

Effect of Land Size on Productivity of Coconut Cultivations in Sri Lanka: An Empirical Investigation

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ABSTRACT

The purpose of this study was to examine empirically the relationship between productivity and size of coconut lands in Sri Lanka. The primary data collected by means of a field survey conducted by the Coconut Research Institute of Sri Lanka from 69 coconut cultivations located in the Kurunegala, Puttalam and Gampaha districts in 2004/05 were used. These cultivations were categorized into three groups depending on their size, namely: (1) Home gardens [less than 2 acres]; (2) Smallholdings [2 – 20 acres], and (3) Estate sector [more than 20 acres] for the purpose of analysis. First, the empirical model explaining the relationship between productivity and land size was tested with different functional forms (linear, quadratic, cubic, logarithmic), and next, several other variables that can have an impact on productivity (e.g. land suitability class, age of the plantation, number of bearing palms per acre, agro-ecological region, availability of labour and management practices adopted by growers such as fertilizer application, soil and moisture conservation and pest and disease control etc.) were added into the selected model (i.e. cubic) and retested.

The outcome of analysis shows that there exists a significant negative relationship between land size and productivity of coconut lands in Sri Lanka for home gardens and smallholders. The minimum productive land size was 21 acres, where the estimated productivity was 426 nuts / acre / year. On the other hand, the productivity of estates increases as the land size increases from 21 acre onwards up to 40 acres. Only the availability of labour was significantly affected on productivity, while the impact of other factors was insignificant in this respect. The results imply that policymakers and regulatory agencies responsible for coconut industry in Sri Lanka must take efforts to secure large estates from unnecessary fragmentation, and fragmentation of smallholding may be allowed if the separated lands are remained predominantly with coconut.

Key words: *Coconut, productivity, land utilization*

INTRODUCTION

Coconut is one of the commercially important plantation crops in Sri Lanka. Currently, the contribution of coconut sector to the Gross Domestic Product (GDP) is about 1.3 percent. It is also responsible for nearly 1.8 percent of the total foreign exchange earnings in Sri Lanka in 2007 (Central Bank of Sri Lanka, 2007). According to

the Census of Agriculture in 2002, which was carried out by the Department of Census and Statistics after two decades (i.e. since 1982), the total land extent under coconut in the country has been reduced from 416,253 ha to 394,836 ha from 1982 to 2002 (Dissanayake, 2005), which is about a 5% (21,417 ha) reduction.

The coconut lands in Sri Lanka are categorized mainly as the "Smallholding Sector [SH] (i.e. lands

less than 20 acres) and the Estate Sector [ES] (i.e. lands more than 20 acres and less than 50 acres). Under this classification, almost 99 percent of coconut growers become smallholders, and the extent under smallholdings is 81.9 percent of the total coconut land extent. According to the census of coconut lands carried out in 2002, the total extent of coconut lands under the estate sector has been reduced from 103,129 ha in 1982 to 71,347 ha in 2002, while that of smallholdings sector has been increased from 313,124 ha to 323,489 ha during this period. This has been caused by, amongst the other reasons, fragmentation of lands that took place extensively in the recent past (Coconut Development Authority, 2005).

Eventhough the extent of land under coconut has been decreased gradually, the national production of coconuts has shown a slight increase during the last 20 years suggesting that the “productivity” of existing coconut lands increases overtime (Table 1). Nevertheless, the potential per capita availability of coconut has been reduced overtime indicating that the production has not been increased sufficiently to meet the requirement of growing population (Coconut Development Authority, 2006).

Although literature suggest that there exists an inverse relationship between the size of a farm and its productivity (see, for example Bardhan, 1973; Zyl *et al.*, 1996), we have no empirical evidence to prove this dilemma in the context of coconut industry in Sri Lanka. If this hypothesis is true, we can predict that smallholders are more productive than larger estates with over 20 acres in extent. In a situation where, the kernel-based coconut processing industry has widened its scope into different products, the major challenge facing the coconut industry of Sri Lanka at present is to increase the national production to satisfy the demand of domestic culinary nuts and the demand of expanding coconut-based industries. Further, the government, through various initiatives, attempts to expand coconut cultivation into non-traditional areas such as Anuradhapura and Moneragala, and newly liberated areas in the eastern Province. However, the scarcity of cultivable lands limits this effort. Therefore, raising productivity of existing coconut lands is inevitable and under these circumstances performance of smallholders become a must as the future of industry almost depend on these growers.

The purpose of this study was to examine empirically the relationship between size of coconut

Table 1. *Contribution of coconut sector to national economy of Sri Lanka*

Year	National Production (Million nuts)	Domestic Consumption (Million nuts)	Export Earnings (Rs Million)	Export Earnings as a % of Total Exports	Contribution to GDP (%)
1997	2,631	2,015	9,070	3.3	3.3
1998	2,504	2,053	8,842	2.9	3.2
1999	2,828	2,063	11,936	3.7	1.7
2000	3,096	2,126	12,504	2.9	1.8
2001	2,769	2,322	10,683	2.5	1.6
2002	2,392	2,056	12,460	2.8	1.3
2003	2,562	1,922	13,731	2.8	1.3
2004	2,591	1,943	17,314	3.0	1.2
2005	2,515	2,047	17,525	2.8	1.1
2006	2,784	2,222	19,661	2.7	1.4

Source: Ministry of Plantation Industries (2006)

land and its overall productivity in Sri Lanka. It uses the primary data collected from 69 coconut plantations with various sizes which are located in the coconut triangle in Sri Lanka for the analysis. In this article, we next present the theoretical framework used in the analysis followed by the results from the empirical analysis. Finally, it discusses the implications of outcome of the analysis for the future of coconut industry in Sri Lanka.

METHODS

Theoretical framework

The following simple theoretical framework was formulated to define the relationship between size of coconut land and its productivity:

$$PRD = f(LAS) \quad (1)$$

Where, *PRD* is productivity of the land *i* (measured in terms of nuts per acre) and *LAS* is the size of the land (acre). With respect to land size, the coconut lands in Sri Lanka are classified into two major categories: (1) "smallholding sector" (with less than 20 acres), and (2) "estate sector" (20 – 50 acres). Within the category (1), the lands that are less than 2 acres can be further classified as "home gardens" (*HG*). For the purpose of this analysis, therefore, we took into account of all these land categories: (1) home gardens (0 – 2 acre), (2) small holders (> 2 to < 20 acre); and (3) estates (> 20 to < 50 acres).

Given the size of land, the productivity of coconut cultivation may depend on a number of other factors such as variety, annual rainfall, age of the plantation, soil type, agro-ecological region, and management practices (e.g. fertilizer application, soil and moisture conservation, weed control and pests and disease control) (Abeywardane, 1971; Samarajeewa *et al.*, 2001). However, many of these factors may be "beyond the control" of a coconut grower (irrespective of size of the land) in terms of their efforts to enhance the productivity of land (e.g. annual rainfall, soil type and agro-ecological region). Based on the type of soil, the coconut lands are, in general, categorized into five "Land Suitability

Classes" (*LSC*), namely: (a) S_1 = highly suitable; (b) S_2 = suitable to highly suitable; (c) S_3 = suitable; (d) S_4 = moderately suitable, and (e) S_5 = marginally suitable (Somasiri *et al.*, 1994). The productivity of a land can, therefore, be significantly varied with respect to which *LSC* it belongs to, and we can indicate that, *ceteris paribus*, lands that belong to *LSC* in higher order are more productive and *vice versa*.

For the simple model explained above, we can include a number of variables mentioned above to show their contribution towards productivity as follows:

$$PRD = f(LAS, LSC, AGE, NP, AER, LAB) \quad (2)$$

where, *LSC* denotes the land suitability class, *AGE* is age of the plantation, *NBP* is number of bearing palms per acre, *AER* is agro-ecological region and *LAB* is availability of labour (both family and hired labour) per acre per year. We expect that *AGE* to have a negative relationship with the productivity and *NBP* to have a positive impact. In addition, a number of management practices adopted by the growers, namely: fertilizer application, soil and moisture conservation, weed control, pest and disease control and fencing were considered in the model by means of a series of dummy variables, where 1 = if adopted and 0 = if otherwise.

Empirical model

As can be seen from equations (3), (4), (5) and (6), the Linear, Quadratics, Cubic and Logarithmic functional forms of the equation (1), respectively, were derived to find the best fitted model explaining the relationship between productivity and land size based on the R-square (R^2) (where, β_0 is the intercept term and β_1 are coefficients of the corresponding variables representing various functional forms).

$$PRD_i = \beta_0 + \beta_1 * LAS_i \quad (3)$$

$$PRD_i = \beta_0 + \beta_1 * LAS_i + \beta_2 * LAS_i^2 \quad (4)$$

$$PRD_i = \beta_0 + \beta_1 * LAS_i + \beta_2 * LAS_i^2 + \beta_3 * LAS_i^3 \quad (5)$$

$$\ln PRD_i = \ln \beta_0 + \beta_1 * \ln LAS_i \quad (6)$$

The explanatory variables discussed above were included to each model specified both individually and collectively and the signs, significance level and R-squared were taken. The best fitted model will be selected based on the outcome of this analysis.

Data collection and analysis

The primary data from 69 coconut growers were used to examine this economic problem, where the survey was administered by the Coconut Research Institute of Sri Lanka (CRISL) in 2004/05. A farm record book prepared by the CRISL was distributed to the coconut growers to collect valid and reliable data, especially to cover the areas of: (i) description of the holding (personal data, location of farm, land size, land suitability class, agro-ecological region); (ii) monthly work of family and hired labour; (iii) crop-wise harvesting and crop disposal data, and (iv) adoption of management practices.

The survey covered a wide range of major coconut growing areas located in the coconut triangle in Sri Lanka, including the Kurunegala, Puttalam and Gampaha districts, which represent 56.4 percent of the total extent under coconut cultivation. Both qualitative and quantitative data analysis techniques were employed to analyze the data using the "Statistical Package for Social Sciences (SPSS)

– version 13". For the purpose of estimation of coefficients of the models, the Regression Analysis was used with the Ordinary Least Square techniques.

RESULTS AND DISCUSSION

Descriptive statistics

Out of 69 coconut cultivations selected to the study, nearly 55 percent of lands were classified under the category of smallholders (Fig. 1).

With respect to the Land Suitability Class (LSC), the majority of coconut lands in the sample belong to the S₃ (Fig. 2). Interestingly, there were no lands found which belong to the land suitability class S₁.

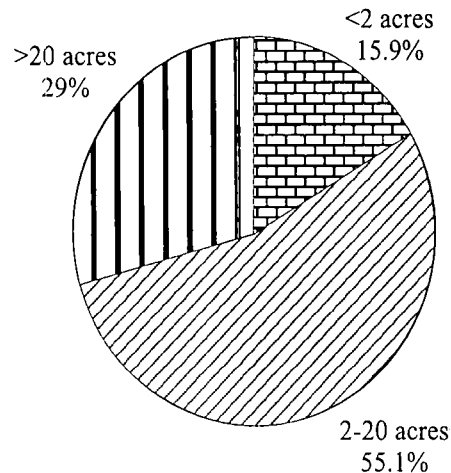


Fig. 1. Distribution of coconut lands

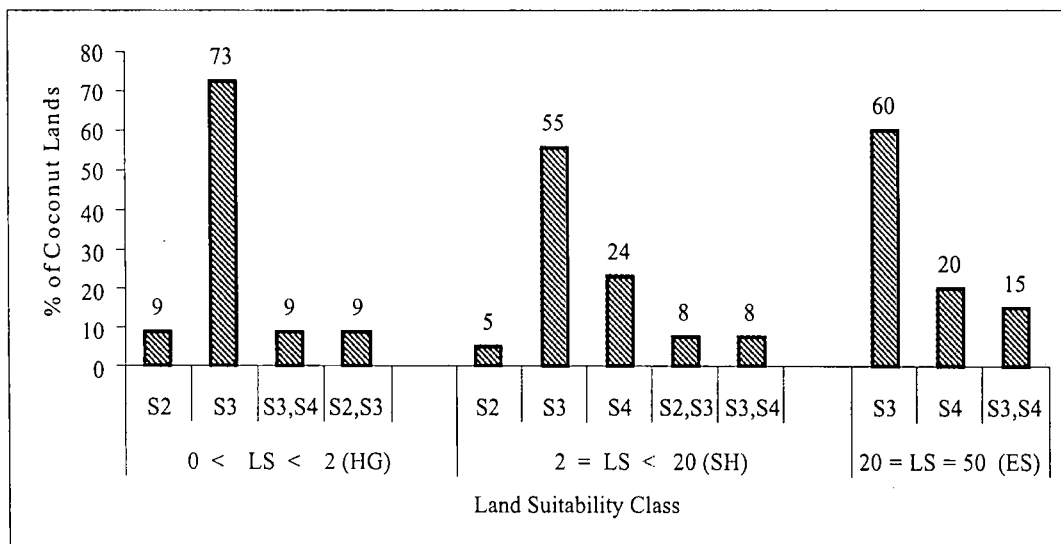


Fig.2. Distribution of Land Suitability Classes

The Mean productivity of lands in the sample was 796 nuts per acre per year (Standard Deviation = 497). The Mean land size was 14.3 acres, where the smallest and largest lands were 0.75 and 50 acres, respectively. The age of coconut plantations ranged from 20 to 70 years with the Mean of 46 years. Number of bearing palms per acre was high as 97 in some holdings while it was as low as 20 in some others (Table 2).

The Mean age of the plantations of the three different sectors was between 43 and 52 years (Table 3). The average number of bearing palms per acre was more or less similar in three sectors. The highest labour use of 12 man days per acre was observed in home gardens.

The degree of adoption of various cultural practices amongst the coconut cultivations considered in this analysis was varied substantially. It was observed that the coconut growers having less than 2 acres of land had not adopted proper mechanisms to control pests and diseases and/or appropriate soil and moisture conservation measures in their cultivations. It was also seen that the adoption of right amount of fertilizer and controlling of weeds in the cultivation were, in general, at a satisfactory level in the estate sector (Table 4).

Next, the level of productivity of each cultivation was plotted against the size of the land as shown in Fig. 3, where the respondents ($n = 69$) were arranged in ascending order by taking into account

Table 2. Descriptive statistics of the variables in the model

Variables	Mean	Minimum	Maximum	Standard Deviation
Productivity (Nuts/ac/year)	796	120	2,400	497
Land size (Acres)	14.3	0.75	50.0	15.8
Age of plantation (Years)	46.5	20.0	70.0	9.6
Bearing no of palms per acre	54.0	23.0	97.0	13.1
Labor use (Man days /acre / year)	7.0	1.0	48.0	8.1

Table 3. Descriptive statistics of the sectors

Variables	Mean (Standard Deviation)		
	Home gardens	Smallholdings	Estates
Age (years)	50(5.49)	43(10.23)	52(6.37)
Number of bearing palms (per ac)	56(11.22)	53(13.53)	53(14.23)
Labor use (Man days /acre / year)	12(13.60)	7(7.04)	4(4.27)

Table 4. Adoption of recommended cultural practices

Type of Cultivation (%)	Fertilizer Application (%)	Weed Control (%)	Pest & Disease Management (%)	Moisture Conservation (%)	Soil Conservation
Home gardens	36	36	0	0	0
Smallholders	57	66	7	7	3
Estates	70	90	2	10	5

of land size. It shows that the productivity of coconut lands tend to decrease (i.e. negative trend) as the land size increases. The Pearson Correlation Coefficient between productivity and land size was -0.513 and which was significant at $p = 0.05$.

Estimates of coefficients of variables

Table 5 reports the results from Regression Analysis between the productivity and land size for the different functional forms considered in this analysis.

It highlights that the R^2 value was increased by 7 percent as we changed the functional form from Linear to the Quadratic. The highest R^2 value was reported under the Cubic functional form and as a result, this functional form was selected as the best fitted model:

$$PRD = 1305.75 - 103.15 LAS + 3.81 LAS^2 - 0.04 LAS^3 \quad (7)$$

Fig. 4 depicts the relationship between productivity and land size using equation (7). This clearly shows that home gardens and smallholders are more

productive than the larger estates. Interestingly, the productivity of a land decreases rapidly as the land size increases up to 20 acres, or in others within the smallholders category small farms performs better than large farms. The lowest productivity of 426 nuts per acre per year was reported at the land size of 21 acres. The results show that the average productivity of smallholding sector was 840 nuts per acre per year. Amongst the estates, the productivity has been increased up to 40 acres and then decreases. The average productivity of estates was 443 nuts per acre per year. Although the

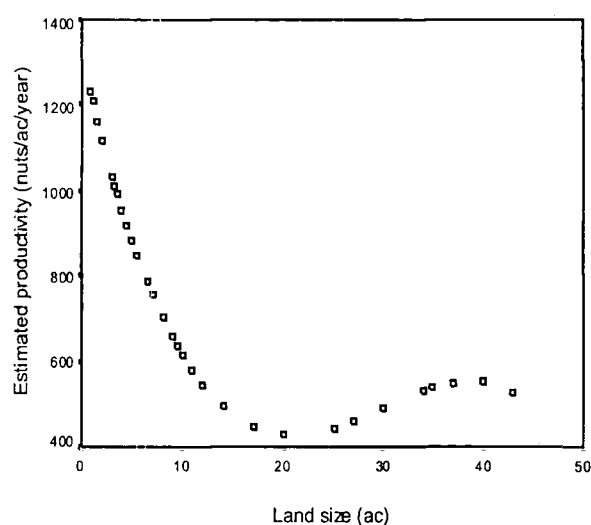


Fig.4. Variation of estimated production with respect to land size

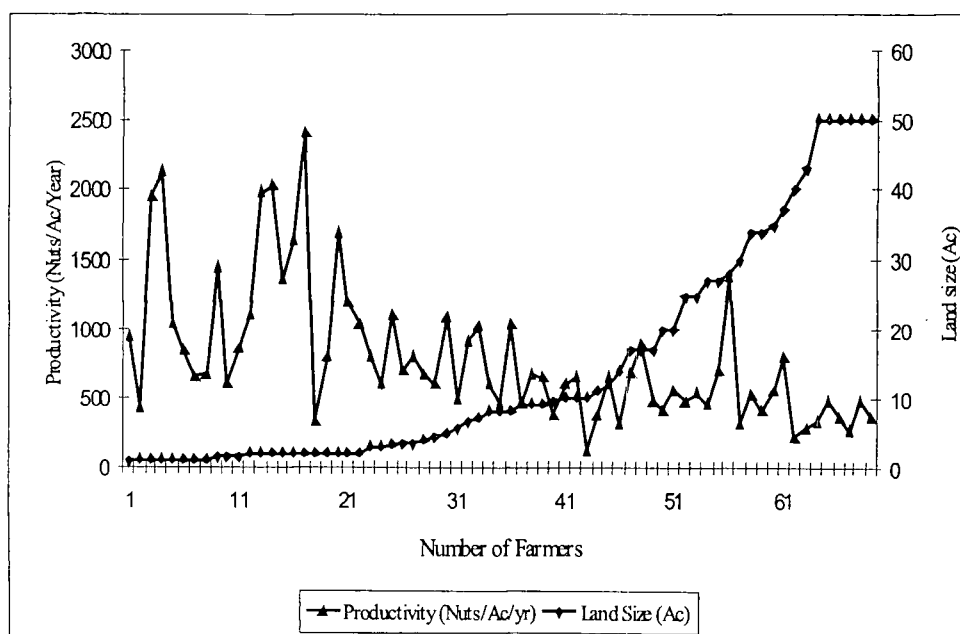


Fig.3. Variation in productivity versus land size

Table 5. *Results of the regression analysis*

Functional Form	Coefficient	Estimated Coefficient (SE)	Adjusted R ²
Linear	β_0	1013.74*** (69.88)	0.251
	β_1	-16.09*** (3.32)	
Quadratic	β_0	1161.46*** (85.09)	0.321
	β_1	-48.07*** (11.9)	
	β_2	0.68*** (0.25)	
Cubic	β_0	1305.75*** (104.35)	0.361
	β_1	-103.15*** (26.98)	
	β_2	3.81** (1.41)	
	β_3	-0.04*** (0.019)	
Logarithmic	β_0	1226.68*** (85.61)	0.359
	β_1	-229.98*** (37.04)	

Note: *** Significant at 1% level, ** Significant at 5% level

Fig. 4 explore that the productivity was decreasing again in the estate sector beyond 40 acres level, we did not have primary data to confirm this behaviour.

Out of 10 explanatory variables included in the model, only the variable explaining "usage of labor" (LAB) was significant at $p = 0.05$ (Table 6).

Table 6: *Impact of other variables on productivity*

Variable	Estimated Coefficient	SE	Significance
LAS	-85.77***	29.63	0.006
LAS ²	2.97	1.50	0.053
LAS ³	-0.03	0.02	0.123
LSC	175.02	92.16	0.063
AGE	-6.29	5.17	0.229
NBP	6.14	3.92	0.123
AER	30.48	93.87	0.747
LAB	15.77*	6.78	0.024
FER	116.85	98.92	0.243
WCL	41.789	110.84	0.708
PDC	-0.59	161.49	0.997
MCN	155.73	184.72	0.403
SCN	123.83	306.98	0.688
FEN	-161.66	109.86	0.147
Constant	446.95	426.97	0.300

Note: *** Significant at 1% level, ** Significant at 5% level

In fact, the usage of labour was the highest in the home gardens (12 man days per acre per year). However, impact of each variable within a sector (i.e. home garden, smallholding and estate) may be significant. According to Table 3 there is no much difference of these variables among three sectors. The average age of plantations were 50 to 55 years. The coconut yield stabilizes after 16 to 17 years of planting. Since the age of the plantations of the sample was more or less similar a significant difference in age of plantations could not be observed.

CONCLUSIONS AND POLICY IMPLICATIONS

These results from the analysis, which were based on the primary data collected from 69 coconut growers located in coconut triangle in Sri Lanka, suggest that the productivity of coconut lands in Sri Lanka depends significantly on the size of holding. The productivity was found to be the highest in the home gardens and it decreases within the smallholding category. One of the major reasons behind this phenomenon may be non-availability of and/or inability to hire required amount of labour to manage these smallholdings productively with all recommended practices since they tend to provide fewer returns on the investment. However, the results highlight that the productivity of coconut estates increases as the land size increases, in general, but at a lower rate. While the labour was having a significant impact on this behaviour, none of the other variables show any significant impact. The descriptive statistics derived from the first hand information obtained from 69 coconut growers in the sample show that they are not much concerned about adopting these practices in their cultivations.

The results emphasize the importance of securing large-scale estate sector to increase the production as well as to increase the productivity, from one hand, and promotion of coconut cultivation amongst the smallholding sector, and specially within the home gardens, as they were proven to be the highest productive in this respect. In a situation where the

majority of coconut lands in the country belong to the smallholding sector and having understood the importance of estate sector, the regulatory agencies governing coconut industry in Sri Lanka may develop sets of two alternative policies for these two sectors (i.e. smallholding and estate) with respect to fragmentation of lands. For example, fragmentation of estates should not be allowed unless it is strongly justifiable as it has direct impact on total coconut production in the country. However, to make the agricultural and land policies to be realistic, fragmentation of smallholdings may be allowed case by case basis by taking into account of the need, however, every effort must be taken to keep those fragmented lands under the coconut, may be under a different ownership.

A difference was not significant in variables of LSC and AER because most of the holdings were in land suitability class S_3 and S_4 . This is a limitation of the study and can be improved by using stratified sampling instead of random sampling.

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REFERENCES

- Abeywardana, V. (1971). Yield variations in coconut. Coconut Research Institute of Sri Lanka. *Ceylon Coconut Quarterly*, 22: 97-103.
- Bardhan, P. K. (1973). Size, productivity and returns to scale: An Analysis of farm-level data in

- Indian agriculture. *The Journal of Political Economy* 81(6): 1370-1386.
- Central Bank of Sri Lanka. (2007). Annual Report. Colombo. Sri Lanka.
- Coconut Development Authority. Coconut Statistics (2005/2006). Colombo. Sri Lanka.
- Dissanayake, A. M. U. (2005). Progress of Coconut Cultivation 1962-2002. Department of Census and Statistics. Colombo, Sri Lanka.
- Samarajeewa, S. R., Thanaweera arachchi, P. T., Fernando, M. T. N. and Rathnasiri, N. G. S. C. (2001). Supply response analysis in coconut production. Sri Lanka Association for the advancement of science, Proceedings of the 57th Annual Session, Part 1. pp 265.
- Somasiri, L. L. W., Nadarajah, N., Amarasinghe, L. and Gunathilake, H. A. J. (1994). *Land suitability assessment of coconut growing areas in the coconut triangle in Sri Lanka*. Coconut Research Institute, Lunuwila, Sri Lanka.
- Zyl, J. V., Miller, B. R. and Parker, A. (1996). Agrarian structure in Poland. the myth of large farm superiority. Policy research working paper. The World Bank.