Economic Analysis of Coffee Farming Systems in Tanzania

Kiwelu, L., Magesa, J.M., Mbwambo, S.G., Ng'homa, N.M., Mushi, I.K., Shao, G., Mdemu, S.Y.S., Tarimo, E., Mtenga, D.J., Magina, F.L., Maro, G.P., Kilambo, D.L. and Teri, J. M

Abstract— The study examined the profitability of coffee production in Tanzania in the context of two farming systems, namely, smallholder pure stand and intercropped farming systems planted with traditional and improved coffee varieties. Data were collected from 381 smallholder coffee growers using a structured questionnaire. The result shows that 77% of respondents practice intercropping farming systems and 23% practice pure stand coffee farming systems. The average yield of smallholder farmers implementing good agricultural practices was 2 kg/tree and 1 kg/tree for farmers with improved coffee varieties, and 1 kg/tree for farmers with traditional coffee varieties and 2.5 kg/tree for farmers with Robusta coffee varieties. The average cost for smallholder farmers is around 3.5 million TZS/ha and 2.3 million TZS/ha for traditional coffee varieties under the same farming system. Also, the cost for smallholder farmers with improved varieties planted under intercropping farming systems is between 2.3 million TZS/ha and 1.7 million TZS/ha for farmers with traditional coffee varieties. Smallholder farmers with improved coffee varieties gain higher gross margin of 3.5 million TZS/ha than smallholder farmers with traditional coffee varieties 0.5 million TZS/ha. The NPV for improved coffee and traditional coffee varieties are positive except for traditional Arabica coffee hard processed produced under intercropping farming system which was negative. The IRR for improved and traditional varieties is greater than the 12% discounted rate except for traditional Arabica coffee hard processed under intercropping farming systems. These results imply that investing in coffee production by planting improved or traditional coffee varieties is profitable regardless of the farming systems except for traditional Arabica coffee hard processed and planted under intercropping farming systems. Therefore, for smallholder farmers to gain good profit they have to adopt improved coffee varieties that combine high yields with disease resistance.

Keywords— Coffee, cost, farming system, production, profitability

1 INTRODUCTION

Coffee is one of the most widely consumed hot beverages all over the world [1]. The demand for this commodity has increased by 50% since 1990s due to increase in domestic coffee consumption from exporting countries and from new emerging markets such as China, Asia, South Korea and Turkey [2]. The average coffee production from all exporting countries for the crop year 2017/18 was 159.7 million bags of 60kg of green coffee whereby Brazil contributed 35% of all coffee produced followed by Vietnam 13%, Colombia 10%, Indonesia 7%, Ethiopia 4%, Uganda 3%, Côte d'Ivoire 2%, Kenya 0.9% and Tanzania 0.7% [1]. In Tanzania coffee is considered to be an important cash crop that provides income to about 450,000 smallholders coffee families who produce about 90-95% of the total coffee production in the country whereby 110 coffee estates account for 5-10% of the total production [3]. The coffee sector contributes about 24% to the annual agricultural foreign currency earnings after Tobacco which contributes 34% [4].

The coffee farming systems in Tanzania include pure stand and coffee banana intercropping/agroforest farming practices [5]–[8]. The important agronomic practices for both farming systems for Arabica and Robusta coffee are well documented in different studied including [5]. Many smallholder coffee farmers lack scientific information about profitability of coffee farming in different farming systems. The objective of this study is to assess the profitability of smallscale coffee farming in Tanzania practicing pure stand farming system and coffee banana intercropping farming systems, both systems using traditional and improved varieties so as to propose possible intervention to sensitize smallholder farmers invest in coffee hence increasing productivity, quality and improving household income security and livelihood.

2.0 RESEARCH METHODOLOGY

2.1 Description of the study area

The study was conducted in 2015/16 production season in Rombo, Hai and Arumeru Districts (Northern zone), Mbinga and Mbozi Districts (Southern Highlands) and Buhigwe District (Western zone) for Arabica coffee and for Robusta coffee in Muleba and Karagwe Districts in Kagera region. The study sites were selected because of different farming systems practiced in the study areas.

2.2 Data Types, Sources of Data and methods of Data collection

For this study both quantitative and qualitative data were collected. This study used both primary and secondary data. The data were collected from primary sources generated through structured questionnaire. Secondary data were collected from internet, through the desk review; the study assessed the existing literature on the coffee farming systems profitability. The data were collected by the instrument Survey questionnaire. Collected data from smallholder coffee growers included farm characteristics (farm size, varieties planted, yield/output, inputs used, crop management practices, agro-climatic conditions), socio-economic characteristics of farmers (age, gender,

education, marital status, household size, experience in coffee farming, etc.).

2.3 Sampling procedures and Sample Size

This study implemented simple random sampling procedures to collect the required primary data. A cross sectional research design was used where data were collected at a single point in time. The sampling frame consisted of smallholder farmers growing improved and traditional coffee varieties in different farming systems. The proportional random sampling method was used to select small holder coffee farmers using [9] sample size formula at 0.05 precision level where confidence level is 95%.

$$n = N/(1 + N(e)^2) \quad \text{.....(1)}$$

$$n = 8000/(1 + 8000(0.05)^2) = 381$$

Where: n is the sample size, N is the population size, and e is the level of precision or margin of error, expressed as a fraction of 0.05.

2.4 Data analysis

The study analyzed the data mean, frequency and percentage. Similarly, the partial budget analysis method was used [10]–[13] to capture profits farmers gain from coffee farming. The gross margin (GM) was computed by using Microsoft Excel. The gross margin of the famers was determined through the sale of coffee produced in the season (TR) subtracting the costs of production (TVC) following [10]–[13]. The variable costs considered for coffee production includes cost for seedlings, planting, weeding, fertilizer and manure, labour costs, cost for pest and disease control, soil and water conservation, pruning, desuckering, irrigation, harvesting and processing. The fixed costs including value for land, farm equipment, labor and biological depreciation of coffee trees were not included in this analysis. The model used for estimating gross margin was represented as:

$$GM = TR - TVC \quad \text{.....(2)}$$

Where: GM = gross margin; TR = Total revenue and TVC = Total variable cost.

2.5 Sensitivity analysis

This study also performed a sensitivity analysis because it is a good measure of a farm's true profitability or a farm's long-term economic viability [10]. The indicators of project profitability provide a valuation in today's money, following the premise that money spent today is more valuable than in the future [14]. The measures reported in this study are the net present value (NPV) and Internal Rate of Return. In order to calculate the NPV it is necessary to establish the discount rate. [14] stated that the proper discount rate for financial analysis should reflect the marginal cost of money to the farm, which would effectively be the rate at which the farmer is able to contract a loan. From our analysis 12% discount rate was used annually to calculate the present values of the incremental net benefit and the net present value. It is assumed that the discount rate does not change over the 15 years of the project.

2.6 Assumptions made for this study

For purposes of this study, several logical assumptions had to be made. Since production costs for coffee vary considerably, from farm to farm and season to season, standardized values were used in the estimation of production costs, assuming typical practices under average conditions on commercial farms. Thus, the costs included in this study, as explained hereunder, are intended to be used as a guide to help producers develop costs of production budgets for their particular operations and for understanding whether and under what conditions coffee farming is profitable.

Plant population: Improved Tall Arabica coffee varieties are planted in a spacing of 2.5 m x 2.5 m and the plant population per hectare under pure stand farming system is 1,600 and 1,200 under intercropping farming system. Improved Arabica coffee compact varieties are planted in a spacing of 2 m x 2.5 m and the plant population per hectare under pure stand farming system is 2,000 and 1,600 under intercropping farming system. Traditional Arabica coffee are planted in a spacing of 2.74 m x 2.74 m and the plant population per hectare under pure stand farming system is 1,332 and 967 under intercropping farming system. Improved Robusta coffee varieties are planted in a spacing of 2.5 m x 3 m and the plant population per hectare under pure stand farming system is 1,333 and 1,000 under intercropping farming system. Traditional Robusta coffee are planted in a spacing of 3 m x 3 m and the plant population per hectare under pure stand farming system is 1,111 and 778 under intercropping farming system.

Prices of clean coffee: Producer prices vary according to supply and demand. As a result, prices are higher in deficit markets within a season than in surplus markets. Also prices differ for various reasons, and particularly reflect the quality of coffee produced. The Auction prices in the 2015/16 production season, whose averages were TZS 2,500/kg for Robusta, TZS 4,000/kg for wet processed Arabica and TZS 2,350/kg for hard processed Arabica, were used in the analysis. The calculations assumed a constant price per kg of coffee over the period covered by the study.

Improved coffee seedlings: The coffee seedlings are produced by TaCRI, district councils, farmer groups, primary cooperatives coffee estates and individual farmers. The cost of coffee seedling varies due to change of government regime. For example, from 2005 price of coffee seedlings was 50 TZS, in 2010 the price of coffee seedlings increased to 300 TZS and 500 TZS then reduced to 300TZS and from 2017 coffee seedlings multiplied by TaCRI and district council are distributed for free to farmers. For the purpose of this study we adopt the price of TZS 300 per seedlings.

Labor Wage rate: The average labor wage rate of TZS 5,500 was used in the analysis. This wage rates were applied to all the labor categories to allow for consistency, regardless of the state of origin. This was due to the fact that, labor costs vary from place to place due to several factors such as market value, availability and also skill.

Irrigation: Irrigation is essential for producing quality coffee. However, costs of installing and operating an irrigation system are not included because majority of smallholder coffee farmers depend on rain fed agriculture.

Land: Cost of land for producing coffee was not estimated. This was done to allow for a more accurate comparison of production costs among the various production areas. The main reason for not including costs of land was due to variability of cost of land among the study areas. Example in Southern highland the price of land in Mbinga and Mbozi is relatively lower than the Northern part of Tanzania (Kilimanjaro, Arusha and Kagera region) where the price of land potential for coffee farming is high.

Interest on Operating Capital: It is a common practice among farmers to incur short term loans to pay for supplies, labor, and purchase inputs. To account for this, interest on operating capital is included as a cost of production. Interest on operating capital was charged on total variable growing costs at a rate of 12.0 percent per annum [4]. Interest on harvesting and marketing costs was calculated for the full year.

3.0 RESULTS AND DISCUSSION

3.1 Socio-economic characteristics of respondents

The results from the study area shows that 54% of respondents had age above 60 years old 30% were between 46-60 years old and the rest 15% were between 18-45 years old. The results also indicate that, 74% of respondent's attained primary education, 17% secondary education, and 6% college education. According to [15], education has casual impact on measures of technologies but does not influence the use of technologies associated with routine tasks. Majority of farmers have primary education and are more experienced in coffee farming. The results also show that 88% of respondents were males and the rest were female, this implies that coffee sector is dominated by male. However, about 50% of agricultural activities are carried out by women who also occupy 52% of the overall economic activity in the country. Concerning coffee, women perform 76% of the crop related and post-harvest activities. Despite their participation and commitments, women are denied of economic gains from coffee. The average land size owned by respondents in the study area under coffee is 0.8 ha which is small hence need to emphasis adoption of improved coffee varieties so as to gain more yield from the available land.

3.2 The farming system in the study area

The result indicates that, 77% of smallholder farmers practice coffee banana intercropping and agroforestry farming systems whereas 23% of smallholder farmers practice pure stand coffee farming systems. In addition, coffee producers in the study area cultivate crops such as maize, beans and horticultural crops. They also keep and rear cows, goats, pig and poultry as additional sources of household income diversification simultaneously improving the household food and nutrition security [16]. Crop and livestock diversification in coffee producing districts is encouraged by TaCRI as a means to reduce chronic malnutrition in Tanzania [17].

3.3 Coffee yield under different farming systems

The result in Table 1 indicates that, the per hectare the average yield of smallholder farmers implementing good agronomic practices was 2 kg/tree and 1 kg/tree for farmers with improved coffee varieties, and 1 kg/tree for farmers with traditional coffee varieties and 2.5 kg/tree for farmers with Robusta coffee varieties. The result in Table 1 also show the peak capital requirement for smallholder farmers to attain the optimal yield per ha. A coffee tree with minimum productive primary branches between 30 – 35 and berry clusters between 9-12 can produce an average yield 2 kg/tree for improved Arabica coffee varieties, 1 kg/tree for traditional Arabica coffee and 3 kg/tree for Robusta coffee. According to [18], [19] the average productivity of improved coffee varieties under well managed research trials are 3000 kg/ha and 1000 kg/ha from traditional varieties under a traditional plant population of 1330 trees per ha.

3.4 Costs of coffee production by smallholder farmer's

The result is Table 2 indicates the cost of coffee production for smallholder farmers with improved coffee varieties planted under pure stand farming system. The results imply that the average cost for smallholder farmers is around 3.5 million TZS/ha [1]and 2.3 million TZS/ha for traditional coffee varieties under the same farming system. Also the cost for smallholder farmers with improved varieties planted under intercropping farming systems is between 2.3 million TZS/ha and 1.7 million TZS/ha for farmer with traditional coffee varieties.

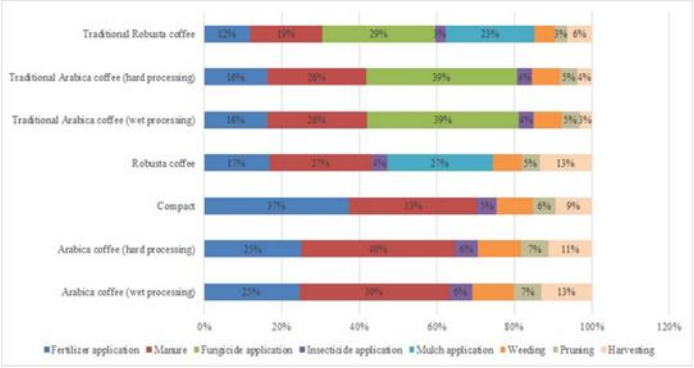

Fig. 1: Costs distribution for improved and traditional coffee varieties produced by smallholder farmers

Results in figure 1 indicates the costs distribution per each variable costs used in coffee production. The results imply that smallholder farmers with improved coffee varieties are related to procurement of manure and fertilizer whereas farmer with traditional coffee varieties use more costs to control coffee diseases such as CBD and CLR by applying fungicides. According to [19] majority of smallholder farmers in Tanzania use manure produced from the livestock kept by their own and only few who buy manure. In this study the assumption was that all farmers buy manure and the cost of manure for those who buy in the study areas was used as benchmark.

The costs distribution by individual smallholder farmers with improved varieties and those with traditional coffee varieties are shown in figure 2 and 3 respectively.

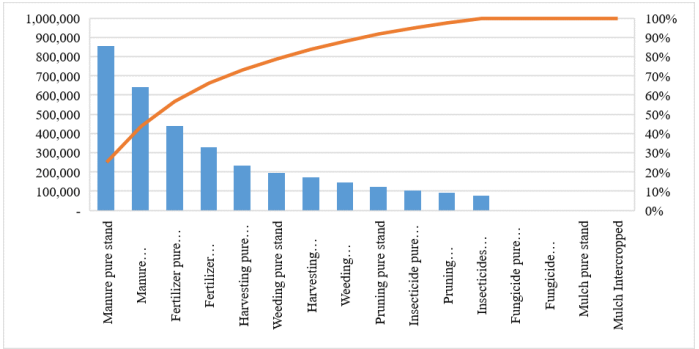

Fig. 2: Cost distribution from smallholder farmers with improved coffee varieties

[1] 1 UD$ exchange rate was 2200 TZS

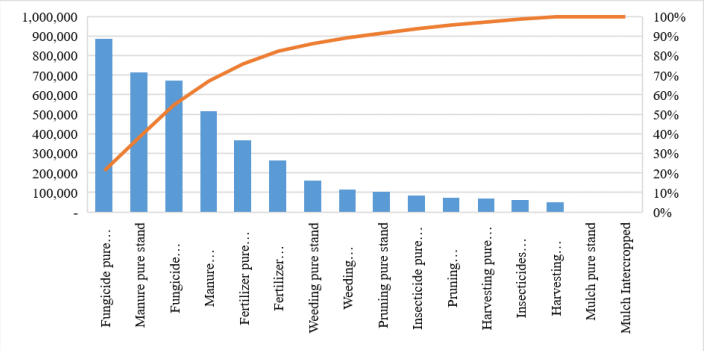

Fig. 3: Cost distribution from smallholder farmers with traditional coffee varieties

3.5 Profitability gained by smallholder farmers

3.5.1 Gross margin analysis

The results in Table 2 shows expected cost, revenue and gross margin for a period of 5 years of investment. Smallholder farmers with improved coffee varieties gain higher gross margin 3.5 million TZS/ha than smallholder farmers with traditional coffee varieties 0.5 million TZS/ha. Majority of smallholder coffee growers can hardly earn TZS 0.75 million TZS/ha [18]. According [20] smallholder farmers gain low profit because they invest low. This is contrary to large scale farmers who invest much in production and gain optimal yield and profit. The yield scenario used by this study and the price assumed shows that smallholder farmers gain profit because the gross margin is positive [10], [21].

3.5.2 Sensitivity analysis

A sensitivity analysis determines how different values of an independent variable affect a particular dependent variable under a given set of assumptions. Results in Table 3 show that, NPV for improved coffee varieties and traditional varieties are positive except for traditional Arabica coffee hard processed which is negative under intercropping farming system. The IRR for improved and traditional varieties are greater than the 12% discounted rate except for traditional Arabica coffee hard processed. These results imply that investing in coffee production by using the improved or traditional coffee varieties regardless of the farming systems is profitable except for traditional Arabica coffee hard processed under intercropping faming systems. [10], [14] stated that the decision rule is to accept projects that show a positive net present value and IRR to be greater than the discounted rate.

3.5.3 Benefit-cost ratio analysis

The benefit-cost ratio (BCR) was analyzed to summarize the overall relationship between the relative costs and benefits of investing in coffee production. In the economic analysis, the benefit-cost ratio was calculated for the aggregated statement of inflows and outflows for a period of 15 years, as in the previous case, with a discount rate of 12%. The results in Table 3 shows that, BCR are greater than 1 for smallholder farmers with improved coffee varieties in all farming systems and for traditional Robusta varieties under pure stand farming system. This implies the smallholder farmers investing in the project of coffee farming and planted improved varieties and traditional Robusta varieties have the capacity to cover the investment and operating expenditures. Meanwhile the BCR for smallholder farmers with traditional Arabica coffee varieties are less than one implying the costs outweigh the benefits and smallholder farmers would run coffee farming at a loss. Following [14], the selection criterion for projects is to consider acceptable those with a benefit-cost ratio equal or higher to one.

4.0 Conclusion and Recommendations

In this study it was observed that smallholder coffee farmers with improved coffee varieties invest much in coffee production. Also the gross margin, NPV, IRR and BCR indicated that coffee production is profitable for smallholder farmers with improved coffee varieties and traditional coffee varieties but except for smallholder farmer with traditional Arabica hard processed under intercropping farming system. Therefore, for smallholder farmers to gain good profit they adhere with implementation of good agronomic practices and adoption of improved coffee varieties which are high yielding and disease resistance.

Acknowledgment

The authors wish to thank coffee growers in Tanzania, the government of Tanzania and the European commission in Tanzania for supporting this work.

References

[1] ICO, “Total production by all exporting countries, International Coffee Organization,” 2018.
[2] C. Sänger, “United Nations Conference on Trade and Development: State of the global coffee market,” in *10th Multi-year expert meeting on commodities and Development*, 2018, p. 36.
[3] TCB, “Bodi ya Kahawa Tanzania: Sekta Mpya ya Kahawa Tanzania; Mkutano Mkuu wa Tisa wa Wadau wa Kahawa,” 2018.
[4] BOT, “Bank of Tanzania, Annual Report,” no. 0067–3757, pp. 213–234, 2017, doi: ISSN 0067-3757.
[5] T. Oberthur, J. Pohlan, and G. Soto, “Plant nutrition: Sustainable nutrient management. In: Oberthur T. et al. (eds). Speciality coffee: managing quality. An IPNI/SEAP publication, Penang, Malaysia.,” vol. 123, no. 149, 2012.
[6] TaCRI, *Agricultural Practices of Arabica. Coffee Productivity and Quality Improvement Programme. Tanzania*. Moshi, Kilimanjaro: Tanzania Coffee Research Institute, 2011.
[7] JN. Wintgens, “Coffee: Growing, Processing, Sustainable Production: A Guidebook for Growers, Processors, Traders, and Researchners. Wiley - VCH; 3 editions.,” no. 1022, 2012.
[8] G. Wrigley, *Coffee. Tropical Agriculture Series*. New York: John Wiley and Sons, 1988.
[9] T. Yamane, “Statistics: An Introductory Analysis, 2nd Edition.” New York: Harper and Row, 1967.
[10] T. Alimi and V. M. Manyong, “Partial budget analysis for on-farm research,” *IITA*, vol. 65, pp. 1–53, 2000.
[11] R. Ghimire, H. Wen-chi, and R. B. Shrestha, “Factors Affecting Adoption of Improved Rice Varieties among Rural Farm Households in Central Nepal,” *Rice Sci.*, vol. 22, no. 1, pp. 35–43, 2015.
[12] A. Arega, A. Tekalign, T. Solomon, and B. Tekile, “Effect of Inter and Intra Row Spacing on Tuber Yield and Yield Components of Potato (Solanum tuberosum L.) in Guji zone, Southern Ethiopia,” *J Adv Plant Sci*, vol. 1, no. 1, p. 102, 2018.
[13] M. Khonje, J. Manda, A. D. Alene, and M. Kassie, “Analysis of Adoption and Impacts of Improved Maize Varieties in Eastern Zambia,” *World Dev.*, vol. 66, pp. 695–706, Feb. 2015.
[14] J. P. Gittinger, “Economic analysis of agricultural projects,” *Econ. Dev. Inst. WORLD BANK Johns Hopkins Univ. Press Baltim. Lond.*, 1982.
[15] W. C. Riddell and X. Song, “The Role of Education in Technology Use and Adoption: Evidence from the Canadian Workplace and Employee Survey,” pp. 1–34, Feb. 2012.
[16] B. D. Parrish, V. a. Luzadis, and W. R. Bentley, “What Tanzania’s coffee farmers can teach the world: A performance-based look at the fair trade-free trade debate,” *Sustain. Dev.*, vol. 13, no. 3, pp. 177–189, 2005, doi: 10.1002/sd.276.
[17] USAID, “Tanzania Nutrition Profile,” p. 7, 2018.
[18] D. Kilambo, D. J. Mtenga, N. Ng’homa, R. Ngomuo, J. Teri, and B. Lwilo, “A Decade of Contributing to a Profitable and Sustainable Coffee

Industry in Tanzania: The Arabica and Robusta Improvement Programmes," *Am. J. Res. Commun.*, vol. 3, no. 4, pp. 42–46, 2015.
[19] G. Maro, B. Janssen, B. Msanya, and J. Mrema, "Economic Optimization of Nutrient Application to Coffee in Northern Tanzania Using SAFERNAC," *Int. J. Plant Soil Sci.*, vol. 3, no. 9, pp. 1096–1111, Jan. 2014, doi: 10.9734/IJPSS/2014/8361.
[20] M. Christophe, "Coffee Production Costs and Farm Profitability," *Spec. Coffee Assoc.*, 2017.
[21] W. H. Greene, *Econometric analysis*, 5. ed. Upper Saddle River, NJ: Prentice-Hall, 2003.

Table 1: Coffee yield (Kg/ha) and Peak capital requirement

Description	Yield kg/ha		Peak capital requirement	
	Pure stand	Intercropped	pure stand	intercropped
Improved				
Arabica coffee Tall varieties (wp)	2,400	1,800	3,055	2,049
Arabica coffee Tall varieties (hp)	3,000	2,400	3,449	2,049
Compact varieties	4,800	3,600	3,055	1,831
Robusta coffee varieties	4,000	3,000	2,793	2,661
Traditional				
Arabica coffee (wp)	959	696	3,055	1,690
Arabica coffee (hp)	1,332	967	2,661	1,690
Robusta coffee	2,222	1,556	1,722	1,503

Note: wp=wet processing hp=hard processing

Table 2: Gross Margin Analysis (TZS/ha x 000)

Descriptions	Revenue		Costs		Gross Margin	
	pure stand	inter-cropped	pure stand	inter-cropped	pure stand	inter-cropped
Improved						
Arabica coffee Tall varieties (wp)	7,200	5,400	3,589	2,754	3,611	2,646
Compact varieties	7,200	5,760	2,840	2,321	4,360	3,439
Arabica coffee tall varieties (hp)	8,460	6,345	4,068	3,080	4,392	3,265
Robusta coffee varieties	7,500	5,625	3,779	2,822	3,721	2,803
Traditional						
Arabica coffee (wp)	2,877	2,089	2,300	1,720	577	369
Arabica coffee (hp)	2,348	1,704	2,098	1,589	250	115
Robusta coffee	4,167	2,917	2,724	2,017	1,443	900

Note: wp=wet processing hp=hard processing

Table 3: Sensitivity Analysis

Descriptions	NPV TZS/ha (000)		IRR (%)		BCR (%)	
	Pure stand	Inter-cropped	Pure stand	Inter-cropped	Pure stand	Intercropped
Improved						
Arabica coffee Tall varieties (wp)	96,123	69,201	0.67	0.60	3.83	3.60
Compact varieties	116,783	91,114	0.70	0.65	3.22	3.11
Arabica coffee tall varieties (hp)	118,678	87,193	0.75	0.68	2.47	4.31
Robusta	99,253	75,734	0.72	0.82	3.27	3.14
Traditional						
Arabica coffee (wp)	11,176	6,082	0.28	0.23	0.60	0.54
Arabica coffee (hp)	1,190	-1,309	0.14	0.09	0.31	0.26
Robusta	35,830	20,988	0. 54	0.46	1.14	0.90

Note: wp=wet processing hp=hard processing