ISSN No:-2456-2165

Profitability Analysis of Coffee Production among Adopters and Non-Adopters of Improved Coffee Varieties in Mbinga And Mbozi Districts

Leonard Kiwelu
PhD Student- School of Agricultural Economics and Business Studies (SAEBS),
Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture (SUA),
Morogoro, Tanzania. P.O. Box 3007, Morogoro, Tanzania

Philip Damas and Zena Mpenda
School of Agricultural Economics and Business Studies (SAEBS),
Department of Food and Resource Economics, Sokoine University of Agriculture (SUA),
Morogoro, Tanzania. P.O. Box 3007, Morogoro, Tanzania

Abstract:- The use of improved varieties is expected to increase coffee productivity and profitability. However, farmers complain regarding low returns from coffee production which is due to inadequate empirical evidence on the benefit of adopting improved coffee varieties for small holder farmers in the country. This study aimed to test the hypothesis on whether it is profitable in the long run to adopt improved coffee varieties in terms of returns on investment. Data were collected from 320 smallholder coffee farmers of which 122 were adopters and 198 were non-adopters of improved coffee varieties randomly selected from Mbinga and Mbozi Districts using questionnaires and oral interview schedules. The descriptive statistics, Gross Margin (GM), Net Farm Income (NFI), Return on Investment (ROI), Net Present Value (NPV), the Benefit-Cost Ratio (BCR), and the Internal Rate of Return (IRR) were used to estimate the viability of adopting improved coffee varieties in the study area. The findings indicate that the GM, NFI, ROI, NPV, BCR and IRR for adopters is higher ($p<0.005$) than for non-adopters. The findings provide evidence that coffee farming using improved coffee varieties is economically viable in the long run. It is, therefore, recommended that farmers should be encouraged to adopt the improved coffee varieties and implement good agricultural practices so as to increase productivity and profitability. The recommended GAPs include applying Integrated Soil Fertility Management Practices (ISFM) to minimize costs of fertilizers, weeding, and disease control. Farmers should also use Integrated Pests Management Practices (IPM) to minimize the cost of pest control.

Keywords:- *Arabica, coffee, profitability, coffee varieties.*

I. INTRODUCTION

Coffee is among the important tropical valuable and traded commodities. The crop is produced in 70 countries in the world including 25 countries in Africa (Sänger, 2018). Brazil is the leading coffee-producing country followed by Vietnam and Colombia. In 2018/19, Brazil produced 3.78 million tonnes (36.8 %) of the world's production and Vietnam contributed 18.2 %, and Colombia 8.1 %. In Africa, Ethiopia is the biggest coffee producer ranked 5th in the world with a production of 0.47 million tonnes followed by Uganda in the 8th position with 0.28 million tonnes and Côte d'Ivoire 13th with 0.14 million tons (ICO, 2019b). In Tanzania, for the past six years coffee has been a primary agricultural export crop contributing 18 % of traditional cash crops earning after cashew nuts (36 %) and tobacco (27 %). Other crops include: cotton (7 %), tea (6 %), sisal (3 %) and cloves (2 %) contribute lower than coffee (BOT, 2020). In Ethiopia coffee accounts for 34 % of the total value of agricultural products exported (Bickford, 2019), Kenya 5.5 % (ICO, 2019b), and Uganda 15 % (ICO, 2019d). Despite the importance of the crop in Tanzania still, coffee farmers are complaining with regards to low returns from coffee production. The possible reasons could be high costs associated with farm management, low productivity caused by coffee varieties, insect pest damage, disease damage, poor crop husbandry practices and low coffee quality which lead to low prices in the market. Tanzanian government put efforts to address these challenges including promoting the adoption of improved coffee varieties through support multiplications and distributions of improved coffee seedlings, training smallholder farmers on implementation of good agricultural practices (GAPs) to increase productivity and quality (TaCRI, 2018) and reduce taxations in the coffee sector to improve profitability. Despite these efforts, information on production costs as a determinant of farm profitability among adopters and non-adopters of improved coffee varieties remains scanty. Lack of this information makes it difficult to tell whether the government efforts are working or not. Different studies have been conducted in the coffee sector to assess various aspects including agronomic practices of coffee farming, production, marketing, and profitability (Jeremiah *et al.*, 2018*;* Kilambo *et al.*, 2015*;* Mhando,2018*;* Mtenga, 2016;

and Otieno *et al.*, 2019). The findings from these studies have generalized or treated all farmers as having one coffee variety irrespective of presence of improved and traditional coffee varieties planted by farmers. The objective of this study was to assess whether adopters and non-adopters of improved coffee varieties in Mbinga and Mbozi Districts get profit from coffee production. The findings from this study will help researchers and other stakeholders in the coffee industry to understand the cost and profitability of coffee production for both adopters and non-adopters of improved coffee varieties.

II. THEORETICAL AND CONCEPTUAL FRAMEWORKS

In order to better understand the subject matter, it is imperative to have some theoretical and conceptual frameworks about coffee husbandry. This will shed light on the industry that will benefit stakeholders including planners, government and smallholder coffee farmers.

A. Theoretical Framework

The major concern in coffee production among farmers is the minimization of cost(s) for a given level of output, and the maximization of revenue for a given level of inputs. However, some farmers incurred high costs of coffee production because they lack alternative means of minimizing the costs and maximizing profit. The literature suggests that farmers may be motivated to produce based on their attitude towards risk; the utility derived from production; and for-profit reasons (Huffman, 2011; and Muellbauer, 1974). Coffee is a cash crop and it employs more than 450 000 families TCB, (2016) who are the owner and managers of coffee farms. It is, therefore, safe to argue that profit maximization is the priority of the majority of coffee farmers. This study was guided by the theory of profit maximization (Debertin, 1986; and Muellbauer, 1974). Coffee producers invest in coffee production to get a certain output that minimizes costs and maximizes profit. According to Cellini (2015) the farmer's profit is equal to total revenue (TR) minus total cost (TC). The production costs of coffee are determined by fixed cost and variable costs invested to produce a certain output through which a profit can be obtained after selling the gained output less the cost of production. Understanding the profitability in coffee production among adopters and non-adopters was at the centre of the present study which aimed at testing the hypothesis on whether it is profitable in the long run to adopt improved varieties in terms of returns on investment.

B. The Conceptual Framework

Achieving profitability in coffee production can be influenced by several factors including the socio-economic, institutional and agronomic factors. The socio-economic characteristics which were assumed to determine farmers` labour availability to operate farm activities and decisions to adopt or not to adopt improved coffee varieties and allocating resources economically to maximize profit. Meanwhile it is assumed that the geographical aspects in the study area create an environment for market factors which affect price of inputs hence some farmers may minimize production cost than others depending on their socio-economic characteristics and capability of price negotiation for discounts when farmers buy inputs as strategy to minimize costs which lead to increased profit. Institutional factors such as research, coffee board, extension, and membership of primary cooperatives provide a framework to support farmers' access to improved seedlings and technologies, skills and knowledge which contribute to improve farm management practices which its result is the improvement in productivity and minimizing costs of production hence profitability. The agronomic factors that combine input costs used in coffee production which by one way or another have influence on coffee productivity, quality hence better price paid to farmers and finally improve profitability. Following that, the conceptual framework as presented in Fig. 1 was developed.

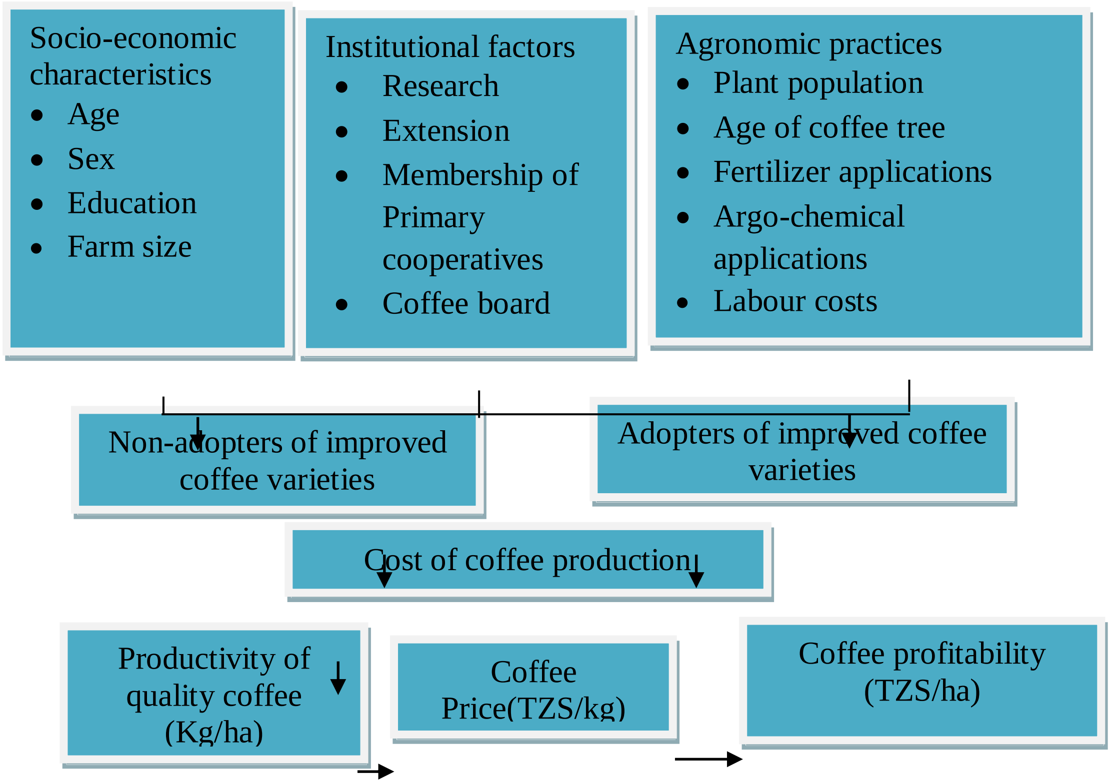

Fig. 1: Conceptual framework

Source: Developed by author

III. METHODOLOGY

A. Description of the Study Area

This study was conducted in Mbozi and Mbinga Districts (Fig 2). The two Districts produce about 50% of the total Arabica coffee produced in Tanzania. Mbozi District lies between 8°45'0" S and 32°45'0" E. It is bordered to the North by Chunya District, to the East by Mbeya Urban and Ileje Districts, to the South by Zambia, and to the West by Rukwa Region. Mbozi District lies between 900 and 2750 metres above the sea level receiving average rainfall between 1350 mm and 1550 mm per annum while temperatures range from 20°C to 28°C. The major food crops grown in the area include maize, paddy, sorghum, finger millet, bulrush millet, sweet potatoes, Irish potatoes, groundnuts, and beans while the cash crops grown are coffee, avocado, simsim, and sunflower. The common types of livestock owned include cattle, goats, sheep, pigs, poultry, donkeys, and turkeys (MDC, 2010).

Mbinga District lies between 10°49'60" S and 34°49'60" E. The District is bordered to the North by Njombe Region, to the East by Songea Rural and Songea Urban Districts, to the South by Mozambique, and to the West by Lake Nyasa. The altitude of Mbinga District ranges between 900 and 1350 metres above sea level; with some points in the highland reaching over 2000 metres above sea level. The District receives average rainfall between 1200 and 1500 mm per annum; while temperatures range between 13°C in the highland and 30°C on the lakeshore. The major crops in the District include maize, sorghum, coconut, bananas, beans, cassava, finger millet, and cash crops like coffee, cashew, tobacco, and Avocado (a new emerging cash crop). Likewise, smallholder farmers deal with livestock keeping, beekeeping, fish farming, and lumbering of hardwood. The common types of livestock owned include cattle, goats, sheep, pigs, and poultry.

ISSN No:-2456-2165

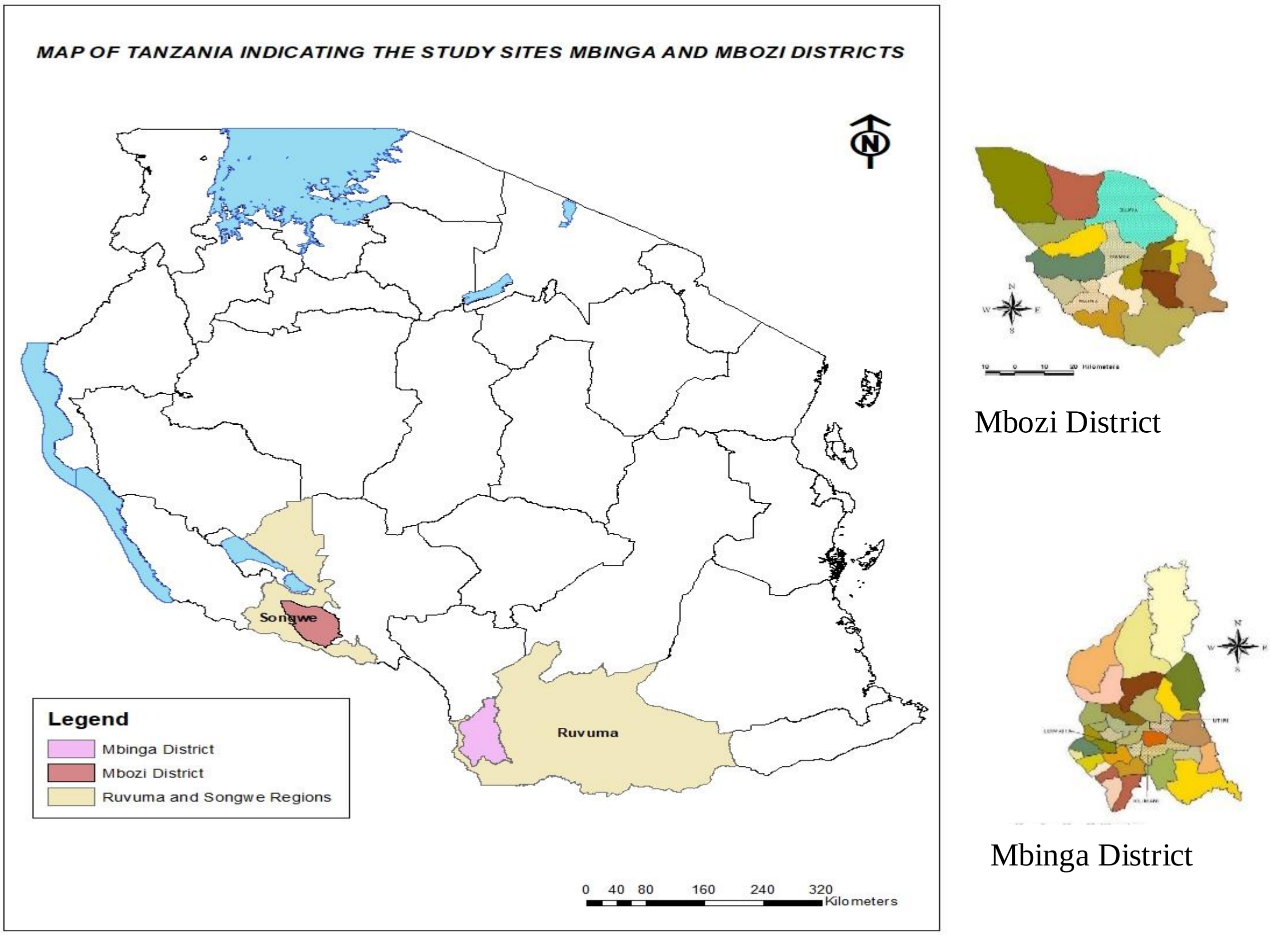

Fig. 2:Map of Tanzania indicating study sites Mbozi and Mbinga Districts

B. Research Design and Sampling Techniques

The present study employed a cross-sectional research design to collect data from two major Arabica coffee producing Districts, Mbinga and Mbozi. In this design, all data collected from the sampled population was done at a single point in time. A multi-stage sampling procedure was used at the first stage to select Arabica-producing wards and villages from Mbinga and Mbozi Districts. Secondly, a random sampling method was applied in selecting wards and villages where coffee is grown. The third stage involved random sampling of villages with adopters of improved coffee varieties and non-adopters (farmers planted traditional coffee varieties). The traditional coffee varieties were distributed to farmers for free by TCB under Coffee Development Programme (CDP) from 1998 to 2003. Finally, random sampling was applied in selecting coffee households growing improved and traditional coffee varieties. A required sample size of respondents was proportionally selected from the list of coffee growers developed in the third stage per village following Krejcie (1970) formula as presented in equation 1. The final dataset consists of a random sample of 320 (Table 1) coffee producers, 122 of which are adopters of improved coffee and 198 were non-adopters.

$$S = \frac{X^2NP(1-P)}{d^2(N-1)+X^2P(1-P)} \quad (1)$$

Where: S=Required sample size, X =z value (assumed to be 1.96 for 95% confidence level), N = Population size, P = Population proportion (assumed to be 0.5 since this would provide the maximum sample size), d = degree of accuracy (5%), expressed as a proportion (0.05). Mbozi District consists of 930 households and Mbinga District consist of 990 households, making a total of 1920 targeted households.

$$n = \frac{1.96^2x1920x0.5x0.5}{0.05^2x(1920-1)+(1.96^2x0.5x0.5)}=320$$

District	Approx. sub-pop. (20-30% are coffee farmers)	Sampling fraction	Sub-sample	Improved varieties	Traditional varieties
Mbozi	930	0.48	155	49	106
Mbinga	990	0.52	165	73	92
Total	**1920**		**320**	**122**	**198**

Table 1: Sample Districts and number of sample households

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C. Data Collection

a) Secondary data collection

Secondary data such as coffee auction price, the contribution of coffee to the national economy, and the trend of coffee productions were collected from various agricultural economic journals and research reports, books, and other publications related to the coffee sector to provide the necessary support to the primary data accumulated.

b) Primary data collection

A sample of 224 farmers was taken randomly from various villages in Mbinga and Mbozi districts and primary data were collected for the 2019/20 crop season from household heads owning traditional coffee varieties and improved coffee varieties using a semi-structured questionnaire. The information collected includes household demographic characteristics such as sex, age, family size, number of years informal education of the household head, household labour capacity; institutional factors such as access to extension services and group membership; farm characteristics such as type of coffee varieties planted and plant population, fixed costs and variable costs. The data on fixed costs collected includes land preparations, pegging, layout, holing, coffee seedlings, growth-enhancing fertilizers like DAP (diammonium phosphate), farmyard manure for planting, mixing, and refilling manure, coffee planting, and equipment. The variable costs as used in this study refer to costs incurred from the time the trees start bearing fruits onwards (third and fourth year onwards). The data on variable costs collected include the cost of manure, fertilizer, herbicides, pesticides, and fungicides, labour costs for weeding, spraying, costs of equipment, harvesting, and post-harvest handling. The study also collected data on coffee yield and coffee price. Since the coffee price varies over time, the present study collected season average auction prices from 2009/2010 to 2019/2020 from the Tanzania coffee board (TCB) as presented in Annex 1 and computed producer price index using the formula using the following formula: Price Index = Sum of all the prices of stocks which are part of Index / Number of Stocks in the Index. Therefore, the coffee price used in the study is 6278 TZS/kg.

D. Data Analysis

The collected data were coded and analyzed using Statistical Package for Social Sciences (SPSS) and MS Excel. The quantitative data were analyzed using descriptive statistics to capture mean, frequency, and percentages. The t-test was used to test for the statistical significance of the variables. The profitability of coffee production was analyzed using two main scenarios: the first is the cash scenario and the second is the economic costs of coffee production for long rung investments as formally used in the study conducted by ICC, (2019) and Montagnon, (2017). The first scenario considers the operational costs where Gross Margin (GM) and Rerun on Investment (ROI) was used to measure profitability whereas the second scenario covers the total production costs including the opportunity costs on land, family labour, and depreciation of assets such as farm equipment.

a) Profitability analysis of coffee production

The analysis of gross margin (GM), net farm income (NFI), and Return on Investment (ROI) aimed at estimating the relative economic profitability of coffee production in the study area. According to Cellini (2015), gross margin per hectare is important because it is a good measure for comparing the profitability of similar-sized farms and it also represents the bare minimum that a farm must generate to stay in business (Debertin, 1986). The advantage of using gross margin is that it does not involve tedious calculations and it is also more flexible in accommodating personal expectations and limitations of the given condition (Huffman, 2011). Likewise, it is the most common profitability criteria that farmers are familiar with and base their production decisions on using the gross margins allows for the most realistic baseline in our case which is also documented by Bonke *et al.*, (2021). However, the gross margin is not a good measure of a farm's true profitability or a farm's long-term viability because cannot be used where varying capital input is needed for an enterprise (Heaslip *et al.*, 2013). The costs of equipment such as hand hoe, bush knife, pruning saw, secateurs, wheelbarrow, slasher, sprayer pump, and spade were assumed to last for ten years and therefore their total value was annualized by dividing them by ten as an approximation of their years of productive life. Since the productive assets may be used in other crops and activities outside of coffee, the cost is scaled by the fraction of the total farm area in coffee which is 50%. Since no new asset were reported during the crop season of the reference year 2019/20, these costs are further scaled by 0.5 to roughly account for the likelihood that most productive assets are not new. Manure is recommended to be applied after every season but its economic value to the crop lasts for more than two seasons TaCRI, (2011). This implies that the cost of manure was annualized by dividing it by three to get the real value.

a. Gross margin analysis

$GM = TR - TVC$ …………………………………………………..……………..……(2)

Where: GM = Gross Margin, TR = Total Revenue ((Coffee Yield in kg x Price (TZS/kg)) and TVC = Total Variable Cost

b. Computation of net farm income (NFI)

$NFI = GM - TC)$ ……………………………………………………………….. (3)

Where: NFI = net farm income, GM = gross margin, TC = total cost.

c. Return on investment (ROI)

Return on investment or return on costs is a ratio between net income and investment. In this analysis of ROI, no deducation was considered, therefore this is the net income for operating capital.

$$ROI = \frac{NFI}{TC} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where: NFI = net farm income and TC= Total costs

b) Economic analysis

To examine the economic feasibility of coffee production in the study area, the following indicators were used:Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR). The following assumptions were made in their calculation: First, coffee producers have matured coffee trees with maximum production. Second, the project lifetime is twenty-five (25) years which is the economic life span of coffee trees (Robinson, 1961). The discounted rate of 8% offered by the Tanzania Agricultural Development Bank (TADB) to smallholder farmers in cooperatives was used in this analysis (TADB, 2020). The coffee producers in the study area use family and hired labour for farm activities. However, they are not counting their family labour as part of the production costs so the costs for the farming activities for farmers who used family labour were taken based on those farmers who used hired labours. Therefore, the NPV, BCR, and IRR were computed as follows:

a. The Net Present Value (NPV)

The NPV is an indicator and method for financial decision-making and it is the primary financial indicator used in this study. Advantages for the NPV method include: First, when calculated properly, it always provides the correct financial decision; and, in comparison to other complex techniques, it is relatively simple to calculate (Alimi, 2000 and Boardman et al., 2018). The net present value of an investment is the algebraic sum of the current net benefits of the project. The NPV is simply the difference between the discounted benefits and the discounted costs, and the investment rule for a project is: If NPV = 0 indifferent, if NPV is greater than 0 invest, and if NPV is less than 0 do not invest.If projects cost money but do not produce financial benefits, the best option is the one in which the NPV is the closest to zero, i.e., the least reduction in wealth (Boardman et al., 2018). The following formula is used to compute NPV:

$$NPV = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+r)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where:

B_t = Benefits in each project year t, C_t = Costs in each project year t, n = Number of years to the end of the project which is the economic life of the coffee tree that ranges from 0 to 25 years) and r = Discount rate.

b. The Benefit-Cost Ratio (BCR)

The benefit-cost ratio is the ratio between the sum of discounted net benefits of returns (R) and the sum of discounted cost (K), i.e., B = R/K.In costs benefit analysis (CBA), future benefits and costs are discounted relative to present benefits and costs to obtain their present values (PV). A cost or benefit that occurs in year t is converted to its present value by dividing it by $(1 + r)t$, where r is the discount rate. The present value of the benefit, $PV(B)$, and the present value of costs, $PV(C)$, of the project, are represented mathematically as follows:

$$PV(B) = \sum_{t=1}^{t=n} \frac{B_t}{(1+r)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$PV(C) = \sum_{t=1}^{t=n} \frac{C_t}{(1+r)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The decision rule is that we accept the project if the BCR ≥ 1 and when the cost and benefit streams are discounted. Thus, if BCR > 1 it implies that coffee production is profitable, if BCR < 1 it implies not profitable, and if BCR =1, the investment break even.

$$BCR = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+r)^t}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where:

B_t = Benefits in each project year, *t*, C_t = Costs in each project year, *t*, n= Number of years to the end of the project (n ranges from 1 to 25) and r= Discount rate

c. The Internal Rate of Return (IRR)

Internal Rate of Return (IRR), a financial indicator also used in this study, is the rate of discount for the point at which the NPV is equal to zero (Alimi, 2000 and Boardman et al., 2018). The IRR measures the profitability of an investment and identifies the interest rate at which the project generates neither losses nor profits. In estimating the internal rate of return, the investment cost and incremental gross returns for each year in the life of coffee production were calculated. The internal rate of return was calculated at the different rate of discount until it satisfies the relationship B – C = 0 where 'B' is the sum of discounted streams of positive value (returns) and 'C' is taken as the sum of discounted streams of negative values (costs). This is represented mathematically as:

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$$IRR = DR + [HDR + LDR]\frac{NPV^{LDR}}{NPV^{LDR} + |NPV^{HDR}|} \ldots\ldots (9)$$

Where: LDR = Lower discount rate HDR =Higher discount rate NPV^{LDR} = NPV at the lower discount rate. $|NPV^{HDR}|$ = Absolute value of NPV at the higher discount rate.

IV.FINDINGS AND DISCUSSION

A. *Costs analysis of coffee production*

a) Fixed costs of coffee production

The average age of the coffee tree considered in this analysis was 10 years for adopters and 20 years for non-adopters (Annex 2). The findings as presented in Table 2 showed that the average fixed costs of establishing coffee farm by adopters of improved coffee varieties are1683384TZS/ha and 933293 TZS/ha for non-adopters. The findings imply that non-adopters of improved coffee varieties encored relative lower costs than adopters and there is a statistically significant difference (p = 0.000) as indicated in Annex 3. The high fixed cost for adopters was associated with plant polulation which contributed to increase in number of man days, fertilizer and manure for planting. According to TaCRI, (2011) improved coffee varieties are planted in a space of 2 metres by 2.5 metres with an average plant population of 2000 per ha while traditional coffee varieties are planted in a space of 2.74 metres by 2.74 metres with average plant populations of 1330 per ha. Planting coffee seedlings requires hole preparation filled with one tin of 20 litres of farmyard manure to be mixed with 100 gm of DAP fertilizers or 150 gm to 300 gm of rock phosphate fertilizers. Therefore, smallholder farmers can minimize the costs of establishing new coffee farms if they get subsidized seedlings and also use farmyard manure produced from their own farms.

Descriptions	Overal			
	Adopters	%	Non-Adopters	%
Costs for land preparations	207201.7	12.3	137801.4	14.8
Costs for peggs preparations	137355.2	8.2	91349.36	9.8
Cost for layout	53218.73	3.2	35393.62	3.8
Costs for holing	274710.4	16.3	182698.7	19.6
Costs for seedlings	354654.2	21.1	104494.4	11.2
Costs for fertilizer for planting	329652.4	19.6	219238.5	23.5
Cost for Manure	274710.4	16.3	182698.7	19.6
Costs for planting	51881.2	3.1	34504.08	3.7
Total Fixed costs	**1683384**	**100.0**	**933292.9**	**100.0**

Table 1: Fixed costs for coffee production (TZS/ha)

b) Variable costs coffee production

The findings presented in Table 3 indicates that the average variable costs for adopters of improved coffee varieties is 714 971 TZS/ha relative higher (p< 0.000) than 554 288 TZS/ha for non-adopters.However, the findings showed that the mean difference between adopters and non-adopters on pesticides applications is not statisticaly difference. The findings imply that adopters encore relativel lower cost on fungicides application but higher cost for labour and fertilizers than non-adopters.

Descriptions		Labour	Fertilizer	Pesticides	Fungucides	Average
Mbinga						
	n	73	52	27	31	73
Adopters	TZS/ha	554685	148866	46221	44226	736709
	n	92	74	51	64	92
Non-adopters		384074	111092	49179	97093	601783
Mbozi						
	n	49	29	19	32	49
Adopters	TZS/ha	515076	161230	40880	39589	682587
	n	106	68	58	78	106
Non-adopters	TZS/ha	310047	122672	33447	98305	513067
Overall						
	n	122	81	46	63	122
Adopters	TZS/ha	538776	153293	44015	41871	714971
	n	198	142	109	142	198
Non-adopters	TZS/ha	344443	116637	40808	97759	554288
t		7.044	2.561	0.439	-4.676	4.494
Sig.		0.000	0.011	0.661	0.000	0.000

Table 2: Variable cost in 2019/20 coffee production season

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c) Labour costs
The findings as presented in Table 4 showed that the costs for weedingand fungicides applications are relative lower for adopters than non-adopters (p<0.000).The main reason is associated with plant population where the improved coffee varieties are planted in closer space than traditional coffee varieties hence they supress weeds. Likewise the improved coffee varieties are fungicides free hence the application rates is low but not recommended. According to TaCRI, (2011) the improved coffee varieties are not infested with CBD and CLR however they are infested with minor fungal diseases such as Fusarium(Kilambo *et al.*, 2015). The costs of fertilizer application (p>0.050), pruning(p>0.064) and harvesting arerelatively higher (p<0.000) for adopters than non-adopters. This is due to the attribyes of improved coffee varieties such as high yielding. Also, according to Robinson, (1961) and TaCRI, (2011) the age of coffee trees has a significant impact on the cost of pruning and canopy management. The analysis showed that the average age of improved coffee trees planted in the field was 10 years while the traditional coffee trees was 20 years.

Descriptions		**Weeding**	**Fertilizer**	**Manure**	**Pesticides**	**Fungicides**	**Mulching**	**Pruning**	**Irrigation**	**Harvesting**	**Total costs**
Mbinga											
Adopters	N	73	27	29	29	23	5	13	18	73	
	Mandays	16	4	4	2	5	4	15	1	86	
	Costs	117061	42963	44138	24074	53043	44000	146154	13333	388027	554685
Non-adopters	N	92	5	8	23	35	10	25	11	92	
	Mandays	28	3	5	2	16	5	12	1	36	
	Costs	227674	34000	49375	20870	155257	47000	120400	11818	161987	384074
Mbozi											
Adopters	N	49	18	12	12	10	5	15	19	49	
	Mandays	13	4	6	2	4	4	16	1	79	
	Costs	90833	37333	56667	22500	44000	38000	159333	17895	355892	515076
Non-adopters	N	106	20	13	26	32	6	30	19	106	
	Mandays	21	3	6	2	16	4	12	1	33	
	Costs	174385	33500	60000	19583	159469	40000	120667	13684	146377	310047
Overall											
Adopters	N	122	45	41	41	33	10	28	37	122	
	Mandays	15	4	5	2	5	4	15	1	83	
	Costs	105953	40952	47805	23590	50303	41000	153214	15676	375120	538776
Non-adopters	N	198	25	21	49	67	16	55	30	198	
	Mandays	24	3	6	2	16	4	12	1	34	
	Costs	203224	33667	55952	20213	157269	44375	120545	13000	153630	344443
t		-5.512	1.895	-1.103	1.877	-4.96	-0.336	3.87	1.139	13.801	7.044
Sig.		0.000	0.063	0.274	0.064	0.000	0.740	0.000	0.259	0.000	0.000

Table 3: Labour cost analysis of coffee production in 2019/20 crop season

d) Costs of fertilizer used in coffee production
The findings as presented in Table 5 showed different types of fertilizers applied by farmers in the study area for 2019/20 crop season. The findings indicated that adopters of improved coffee varieties encored relative higher costs of fertilizer than non-adopters (p<0.011) and the possible reasons is the number of plant populations which is high as opposed to traditional varieties. Maro, (2014) and TaCRI, (2011) documented that the adoption of improved varieties have more costs associated in terms of fertilizer applications. According to TaCRI, (2011)farmers are advised apply different type of fertilizer because using one type of fertilizer continuously affect the pH of the soil.Also, farmers are encouraged to adopt Integrated Soil Fertility Management Practices (ISFM) such as shed tree planting, mulching, intercropping, green manuring, and farmyard manure or composite which they contribute to soil organic matter enrichment (Maro, 2014).

e) Costs for fungicides used in coffee production
The findings as presented in Table 6 showed that adopters of improved coffee varieties encored relative lower costs for fungicides to control coffee diseases. According to Kilambo *et al.*, (2013), fungicides are applied in coffee farms to control

ISSN No:-2456-2165

Coffee Berry Disease (CBD) and Coffee Leaf Rusts (CLR) which affect coffee productivity and quality especially for traditional coffee varieties. Kilambo *et al.*, (2015)and TaCRI, (2011), documented that improved varieties are infested with scaly bark disease caused by *Fusariumlateritium* and root rot disease caused by *Armillaria mellea*. However, the impact of these two diseases are not high compared to CBD and CLR.

Descriptions		UREA	CAN	SA	NPK	YARA mila java	Booster (kg/ha)	Average
Mbinga								
	N	8	29	13	15	13	1	52
	Bag of 50kg/ha	1	2	2	2	2	5	
Adopters	Costs (TZS/ha)	65425	100412	76717	121148	113220	19277	148866
	N	6	30	16	22	28	6	74
	Bag of 50kg/ha	1	1	1	1	2	3	
Non-Adopters	Costs (TZS/ha)	90995	72066	39062	92852	99279	10879	111092
Mbozi								
	N	4	9	4	14	6	4	29
	Bag of 50kg/ha	3	2	1	2	3	2	
Adopters	Costs (TZS/ha)	172301	96235	46368	127821	179552	17024	161231
	N	7	36	8	18	24	5	68
	Bag of 50kg/ha	1.231	1.6666	0.683	1.4559	1.8375	1.2562	
Non-Adopters	Costs (TZS/ha)	79568	88846	30270	88991	112535	8289	122672
Overall								
	N	12	38	17	29	19	5	81
	Bag of 50kg/ha	1.67	1.95	1.67	2.12	2.13	2.91	
Adopters	Costs (TZS/ha)	101283	102321	69960	125009	137017	19210	153293
	N	13	66	24	40	52	11	142
	Bag of 50kg/ha	1.35	1.52	0.82	1.48	1.72	1.97	
Non-adopters	Costs (TZS/ha)	86271	80877	34533	90989	105567	11805	116637
t		0.645	1.413	3.025	2.562	0.845	1.233	2.561
Sig.		0.525	0.161	0.004	0.013	0.401	0.238	0.011

Table 4: The costs of fertilizer (TZS/ha) used by farmer in 2019/20 crop season

Descriptions		Blue copper	Red copper	Xanthos	Ninja	Snow plus	Snow viL	Quadric	Mpavil	Twigafosi	Santo	Karat	Average cost for Fungicide
Mbinga													
	n	20.000	6.000	6.000	2.000	3.000	3.000		10.000	1.000	3.000	4.000	
	Kg/lrt/ha	2	1	1	1	1	1		2	2	1	1	
Adopters	Cost	12441	16875	17500	15000	21667	18500		26100	36000	16000	25000	44226
	n	34	18	13	11	12	6	3	8	1	8		
Non-	Kg/lrt/ha	5	2	1	2	2	5	1	2	7	3		
Adopters	Cost	28463	66778	45923	32273	51658	85833	30000	25250	126000	27750	.	97093
Mbozi													
	n	20	3	3	3	4	4	3	9	1	1	2	
	Kg/lrt/ha	3	1	1	2	0	1	1	1	1	1	1	
Adopters	Cost	33313	17533	20000	25000	8750	18125	12500	22111	9000	20000	20000	39589
	n	42	14	11	18	18	8	4	24	3	4	2	
Non-	Kg/lrt/ha	5	4	1	2	1	4	3	2	5	3	2	
Adopters	Cost	63023	109963	42091	26306	35656	73000	50500	25417	87000	41500	40000	98305
Overall													
	n	40	9	9	5	7	7	3	19	2	4	6	
	Kg/lrt/ha	3	1	1	1	1	1	1	1	1	1	1	
Adopters	Cost	30888	17094	18333	21000	14286	18286	12500	24211	22500	17000	23333	41871
	n	76	32	24	29	30	14	7	32	4	12	2	
Non-	Kg/lrt/ha	5	3	1	2	2	4	2	2	5	3	2	
Adopters	Cost	64895	85671	44167	28569	42057	78500	41714	25375	96750	32333	40000	97759
t		-4.587	-2.051	-2.638	-0.885	-2.415	-2.304	-1.754	-0.265	-1.663	-1.38	-2.739	-4.676
Sig.		0	0.047	0.013	0.383	0.021	0.033	0.117	0.792	0.172	0.189	0.034	0.000

Table 5: The costs of fungicides used in 2019/20 coffee production season

ISSN No:-2456-2165

f) Costs for pesticides used in coffee production

The findings as presented in Table 7 showed that the mean difference between the cost of pesticides used in 2019/20 crop season among adopters and non-adopters are not statistically significant. This is because farmers are required to apply pesticides when substantial number of pests are identified in coffee farm.Also, they are encouraged to use Integrated Pest Management Practices (IPM) such as natural products like: use of biopesticides (botanicals) to minimize or reduce the use of industrial pesticides. Meanwhile blanket application of pesticides is discouraged(Magina, 2011 and TaCRI, 2011).

Descriptions	Adopters				Non-adopters					
	n	Litres /ha	Unit costs	Total cost	n	Ltr /ha	Unit costs	Total cost	t	Sig.
Selecrone	6	2	17667	29445	37	2	17243	39147	-0.862	0.394
Dusban	25	1	16655	24476	54	1	23696	30089	0.767	0.445
Agrocron	10	3	25500	70635	10	2	28400	70347	0.058	0.954
Crush	4	2	22000	44000	2	2	24500	36750	0.233	0.828
Roundup	18	2	10278	20008	55	2	11846	18672	-0.037	0.971
Total cost	**46**			**44015**	**109**			**40808**	**0.439**	**0.661**

Table 6: The costs of pesticides used in 2019/20 coffee production season

B. *Profitability analysis of coffee production*

a) Gross margin analysis

The findings as presented in Table 8 showed that the gross margin for adopters of improved coffee varieties for the 2019/20 crop season is7 135 050 TZS/ha significantly (p<0.000) higher than 2 660 682TZS/ha for non-adopters.The findings were also desegregated by districts and showed that both adopters from Mbinga and Mbozi districts gained higher gross margin than non-adopters. These findings provide evidence that the adoption of improved coffee varieties is more profitable in the study area. The study conducted by Samuel and Beza, (2019) in Jimma Zone Ethiopia reported that adopters of improved coffee varieties get higher profits than non-adopters.

Descriptions	Mbinga		Mbozi		Overall	
	Adopters (n=73)	Non-Adopters (n=92)	Adopters (n=49)	Non-adopters (n=106)	Adopters (n=122)	Non-adopters (n=198)
Average yield (kg/ha)	1293	540	1186	488	1250	512
Average yield (Kg/tree)	1.29	0.37	1.12	0.38	1.21	0.38
Price TZS/kg	6278	6278	6278	6278	6278	6278
Revenue (TZS/kg)	8099	2323	7031	2386	7596	2386
Revenue (TZS/ha)	8120120	3389847	682587	513067	7850021	3214970
TVC (TZS/ha)	736709	601783	682587	513067	714971	554288
TVC (TZS/kg)	570	1114	576	1051	572	1083
GM (TZS/kg)	7529	1208	6456	1334	7024	1303
GM (TZS/ha)	**7383411**	**2788064**	**6765043**	**2550123**	**7135050**	**2660682**
Std. Deviation	4244751	1243307	4239115	605588	4235880	383499
Std. Error Mean	496810	129624	1128398	109600	1186113	84293
t-test		9.871		9.562		14.011
Sign		0.000		0.000		0.000

Table 7: Profitability analysis of coffee production among smallholder farmers

b) Net Farm Income (NFI) and Return on Investment (ROI) analysis

The findings as presented in Table 9 showed that the overall NFI for adopters of improved coffee varieties is4 736 695 TZS/ha and non-adopters is 1 173 101 TZS/ha. The findings also showed that the overall return on investment (ROI) for adopters is 1.87for each shilling investedand0.84 gained by non-adopters. The findings imply that the adopters of improved coffee varieties gain a higher return than non-adopters. This can be attributed to the fact that the improved coffee varieties have higher productivity than traditional varieties which are prone to infestation of CBD and CLR hence low productivity and profitability as early documented by Kilambo *et al.*,(2015).

Descriptions	Mbinga		Mbozi		Overall	
	Adopters (n=73)	Non-Adopters (n=92)	Adopters (n=49)	Non-adopters (n=106)	Adopters (n=122)	Non-adopters (n=198)
TC	2428057	1541432	2354107	1440843	2398355	1487581
GM	7383411	2788064	6765043	2550123	7135050	2660682
NFI	4955355	1246633	4410937	1109280	4736695	1173101
ROI	1.94	0.85	1.78	0.83	1.87	0.84

Table 8: Net Farm Income (NFI) and Return on Investment (ROI) analysis

c) Benefit cost ratio analysis

The findings provided in Table 10 and detailed in Annex 6 showed that the BCR for coffee production is 4.69 and 1.49 for adopters and non-adopters of improved coffee varieties respectively. The findings imply that, for every one TZS invested in coffee production, a profit was realized for both adopters and non-adopters. However the BCR analyses results revealed that coffee production is more viable for adopters than non-adopters. According to Gittinger (1982), projects with BCR equal to or higher to 1 are considered and accepted to be economically viable because they indicate the project's capacity to cover the investment and operating expenditures.

d) Net Present Value (NPV) analysis

The findings as presented in Table 7 and detailed in Annex 7 showed the NPV for adopters of improved coffee varieties is 18 311 736 TZS/ha and for non-adopters is 720 697 TZS/ha. The NPV findings imply that investing in coffee production is more economically viable in the study area for adopters of improved coffee varieties than non-adopters because the NPV for adopters is greater than that for non-adopters. According to Boardman *et al.*, (2018) and Kumar, (2019), when there is more than one alternative project analysed and all the alternatives are mutually exclusive, then the rule is to select the project with the largest NPV which reflects the economic worthiness and the opportunity cost of investment and operating capital.

e) Internal Rate of Return (IRR) analysis

The findings as presented in Table 10 and detailed in Annex 7 showed that the IRR for adopters of improved coffee varieties is 42 % and for non-adopters is 11 %. This implies that investing in coffee production is economically viable for both adopters and non-adopters because the IRR is higher than the discounted rate of 8 % adopted from Tanzania Agricultural Development Bank (TADB). Furthermore, the findings depict that adopters of improved varieties are more economically viable than non-adopters in the long run because the IRR for adopters is greater than that of non-adopters. According to Alimi, (2000) and Cellini, (2015), the project with an IRR greater than the discounted rate is the best because it indicates the percentage rate earned on each shilling invested for each period it is invested.

Descriptions	Mbinga		Mbozi		Overall	
	Adopters	Non-Adopters	Adopters	Non-Adopters	Adopters	Non-Adopters
NPV	19197669	1132681	16984363	498072	18311736	720697
BCR	4.80	1.57	4.53	1.45	4.69	1.49
IRR	43%	12%	41%	10%	42%	11%

Table 9: Economic analysis of coffee production among smallholder farmers

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

This study aimed to test the hypothesis on whether it is profitable in the longrun to adopt improved coffee varieties. Based on the findings of this study, it could be concluded that coffee production in the study area is more profitable for adopters of improved coffee varieties than for non-adopters. This because the GM, NFI, ROI, NPV, BCR, and IRR for adopters were greater than that of non-adopters. Hence the findings provide evidence that coffee farming using improved coffee varieties is more economically viable for long-run investment. Therefore, the government efforts to promote the adoption of improved coffee varieties have a significant contribution to improving smallholder coffee farmers' profitability.

B. Recommendations

Given the significant contribution of improved coffee varieties on profitability and economically viable among smallholder farmers who adopted these varieties in the study area, the following recommendations were made:

- The coffee industry should strengthen extension services to and training farmers on good agricultural practices;
- The government should encourage stakeholders to invest in multiplications and dissemination of the improved coffee seedlings;
- Farmersshould be encouraged to adopt the improved coffee varieties to increase productivity and profitability
- This will ultimately help farmers increase the productivity of quality coffee and fetch a high price in the market hence improving household profitability.

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APPENDICES

APPENDIX 1: TREND OF COFFEE PRICE

Year	New York Price	Auction Price($/50kg)	$/kg	Exchange rate	TZS/kg
2009/2010	138.17	161.38	3.2276	1475	4761
2010/2011	216.95	235.31	4.7062	1611.5	7584
2011/2012	239.3	255.12	5.1024	1602.1	8175
2012/2013	168	157.54	3.1508	1603.5	5052
2013/2014	123.25	131.61	2.6322	1749	4604
2014/2015	188.18	201.59	4.0318	2160.7	8712
2015/2016	122.97	131.49	2.6298	2214.4	5823
2016/2017	154.85	161.61	3.2322	2240.5	7242
2017/2018	128.75	142.55	2.851	2303.5	6567
2018/2019	108.61	111.36	2.2272	2297	5116
2019/2020	106	117	2.34	2316.6	5421
Total					69056
	Price index				6278

Sources TCB 2020

APPENDIX 2: AGE OF COFFEE TREE IN THE STUDY AREA

Year planted	Mbozi: Frequency of respondents	Mbozi: %	Mbinga: Frequency of respondents	Mbinga: %	Total: Frequency of respondents	Total: %	The average age of the coffee tree
			Adopters of improved coffee varieties				
2006/07	4	8	3	4	7	6	13
2007/08	2	4	3	4	5	4	12
2008/09	2	4	4	5	6	5	11
2009/10	3	6	5	7	8	7	10
2010/11	3	6	5	7	8	7	9
2011/12	4	8	11	15	15	12	8
2012/13	12	25	20	27	32	26	7
2013/14	18	38	23	31	41	34	6
Total	**48**	**100**	**74**	**100**	**122**	**100**	**10**
	Non-Adoptersadopters of improved coffee varieties						
1998/99	6	10	5	11	11	11	22
1999/20	9	16	6	14	15	15	21
2000/01	10	17	9	20	19	19	20
2001/02	12	21	9	20	21	21	19
2002/03	8	14	8	18	16	16	18
2003/04	13	22	7	16	20	20	17
Total	**58**	**100**	**44**	**100**	**102**	**100**	**20**

ISSN No:-2456-2165

APPENDIX 3: FIXED COST OF ESTABLISHING A NEW COFFEE FARM

```
. ttest TFC, by(Responde)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Adopter	122	1683384	13103.35	144731.3	1657443	1709326
Non-adop	198	933292.9	4179.426	58809.73	925050.7	941535
combined	320	1219265	21155.86	378447.6	1177643	1260888
diff		750091.3	11574.53		727319	772863.6

```
    diff = mean(Adopter) - mean(Non-adop)                         t =  64.8054
Ho: diff = 0                                     degrees of freedom =      318

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

APPENDIX 4.4: VARIABLE COSTS OF COFFEE PRODUCTION AMONG SMALLHOLDER FARMERS

```
. ttest VARIABLE, by(Responde)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Adopter	122	714971.2	26180.08	289168.5	663140.8	766801.6
Non-adop	198	554288.3	22964.97	323145.8	508999.6	599577.1
combined	320	615548.7	17881.04	319865.8	580369	650728.3
diff		160682.8	35755.4		90335.8	231029.9

```
    diff = mean(Adopter) - mean(Non-adop)                         t =   4.4939
Ho: diff = 0                                     degrees of freedom =      318

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

APPENDIX 5: COSTS OF COFFEE PRODUCTION (TZS/HA)

Cost description	Farmers category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5+
Land preparations	Adopter	207,202					
	Non-Adopter	137,801					
Pegging	Adopter	137,355					
	Non-Adopter	91,349					
Layout	Adopter	53,219					
	Non-Adopter	35,394					
Holing	Adopter	274,710					
	Non-Adopter	182,699					
Seedlings	Adopter	354,654					
	Non-Adopter	104,494					
Fertilizer for planting	Adopter	329,652					
	Non-Adopter	219,238					
Manure	Adopter	274,710					
	Non-Adopter	182,699					
Planting	Adopter	51,881					
	Non-Adopter	34,504					
Farm equipments	Adopter	-	-	-	-	-	-
	Non-Adopter	-	-	-	-	-	-
Hand weeding	Adopter	105,953	105,953	105,953	105,953	105,953	105,953
	Non-Adopter	203,224	203,224	203,224	203,224	203,224	203,224
Fertilizer applications	Adopter		12,286	20,476	30,714	40,952	40,952
	Non-Adopter		10,100	16,834	25,250	33,667	33,667
Manure applications	Adopter			14,342	23,903	35,854	47,805
	Non-Adopter			16,786	27,976	41,964	55,952
Pesticides applications	Adopter			7,077	11,795	17,693	23,590
	Non-Adopter			6,064	10,107	15,160	20,213
Fungicides applications	Adopter			15,091	25,152	37,727	50,303
	Non-Adopter			157,269	78,635	117,952	157,269
Mulching	Adopter			41,000	41,000	41,000	41,000
	Non-Adopter			44,375	44,375	44,375	44,375
Pruning	Adopter			-	76,607	114,911	153,214
	Non-Adopter			-	60,273	90,409	120,545
Irrigation	Adopter		15,676	15,676	15,676	15,676	15,676
	Non-Adopter		13,000	13,000	13,000	13,000	13,000
Cost for fertilizer	Adopter		45,988	76,647	114,970	153,293	153,293
	Non-Adopter		34,991	58,319	87,478	116,637	116,637
Cost for pesticides used	Adopter			22,008	33,011	44,015	44,015
	Non-Adopter			20,404	30,606	40,808	40,808
Cost of fungicides used	Adopter			12,561	20,936	31,403	41,871
	Non-Adopter			29,328	48,880	73,319	97,759
Harvesting	Adopter			187,560	281,340	375,120	375,120
	Non-Adopter			76,815	115,223	153,630	153,630
Total costs	Adopter	1,789,337	179,903	518,390	781,056	1,013,596	1,092,792
	Non-Adopter	1,191,403	261,315	642,416	745,025	944,145	1,057,079

APPENDIX 6: COST AND RETURN ANALYSIS (TZS/HA)

Descriptions		**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	
Discounting factor		1.00	0.93	0.86	0.79	0.74	0.68	0.63	0.58
Discounted costs	Adopters	**1789337**	**166576**	**444436**	**620027**	**745024**	**743736**	**688644**	**637,634**
	Non-Adopters	**1191403**	**241959**	**550768**	**591424**	**693974**	**719430**	**666139**	**616,795**
		Adopter	Non-Adopter						
Sum (A) Improved		**11811244**	**11052431**						
Benefit			1	1	1	1	0	0	
Percent of peak yield:		0%	0%	30%	50%	75%	100%	100%	100%
Yield kg per ha									
Yield kg per ha	Adopters	0	0	375	625	938	1250	1250	1,250
	Non-Adopters			154	256	384	512	512	512
Selling price		6278	6278	6278	6278	6278	6278	6278	6278
Revenue per ha	Adopters	0	0	2354250	3923750	5885625	7847500	7847500	7,847,500
	Non-Adopters	0	0	964301	1607168	2410752	3214336	3214336	3,214,336
Gross margin per ha	Adopters	-1789337	-179903	1835860	3142695	4872029	6754708	6754708	6,754,708
	Non-Adopters	-1191403	-261315	321885	862144	1466608	2157257	2157257	2,157,257
Discounted revenue (Gross margin per ha)	Adopters	-1789337	-166576	1573954	2494772	3581087	4597141	4256612	3,941,307
	Non-Adopters	-1191403	-241959	275964	684397	1078000	1468193	1359438	1,258,739
		Adopter	Non-Adopter						
Sum (B)		**55426446**	**16488127**						
BCR		4.69	1.49						
Net cash flow	Adopters	-3578674	-359805	1317471	2361639	3858433	5661916	5661916	5,661,916
	Non-Adopters	-2382806	-522630	-320532	117119	522463	1100178	1100178	1,100,178
Cumulative cash flow	Adopters	-3578674	-3938479	-2621009	-259370	3599063	9260979	14922895	20,584,811
	Non-Adopters	-2382806	-2905436	-3225968	-3108849	-2586386	-1486208	-386030	714,148

APPENDIX 7: NPV AND IRR ANALYSIS

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
Adopters													
Cash flow	(3,578,674)	(333,153)	1,129,519	1,874,745	2,836,063	3,853,405	3,567,967	3,303,674	3,058,957	2,832,368	2,622,563	2,428,299	2,248,425
PV factor	100%	93%	86%	79%	74%	68%	63%	58%	54%	50%	46%	43%	40%
PV of cash flow	(3,578,674)	(308,475)	968,380	1,488,233	2,084,591	2,622,563	2,248,425	1,927,662	1,652,659	1,416,889	1,214,754	1,041,456	892,880
NPV	18,311,736												
IRR	42%												
Discount Rate	8%												
Non-adopters													
Cash flow	(2,382,806)	(483,917)	(274,804)	92,973	384,026	748,763	693,299	641,943	594,392	550,363	509,595	471,847	436,896
PV factor	100%	93%	86%	79%	74%	68%	63%	58%	54%	50%	46%	43%	40%
PV of cash flow	(2,382,806)	(448,071)	(235,600)	73,805	282,271	509,595	436,896	374,568	321,131	275,318	236,041	202,367	173,497
NPV	**720,697**												
IRR	**11%**												
Discount Rate	**8%**												