Institute of Sri Lanka, 2005a; 46:25-31.
13. Dissanayake DMAP, Wijesuriya W, Abeyawardene V. Farmers' Perspectives: Expectations and Constraints Faced by Smallholder Rubber Farmers in Moneragala District: Potentials and Constraints. Bulletin of Rubber Research Institute of Sri Lanka, 2005b; 46:70-78.
14. Dissanayake DMAP, Wijesuriya Wasana, Herath K, Gunaratne PKKS. Socio-economic Status of Smallholder Rubber Farmers in Moneragala District. Journal of Food and Agriculture, University of Wayamba, Sri Lanka, 2010; 03(No 1-2):41-49.
15. Dissanayake DMAP, Wijesuriya W. Growing Rubber in Uva, Northern and Eastern Provinces in Sri Lanka: Importance of an Effective Institutional Role. Journal of the Rubber Research Institute of Sri Lanka, 2012; 92:78-91.
16. Edirisinghe JC, Dissanayake DMAP, Warnajith KAD. Rubber Marketing and Related Problems in the Moneragala District. Bulletin of Rubber Research Institute of Sri Lanka, 2005; 46:62-69.
17. Elahi M, Khan MJ. Labour in Crop Production. In: Hirashima, S. and Muqtada, M. eds. Hired labour and rural labour markets in Asia, International Labour Organization ILO, Asian Employment programme ARTEP, New Delhi, 1986, 97-110.
18. Erick Owino Onyuka, Joash Kibbet Keino, Christopher Obel Gor. Socio-Economic Determinants of Groundnut Production in Ndhiwa Sub-County, Kenya. International Journal of Agricultural and Food Research, 2017; 6:705.
19. Fafchamps M, Quisumbing AR. Human capital, productivity and labour allocation in rural Pakistan. Journal of Human Resources. 1999; 34(2):369-406.
20. Gastão Lukanu, Maryann Green, Steve Worth. The influence of smallholder labour demand on cultivation of cash crops in northern Mozambique, Development Southern Africa, 2007; 24:553-573.
21. Gray A. Report for the Institute of Terrestrial Ecology Bangor on a visit to Sri Lanka to assess the market impact of a potential increase in production of banana resulting from high density intercropping of banana with rubber. National Resources Institute, UK, 1997, 33.
22. Gunasekara HDBH. Allocation of labour in a smallholder rubber farms in selected areas in Sri Lanka. MSc. Thesis, Australian National University, Australia, 1980.
23. Harwood RR. Small Farm Development: Understanding the Improving Farming systems in the Humid Tropics. West View Press, Colorado, 1979.
24. Hill B, Ray D. Economics for Agriculture. Food, Farming and the Rural Economy. The Macmillan, London, 1987.
25. Huvio T. Women's role in Rice Farming. Women and Development Service SDWW, Food and Agriculture Organization of the United Nations FAO. http://www.fao.org/WAICENT/FAOINFO/SUSTDEV/wpdirect/wpan0027.htm, 1998.
26. SMM Iqbal, Ireland CR, VHL Rodrigo. A logistic analysis of the factors determining the decision of smallholder farmers to intercrop: A case study involving rubber-tea intercropping in Sri Lanka Agricultural Systems, 2006; 87:296-312.
27. Islam MT, Sulaiman WHW, Singh S. Estimation and Comparison of Water Use between Transplanted and Direct Seeded Rice. http://www.sfst.org/proceedings/paddy_soil/session72.html, 2002.
28. Jacob VJ, Alles WS. Kandyan Gardens in Sri Lanka. Agroforestry Systems, 1987; 5:123-137.
29. Jayasundera MW. A survey of Smallholder Rubber Intercropping in Selected Villages of the Intermediate and Wet Zones of Sri Lanka, 1998, 12.
30. Konchan S, Kono Y. Spread of direct seeded lowland rice in North East Thailand: farmers' adaptation to economic growth. Southeast Asian Studies. 1996; 33(4):5-28.
31. Levi J, Havinden M. Economics of African Agriculture, Longman Group Ltd, UK, 1982.
32. Luechai C, Suwarat B, Thongchai S. Family labour, Hired

labour and Employment linkages in Rural Thailand. In: Hirashima, S. and Muqtada, M. eds. Hired labour and rural labour markets in Asia, International Labour Organization. ILO, Asian Employment programme ARTEP, New Delhi, 1986, 151-177.
33. Mendez VE, Lok R, Somarriba E. Interdiciplinary analysis of homegardens in Nicaragua: micro-zonation, plant use and socio-economic importance. Agroforestry Systems, 2001; 51:85-96.
34. Muqtada M, Alam MM. Hired labour and Rural Labour Market in Bangladesh. In: Hirashima, S. and Muqtada, M. eds. Hired labour and rural labour markets in Asia, International Labour Organization ILO, Asian Employment programme ARTEP, New Delhi, 1986, 21-71.
35. Nathalie Girard. Knowledge at the boundary between science and society: a review of the use of farmers' knowledge in agricultural development, Journal of Knowledge Management, 2015; 19:949-967.
36. NRI. The allocation of labour to perennial crop: decision making by African Smallholders. NRI Socio-economic Series, Natural Resource Institute, ODA, 1993, 3.
37. Olenja JM. Gender and agricultural production in Samia, Kenya: strategies and constraints. Journal of Eastern African Reasearch and Development, 1991; 21:81-92.
38. Osugiri II, Albert I, Ugochukwu Onyaguocha, SUO Onyemauwa CS, Ben-Chendo GN. Population Dynamics, Labour and Small-Holder Farmers' Productivity in Southeast Nigeria, Journal of Economics and Sustainable Development, 2012, 3.
39. Raedeke AH, Rikoon JS. Temporal and spatial dimensions of knowledge: Implications for sustainable agriculture. Agriculture and Human Values, 1997; 14:147-158.
40. Rajendran S. Determinants of labour power use in Agriculture: a study of the disaggregated level in Thanjavur district of Tamil Nadu. Manpower Journal. 1993; 28(4):49-59.
41. Roder W. Slash and burn rice systems in transition: changes for agricultural development in the hills of northern Laos. Mountain Research and Development. 1995; 17(1):1-10.
42. Rodrigo VHL. Rubber-based intercropping systems. In: Tillekeratne, L.M.K. and Nugawela, A. eds. Handbook of Rubber, Agronomy, Rubber Research Institute of Sri Lanka, Sri Lanka, 2001; 1:139-155.
43. Rodrigo VHL, Stirling CM, Naranpanawa RMAKB. Intercropping of immature rubber in ri Lanka: Present status and financial analysis of intercrops planted at three densities of banana. Agroforestry Systems, 2001; 51:35-48.
44. Samarappuli IN, Wickramaratne CS, Dias DGSB. Economics of reinvestment on rubber in the estate sector. Journal of the Rubber Research Institute of Sri Lanka, 1997; 79:45-61.
45. Senevirathna AMWK. The Influence of Farmer Knowledge, Shade and Planting Density on Smallholder Rubber/Banana Intercropping in Sri Lanka. PhD. Thesis. School of Agricultural and Forest Sciences, University of Wales, Bangor, U.K, 2001.
46. Stirling CM, Rodrigo VHL, Sinclair FL, Thennakoon TMSPK, Senevirathna AMWK. Final Technical Report. Project R7212 of Incorporating local and scientific knowledge in the adaption of intercropping practice for smallholder rubber, funded by Department for International Development's Plant Science Research Programme. U.K, 2002.
47. Talgaswatte H. Technical efficiency of rubber production in Sri Lanka: Frontier production functions approach. PhD. Thesis. Lincoln University, 1995.
48. Thennakoon TMSPK. Report on the Village Surveys relating to Intercropping on Rubber Smallholdings in Monaragala and Kalutara Districts, 1998, 73.
49. Thennakoon TMSPK. Influence of Crop profitability, Market, Labour and Land on Smallholder Cropping Systems in Rubber Growing Areas of Sri Lanka. PhD. Thesis, School of Agricultural and Forest Sciences, University of Wales, Bangor, UK, 2002.
50. Thennakoon TMSPK. Influences of Market Accessibility and Price Behavior on Smallholder Cropping Systems: A Case Study in Sri Lanka. Elixir International Journal. ISSN 2229-712x, 2017.
51. Thilakarathne L, Yanagita Y, Imai K. Land and labour use pattern of paddy farming practices in Sri Lanka peasant farm sector. Research Bulletin of the Faculty of Agriculture, Gifu University, 1997; 62:33-43.
52. Thomas Woldu Assefa. Raising labour productivity to solve the paradox; labour shortage in the labour surplus economy; Malawi Is Targeted Fertilizer Subsidy the solution? MA Thesis, Norwegian University of Life Sceinces, Department of Economics and Resource Management. Norway, 2010.
53. Tiffen M, Mortimore M. Theory and practice in plantation agriculture: an economic review. Overseas Development Institute. London, 1990.
54. Wilson J, Leonardo Gerrie WJ, Van de Ven, Henk Udo, Argyris Kanellopoulos, Almeida Sitoe *et al.* Labour not land constrains agricultural production and food self-sufficiency in maize-based smallholder farming systems in Mozambique, Food Security, 2015; 7:857-874.
55. Yamauchil M, Biswas JK. Direct Seeding of Rice in Asia and the Process of Seedling Development in Anaerobic Soil. http://www.sfst.org/proceedings/paddy soil/session72.html, 2002.
56. Yannick Djoumessi, Victor Afari-Sefa, Cyrille Bergally Kamdem, Jean-Claude Bidogeza. Socio-economic and institutional factors underlying efficiency of smallholder vegetable farms in Southwest region of Cameroon, International Journal of Social Economics, https://doi.org/10.1108/IJSE-09-2016-0256, 2016.
57. Yogaratnam N, Samarappuli IN, Iqbal SMM. Economics of interplanting rubber with tea in the low country Wet Zone. Journal of the Rubber Research Institute of Sri Lanka, Sri Lanka, 1995; 79:72-89.