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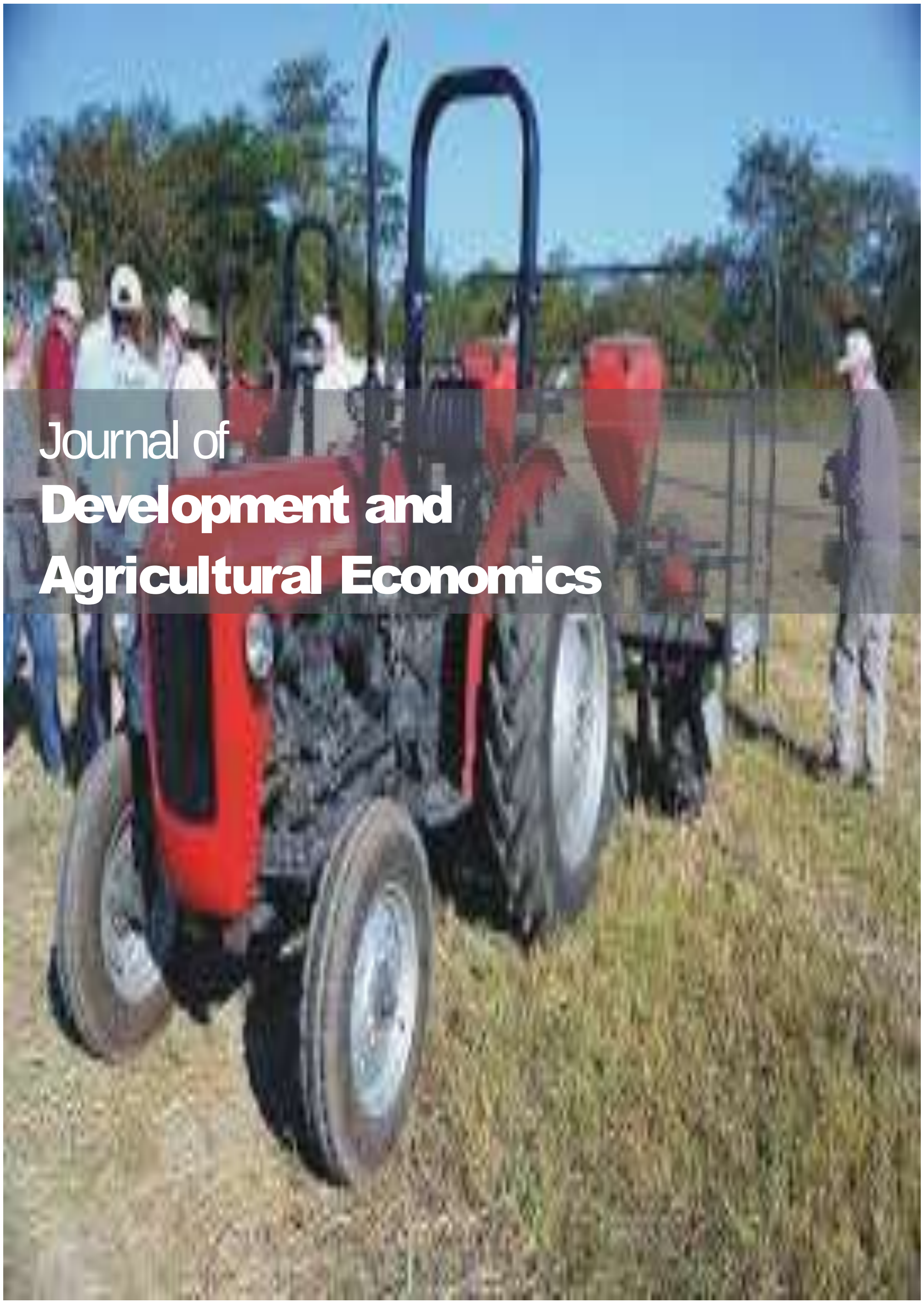

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Full Length Research Paper

Livelihood impacts of *Calliandra calothyrsus* and *Sesbania sesban*: Supplementary feed in smallholder dairy farms in Kenya

Makau D. N.[1*], VanLeeuwen J. A.[1], Gitau G. K.[2], McKenna S. L.[1], Walton C.[3], Muraya J.[1] and Wichtel J. J.[4]

[1]Department of Health Management, Atlantic Veterinary College, University of Prince Edward Island, Canada.
[2]Department of Clinical Studies, Faculty of Veterinary Medicine, University of Nairobi, Kenya.
[3]Department of Applied Human Sciences, University of Prince Edward Island, Canada.
[4]Ontario Veterinary College, University of Guelph.

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An agroforestry land use system aimed at improving the productivity of smallholder dairy farms using *Calliandra calothyrsus* and *Sesbania sesban* shrubs as feed supplements was introduced to semi-commercial SDFs in Meru, Kenya, as part of a field trial. The objective of this study was to assess the impact of using the *C. calothyrsus* and *S. sesban* on family income and livelihoods during the 16-month trial period. Eighty farmers randomly allocated to four groups (nutrition, reproduction, combined nutrition and reproduction, and a comparison group) were enrolled in this study. The nutrition intervention included nutritional management advice and provision of 150 *C. calothyrsus* seedlings and 150 *S. sesban* seedlings to each farm. Farms were visited every 1-2 months during the trial to collect data on milk production and feeding practices during the previous day. Seventy of these farms completed the trial and were interviewed post-intervention. Partial budget analysis of their farms was done by comparing changes in average monthly profits (from milk) and feeding costs/cow for the first 6 months and last 6 months of the intervention. Focus group discussions were used to collect qualitative information on livelihood effects from the trial. There was a KES 2,380.3 (USD 23.5) increase in average monthly profit/cow in the nutrition group comparing the first and last 6 months of the trial, representing a 68.8% improvement (p = 0.02). Average feeding costs significantly decreased across all groups over the trial period. Knowledge on dairy cow nutrition, level of confidence on calf management, and feeling of empowerment to raise calves/heifers to achieve first calving by 27 months were higher among farmers in the nutrition and combined groups than farmers in the other groups. There were positive direct and indirect impacts on the income and livelihoods of farmers in the two groups receiving nutritional interventions. Agroforestry, using *C. calothyrsus and S. sesban* shrubs can improve household livelihoods if adopted by SDFs in Kenya.

Key words: Smallholder dairy, agroforestry, partial budget analysis, leguminous shrubs.

INTRODUCTION

Agroforestry has been used in agricultural production to reduce the effects of harsh climatic changes on farmers' incomes and livelihoods (Patel-Weynand et al., 2017) and is a promising pathway out of poverty (Rahman et al., 2012; Thorlakson and Neufeldt, 2012). The quality of life and household living standards of farmers practicing some level of agroforestry in parts of Kenya was observed to improve as a result of better farm productivity, mitigated farm losses, increased off-farm income generation and improved general environmental conditions (micro-environment) of their farms (Thorlakson and Neufeldt, 2012; Wilson and Lovell, 2016).

Smallholder dairy production plays a major role in food security and poverty alleviation in Kenya (Muriuki et al., 2001; Van Leeuwen et al., 2012) as has been documented in other neighboring countries (Pandey, 2014). In Kenya, about 40-45% of daily milk production on smallholder farms (SDFs) is not sold but used for household nutrition (~35%) and calf nutrition (~10%) (Muriuki, 2011). The role of livestock in human health and nutrition in developing countries is substantial and is influenced by many factors (Randolph et al., 2007; Makau, 2014). In Kenya, the dairy value chain is one of the largest avenues for job creation and employment in the informal sector, with every 1000 L of daily milk produced estimated to generate approximately 77 jobs (Muriuki, 2011).

Smallholder dairy farming complements crop production through daily/monthly income generation, creation of employment, and stimulation of infrastructural developments, and it is considered a pathway out of poverty (Muriuki, 2003; Van Leeuwen et al., 2012). Both economic recovery and wealth creation in many rural communities in Kenya are directly related to the production level of the dairy sector (The Dairy Policy Forum, 2004). There is a positive association between poverty and food insecurity (Wight et al., 2014); also, households that sell the lowest volumes of milk to collection and processing centers in Kenya are poorer and more food insecure than households selling more milk (Muriuki et al., 2001; Boor, 2012).

Incorporation of diet supplementation with good quality grass and legume fodder in Mexico have resulted in increased lactation performance of cows from an average of USD 866 - 1,311 marginal profits per three lactation lifetimes of a cow (Absalón-Medina et al., 2012). Although SDFs in Uganda adopted growing of Napier grass for fodder, there was a general decrease in family incomes observed in the dry season because of reduced dairy production (a consequence of inadequate feed) coupled with reduced food produced for the family due to small land acreage (Kabirizi et al., 2007). Intercropping of food crops and leguminous forages was subsequently identified as an alternative production technique to mitigate the effects of dry seasons. This integrated farming method was a better production system with additional benefits, including better quality of food crop yields and improving soil health (Kabirizi et al., 2007; Dollinger and Jose, 2018).

In a related study (Makau, 2019), the milk production benefits of feeding leguminous shrubs were investigated on smallholder dairy farms in Kenya. Two types of leguminous shrubs were used in that study since there was a large difference in altitude among the farms in the study area, and it was unclear which type of shrub would be best on the farms. *Sesbania* is known to be harder at higher altitudes than *Calliandra* but has slightly lower protein content than *Calliandra* (Devendra, 1992; Trees for the Future, 2016). Economic costs and benefits of the extra milk production remain unclear.

Chakeredza et al. (2007) observed that SDFs, in Tanzania, that supplemented their cattle diets with fodder trees saved an average of USD 310/cow/year in production costs, primarily from reduced purchases of commercial concentrate feed for the cows. In Kenya, it is estimated that the cumulative net returns to smallholder farms that had adopted fodder tree technologies between 1993-2008 was between 18.7 - 29.6 million USD/year (World Agroforestry Center, 2011). However, there is a paucity of current research on benefits (to family livelihoods) of using *Calliandra calothyrsus and Sesbania sesban* agroforestry on semi-commercial SDFs in Kenya. The objective of this study was to assess the impact of using *C. calothyrsus* and *S. sesban* as feed supplements for dairy cattle on family income and livelihoods on semi-commercial SDFs based on an agroforestry land management model. This assessment was done using income generated from milk production.

In this study, livelihoods were defined as the means of living as constituted by various capabilities, assets, and activities (Serrat, 2017). Therefore, livelihoods would be considered sustainable based on their ability to withstand and recover from stresses and threats to the means of living. Such livelihoods are capable of enhancing interventions that mitigate vulnerability to stressful situations (Krantz, 2001). Level of income/economic capital is one of the indicators used to gauge a sustainable livelihood (Department for International Development, 1999; Ma et al., 2018).

MATERIALS AND METHODS

Description of the study area

This randomized controlled field trial was carried out in Naari sub-location of Meru County, Kenya (0°6'0" N and 37°35'0" E). Meru County is located on the slopes of Mount Kenya, 270 km north of Nairobi, the capital city of Kenya (Figure 1). Naari sub-location has an altitude of approximately 2,000 m above sea level. The main agricultural activities in Naari include dairying, subsistence crop farming, horticulture, and lumbering. The study area was purposively selected since this research was part of a larger study involving dairy farmers in the area. A non-governmental organization,

*Corresponding author. Email: dmakau@upei.ca.

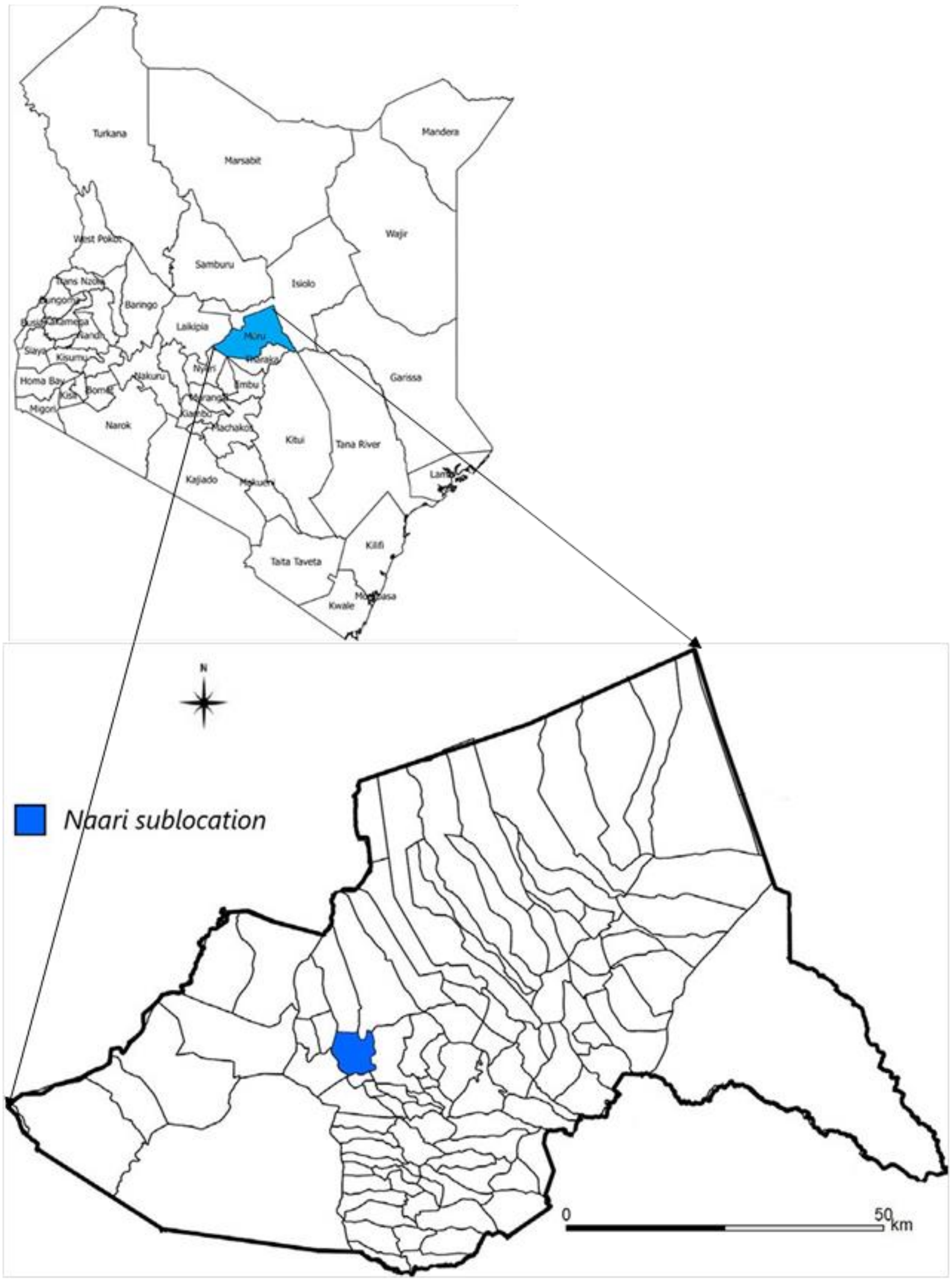

Figure 1. Study area showing Naari sub-location in Meru County, Kenya.

Farmers Helping Farmers (FHF), and University of Prince Edward Island (UPEI) had an existing developmental partnership with Naari Dairy Farmers Cooperative Society (NDFCS). This rapport provided a strong foundation for the work and the entry point to the community.

Sample population and data collection

The farmers included in the study had been involved in a 16-month randomized controlled nutrition trial evaluating the effect of *C. calothyrsus* and *S. sesban* on milk production (Makau, 2019).

Eighty farms had been randomly selected based on the inclusion criteria of active membership with the NDFCS, zero-grazing, and <4 milking cows. Membership with NDFCS was prerequisite since the project was a partnership between UPEI, FHF and NDFCS. Farms included in the study had to be practicing zero grazing since this form of livestock keeping allowed some control in feeding. Farms with more than 4 milking cows would be considered medium-sized. Selected farms were part of a larger study that included observational studies (Muraya et al., 2018; Makau et al., 2018) and randomized controlled trials (Kathambi et al., 2018; Makau, 2019; Muraya, 2019). The 80 farms were randomly block-allocated into four different groups in the randomized controlled field trial, with average days in milk (DIM) as a blocking variable. Since changes in milk production due to enhanced feeding are likely to be greater in early lactation, DIM was deemed a very important variable for block randomization. The four intervention groups included nutrition interventions only, reproduction interventions only, nutrition + reproduction (combined) interventions, and a comparison group that received neither intervention. Farmers in the nutrition and combined groups were issued with at least 150 *C. calothyrsus* seedlings and 150 *S. sesban* seedlings (in early 2016) to plant on their farms prior to the commencement of the monitoring visits (July 2016-October 2017) of the project. The nutrition and combined groups also received monthly advice on how to feed their cattle better with the feeds and resources available on the farm. Seventy out of the 80 farms completed the trial from July 2016 to October 2017 (Makau, 2019). On average, 500 shrubs in smallholder farms in Kenya were estimated to produce enough foliage to feed 6 kg/cow/day for one year (Franzel et al., 2003; Trees for the Future, 2016).

Farms in the 2 nutrition intervention groups were visited monthly during the trial to troubleshoot any issues with tending or harvesting of the *C. calothyrsus and S. sesban* shrubs. Additionally, data on milk production and feeding practices during the previous day were recorded in a questionnaire adapted and modified from the 2015 baseline study (Makau et al., 2018). Farms in the reproduction and comparison group were visited bi-monthly to collect similar milk and nutrition data.

A post-intervention questionnaire was administered to assess the knowledge, attitudes, and practices (KAP) of the farmers on the use of leguminous shrubs and dairy cow management at the end of the trial period, and whether farmers' KAP was different by intervention group. The analysis in this paper focuses on some indicators of farmers' livelihood impact assessment which included a feeling of empowerment in dairy management, knowledge and awareness of general nutrition and use of *C. calothyrsus and S. sesban* shrubs on their farms, as well as confidence in the management of dairy cows and calves. The level of confidence on dairy cow nutrition was assessed on a scale of 1 (Not confident), 2 (Somewhat confident), 3 (Confident), and 4 (Very confident).

Focus group discussions (FGDs) were used to collect qualitative information on livelihood effects from the trial. Discussions were classified into four themes relevant to the intervention (that is, milk production and feeding practices, the importance of dairy products to the households, the project intervention and its effect on household livelihoods (economies) and knowledge dissemination to and by the farmers). Farmers in the nutrition and combined groups were invited to the first FGD, while a second separate FGD was held for the reproduction and comparison groups on the following day. Proceedings of the FGDs were facilitated by the researcher and were recorded for reference to inform the quantitative data.

Data management and analysis

Data from the questionnaires were entered into MS Excel 2010 (Microsoft, Sacramento, California, USA) and checked for errors. Data were then transferred to STATA software Version 13.0 (Stata Corp LLC, College Station, Texas, USA) for statistical analysis. Descriptive statistical analysis (summarizing distributions, means, and medians) was done for continuous variables. Categorical variables were also summarized using frequencies and percentages. Significant differences among these demographic and other characteristics were determined using ANOVA.

Partial budget analysis was used to assess marginal changes in revenues in Kenya shillings (KES) by comparing farms receiving nutritional interventions with those not receiving nutritional interventions. A comparison of milk production revenue and feeding costs was done for the baseline (that is, first 6 months – July to December 2016) and the end-line (that is, last 6 months of the trial – May to October 2017) for each farm. The comparative periods included both dry and wet seasons.

This partial budget was focused on the milk production revenue and typically purchased feed costs and assumed that all other costs (e.g. labor associated with tending and harvesting fodder crops) were constant. Purchased feeds of interest for the analyses were: dairy meal, maize germ, wheat bran, and mineral supplementation. Maize silage was also included in the cost of production for three reasons: 1) there is a substantial amount of energy in maize silage (Kordi and Naserian, 2012), having a substantial impact on milk production (Rengman et al., 2014); 2) some farmers fed maize silage while others did not; and 3) there are costs associated with the proper storage of maize silage from the harvested maize plants (e.g. chopping, mixing in molasses or some other product to assist fermentation, packing and plastic), which should be reflected in the feed costs. The cost of the *C. calothyrsus* and *S. sesban* seedlings was a one-time small cost, and therefore was not included in the partial budget but is factored in at the end. Profit was used for the analysis of net change in monthly profit/cow between the first six months and last six months within groups, for each intervention group.

Average monthly profit (μ) was calculated using the formula below:

$$\mathbf{\mu} = \left(\frac{\sum \mathbf{x}}{\mathbf{t}}\right) - \left(\frac{\sum \mathbf{y}}{\mathbf{t}}\right)$$

Where: $\sum x$*= sum of assessments of milk (L/cow/day) × 30 days × average price of milk (KES/L),*

$\sum y$*= sum of assessments of feed volumes consumed/cow × 30 days × the average cost of feed (KES/kg or g) for each purchased feed and corn silage.*

t*= number of assessments during the 6-month period.*

Bonferroni adjusted one-way ANOVA was used to evaluate statistically significant differences in average monthly production costs and profits among study groups. Significant differences in net change in profit were calculated within the intervention groups using paired t-tests, comparing average monthly profit during the baseline 6 months and during the end-line 6 months. Unpaired t-tests were used to determine significant differences between two-way group comparisons of net profit changes for all possible combinations of intervention groups.

For dichotomous variables from the post-intervention interview data, Pearson's Chi-square and Fisher's exact tests (if cells had fewer than 5 farmers) were used to check for differences between the different groups. Results were considered significant when p-value ≤ 0.05. Focus group discussion data were recorded and transcribed for qualitative analysis to provide contextual information. Farmers agreed to the use of the data for research purposes as long as confidentiality was maintained.

RESULTS

During the 16-month study period, 10 farms were lost to

Table 1. Demographic and other characteristics of 114 cows from 80 Kenyan smallholder dairy farms on 378 farm-visits (606 cow-visit observations) over a 6-month baseline period in 2016-2017, by intervention group.

Parameter	Overall (n=606)	Comparison group (n=119)	Nutrition group (n=194)	Combined group (n=183)	Reproduction group (n=110)	ANOVA P- value
Average # of milking cows/farm (s.d.)	1.8 (0.7)	2.1 (0.6) ^{a}	1.8 (0.7) ^{bc}	1.7 (0.6) ^{c}	1.9 (0.8) ^{b}	0.0002
Average # of acres/farm (s.d.)	2.1 (1.8)	2.1 (1.8) ^{a}	1.8 (1.5) ^{a}	1.9 (0.6) ^{a}	2.8 (2.7) ^{b}	0.338
Average # of days in milk (s.d.)	242.5 (176)	251.8 (166) ^{a}	276.9 (73) ^{ab}	215.6 (182) ^{ac}	216.2 (176) ^{ac}	0.002
Breed						<0.001
Zebu or dual purpose (#)	2.6% (16)	5.0% (6) ^{a}	0% (0) ^{b}	3.3% (6) ^{a}	3.6% (4) ^{a}	
Friesian crosses (#)	56.6% (343)	46.2% (55) ^{a}	52.6% (102) ^{a}	57.4% (105) ^{a}	73.6% (81) ^{b}	
Ayrshire crosses (#)	15.0% (91)	13.5% (16) ^{a}	16.4% (32) ^{ab}	11.5% (21) ^{ac}	20.0% (22) ^{ab}	
Guernsey crosses (#)	19.5% (118)	33.6% (40) ^{a}	21.7% (42) ^{b}	18.0% (33) ^{b}	2.7% (3) ^{c}	
Jersey crosses (#)	6.3% (38)	1.7% (2) ^{a}	9.3% (18) ^{b}	9.8% (18) ^{b}	0% (0) ^{a}	
Pregnant (#)	23.8% (144)	24.4% (29) ^{a}	27.3% (53) ^{a}	16.4% (30) ^{ab}	29.1% (32) ^{ac}	0.030
Subclinical mastitis positive (#)	27.1% (164)	26.1% (31) ^{a}	34.5% (67) ^{ab}	22.9% (42) ^{ac}	21.8% (24) ^{ac}	0.038
Wet Season (#)	24.6% (149)	16.8% (20) ^{a}	18.0% (35) ^{a}	19.7% (36) ^{a}	52.7% (58) ^{b}	<0.001

[a-c] Different letter superscripts represent significant differences between coefficients of different levels (other than the reference level which use the category p-values) for interaction variables and categorical variables not involved in interactions when they have more than 2 levels.

follow-up at different times of the study (3 from each of the nutrition, combined and comparison groups and 1 from the reproduction group). Reasons for the losses to follow-up included cessation of membership to NDFCS, cattle sales or death, change in farm priorities, and family issues. These reasons were not related to the objective of the study and so minimal selection bias was expected from this attrition of farms.

Table 1 provides a summary of demographic and other characteristics of the cows and farms over the first 6 months of the study, by intervention group and overall. Despite the random allocation of herds, some of the herd demographics (number of milking cows/farm), animal characteristics (days in milk, breed, and pregnancy status), the prevalence of subclinical mastitis and number of cow observations during the different seasons were different among the four trial groups at baseline. In particular, the nutrition group cows had the highest DIM and most subclinical mastitis at baseline. Conversely, the reproduction group had a higher proportion of Friesian crosses (Table 1).

Table 2 provides a summary of demographic and other characteristics of the cows and farms over the last 6 months of the study, by intervention group and overall. For the 70 farms that completed the trial, the mean land size and mean a number of milking cows per farm remained unchanged at 2.1 acres and 1.8 milking cows per farm respectively. The breeds and percent pregnant were also similar among the 80 farms starting the trial and the 70 farms completing the trial (Tables 1 and 2). Furthermore, similar group differences were observed between the two-timeframes. However, cases of mastitis decreased significantly ($p<0.05$) in all groups when comparing baseline versus end-line data (due to interventions provided to the farms during the visits). Also, the proportion of observations when cows were pregnant in the combined group also increased significantly from 16.4% at baseline to 28.2% at end-line (Tables 1 and 2). With the higher proportion of pregnant cows in the combined group, along with modest increases in proportion of pregnant cows in the comparison group and overall, substantial increases in DIM were also observed.

Partial budget analysis

The average cost of dairy meal was calculated as the average retail price of all dairy meal brands sold at the NDFCS during the trial period, which was (34.8 KES/kg). The same approach was used for the other feeds of interest, producing the following average costs: maize germ (18.7 KES/kg), bran (19.0 KES/kg), and mineral supplement (0.6 KES/g). The estimated cost of maize silage was 12.8 KES/kg, calculated as an average of retail prices for silage and labor costs for silage-making documented between 2015 and 2018 (Sawa, 2015; Caroline, 2016; Nanjinia, 2018; Obi, 2018).

The average monthly milk production among the 70 farms ranged between 161.5 – 204.5 L/cow at baseline (Table 3) and between 167.9 – 237.2 L/cow at the end of the study, which represented an increase in all groups except the farms in the combined group, who had a 17.6 L decrease in their average milk production (Table 3), likely due to the significant increase in pregnant late lactation cows. The changes in milk production were only significant in the nutrition and reproduction groups (Table 3). The average price of milk, calculated as an average of prices offered to the farmers by NDFCS during the trial period, was KES 37.0/L.

Table 2. Demographic and other characteristics of 121 cows from 70 Kenyan smallholder dairy farms on 326 farm-visits (519 cow-visit observations) over a 6-month end-line period in 2016-2017, by intervention group.

Parameter	Overall (n=519)	Comparison group (n=71)	Nutrition group (n=129)	Combined group (n=163)	Reproduction group (n=156)	ANOVA P-value
Average # of milking cows/farm (s.d.)	1.8 (0.8)	1.8 (0.7) [a]	1.6 (0.8) [ab]	2.0 (0.8) [ac]	1.8 (0.7) [ad]	0.002
Average # of acres/farm (s.d.)	2.1 (1.7)	1.6 (1) [a]	1.7 (1.4) [ab]	2.0 (0.6) [c]	2.8 (2.7) [ad]	0.11
Average # of days in milk (s.d.)	330.6 (210)	404.1 (252) [a]	318.8 (174) [bc]	288.8 (171) [d]	350.5 (243) [ac]	0.001
Breed						**<0.001**
Zebu or dual purpose (#)	3.7% (19)	2.8% (2) [a]	3.1% (4) [a]	0% (0) [b]	8.3% (13) [a]	
Friesian crosses (#)	59.9% (311)	50.7% (36) [a]	58.9% (76) [a]	55.2% (90) [a]	69.9% (109) [b]	
Ayrshire crosses (#)	15.6% (81)	16.9% (12) [a]	18.6% (24) [a]	12.3% (20) [a]	16.0% (25) [a]	
Guernsey crosses (#)	17.0% (88)	25.4% (18) [a]	15.5% (20) [a]	25.2% (41) [ab]	5.8% (9) [c]	
Jersey crosses (#)	3.9% (20)	4.2% (3) [a]	3.9% (5) [a]	7.4% (12) [ab]	0% (0) [c]	
Pregnant (#)	25.6% (133)	29.6% (21) [a]	27.9% (36) [a]	28.2% (46) [a]	19.2% (30) [a]	0.183
Subclinical mastitis positive (#)	7.9% (41)	11.3% (8) [a]	7.0% (9) [a]	9.2% (15) [a]	5.8 (9) [a]	0.45
Wet Season (#)	13.3% (69)	0% (0) [a]	12.4% (16) [b]	11.7% (19) [b]	21.8% (34) [c]	<0.001

[a-c] Different letter superscripts represent significant differences between coefficients of different levels (other than the reference level which use the category p-values) for interaction variables and categorical variables not involved in interactions when they have more than 2 levels.

Table 3. Average monthly milk production cow^{-1} at the start of the intervention (6-month baseline) and at the end of the intervention (6-month end-line) for 70 Kenyan smallholder dairy farms from 2016-2017, by intervention group (1 USD=KES 101.2).

Group	Average milk production - Baseline (liters)	Average milk production - End-line (liters)	Change in milk production (liters)	Paired t-test p-value
Comparison (n=17 farms)	161.5	167.9	+6.4	0.80
Nutrition (n=17 farms)	183.3	237.2	+53.9	0.04
Combined (n=17 farms)	204.5	186.9	-17.6	0.40
Reproduction (n=19 farms)	169.2	201.7	+32.5	0.05

Table 4. Average monthly feeding cost cow^{-1} per month at the start of the intervention (6-month baseline) and at the end of the intervention (6-month end-line), for 70 Kenyan smallholder dairy farms in 2016-2017, by intervention group (1 USD=KES 101.2).

Group	Average feeding cost- Baseline in KES (USD)	Average feeding cost - End-line KES (USD)	Change in average feeding cost in KES (USD)	Paired t-test p-value
Comparison (n=17)	3,669.3 (36.3)	2,286.9 (22.6)	-1,382.4 (13.7)	0.03
Nutrition (n=17)	3,325.1 (32.9)	2,939.7 (29.1)	-385.4 (3.8)	0.35
Combined (n=17)	3,879.1 (38.3)	2,529.0 (25.0)	-1,350.1(13.3)	0.001
Reproduction (n=19)	4,699.6 (46.4)	3,597.5 (35.6)	-1,102.1(10.8)	0.04

Mean feeding expenses decreased from baseline to end-line across all groups by 44.1% for maize silage, 40.4% for wheat bran, 32.2% for dairy meal and 31.7% for maize germ. Across the groups, the mean monthly feeding expenditure decreased, from an average of KES 3,325.1 – 4,699.6 (USD 32.9 – 46.4)/cow at baseline to KES 2,286.9 – 3,597.5 (USD 22.6 – 35.6)/cow at end-line (Table 4). The decrease in feeding expenses was significant in all groups ($p < 0.05$), except for the nutrition group.

The average monthly profits/cow significantly increased from the baseline to the end-line for all groups except the combined group (Table 5). The change in average monthly profits/cow in the nutrition group increased by 68.8%. Table 6 provides two-way group comparisons of net profit changes for all possible combinations of intervention groups. There were significant net changes in average monthly profits/cow across all groups except between the nutrition and reproduction groups.

KAP questionnaire responses

Compared to the comparison and reproduction groups,

Table 5. Average monthly profit cow^{-1} at the start of the intervention (6-month baseline) and at the end of the intervention (6-month end-line), for 70 Kenyan smallholder dairy farms in 2016-2017, by intervention group (1 USD=KES 101.2).

Group	Average profit – Baseline in KES (USD)	Average profit – End-line in KES (USD)	Change in average profit in KES (USD) (%)	Paired t-test p-value
Comparison (n=17)	2,307 (22.8)	3,923.5 (38.8)	+1,616.5 (16.0)	0.03
Nutrition (n=17)	3,457.6 (34.2)	5,837.9 (57.7)	+2,380.3 (23.5)	0.02
Combined (n=17)	3,688.1 (36.4)	4,387.9 (43.3)	+699.8 (6.9)	0.40
Reproduction (n=19)	1,561.5 (15.4)	3,866.9 (38.2)	+2,305.4 (22.8)	0.002

Table 6. Two-way group comparisons of net change in average monthly profit cow $^{-1}$ at the start of the intervention (6-month baseline) and at the end of the intervention (6-month end-line), for 70 Kenyan smallholder dairy farms in 2016-2017 (1 USD=KES 101.2).

Profit change in KES (USD)	Profit change in KES (USD)	Unpaired t-test p-value
Comparison= 1,616.5 (16.0)	Nutrition = 2,380.3 (23.5)	0.01
Comparison= 1,616.5 (16.0)	Combined = 699.8 (6.9)	0.001
Comparison= 1,616.5 (16.0)	Reproduction = 2,305.4 (22.8)	0.004
Reproduction = 2,305.4 (22.8)	Nutrition = 2,380.3 (23.5)	0.78
Reproduction = 2,305.4 (22.8)	Combined = 699.8 (6.9)	<0.001
Combined = 699.8 (6.9)	Nutrition = 2,380.3 (23.5)	<0.001

Profit change = (Average baseline profit) - (Average end-line profit).

Table 7. Summary of selected questionnaire responses by 70 smallholder dairy farmers post-intervention in Kenya in 2017, by intervention group.

Question	Comparison group (n=17)	Nutrition group (n=17)	Combined group (n=17)	Reproduction group (n=19)	P-value
Feeling of empowerment to raise calves/heifers to achieve first calving at 27 months					<0.001
Yes	17.6% (3)[a]	100% (17)[b]	88.2% (15)[b]	21.1% (4)[a]	
No	82.4% (14)	0% (0)	11.8% (2)	78.9% (15)	
There is special mineral supplement for dry cows					0.007
True	52.9% (9)[a]	82.4% (14)[a]	100% (17)[b]	73.7% (14)[a]	
False	47.1% (8)	17.6% (3)	0% (0)	26.3% (5)	
Agroforestry can be a sustainable land use system					<0.001
Yes	0% (0)[a]	94.1% (16)[b]	64.7% (11)[c]	5.3% (1)[a]	
No	100% (17)	5.9% (1)	35.3% (6)	94.7% (18)	

all the farmers in the nutrition group and most of the combined group (88.2%) felt they were now more empowered in dairy management. For example, at the end of the trial, these farmers felt that they were able to raise calves and heifers optimally to achieve age at first calving (AFC) of about 27 months of age (Table 7). As well, significantly more farmers in the nutrition and combined group than the comparison group correctly indicated that the main benefit of colostrum was to provide the calf with immunity (Figure 2). Also, more farmers in the combined group than in the other groups knew that there was a difference in mineral for dry cows and for milking cows (Table 7). More farmers in both the nutrition and combined groups than the comparison and reproduction groups reported that agroforestry could be a sustainable land use system (Table 7).

More farmers in the nutrition and combined groups felt confident and informed on matters of dairy farming and

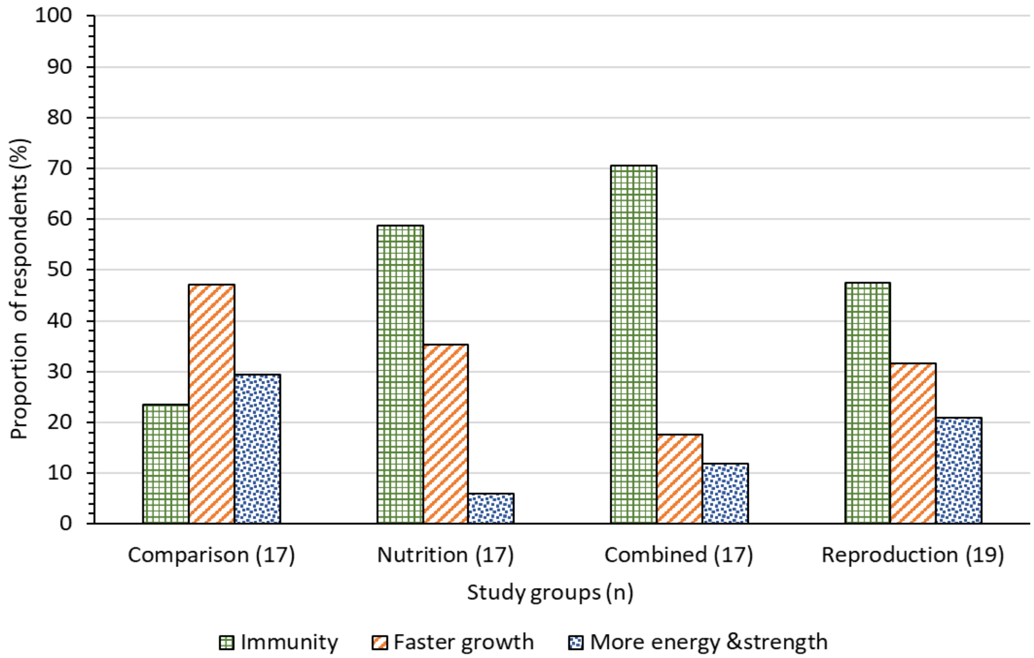

Figure 2. Post-intervention descriptive analysis of the knowledge of farmers on the main reason for feeding first colostrum to calves among 70 Kenyan smallholder farms in 2017, by intervention group.

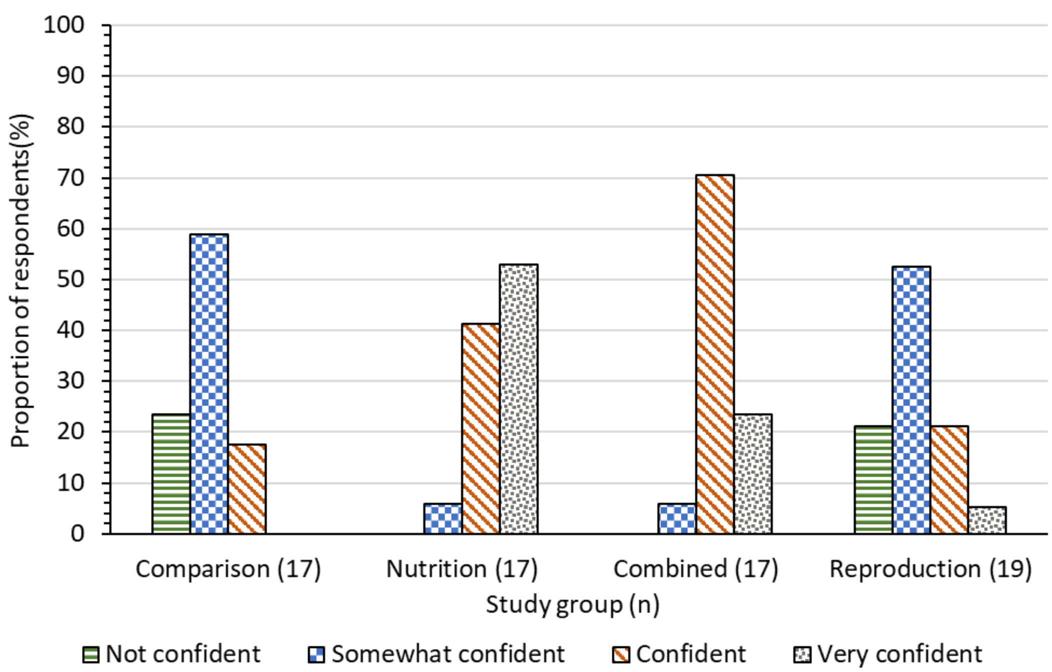

Figure 3. Post-intervention descriptive analysis of levels of confidence of farmers on dairy farming and nutrition among 70 Kenyan smallholder farms in 2017, by intervention group.

nutrition, compared to the comparison and reproduction groups (Figure 3). The mean, standard deviation and median scores of confidence levels were 1.9, 0.7, 2.0 for the comparison group, 3.5, 0.6, 4.0 for the nutrition group, 3.1, 0.7, 3.0 for the combined group, and 2.1, 0.8, 2.0 for the reproduction group. These scores were significantly higher for the nutrition and combined groups compared to the comparison and reproduction groups ($p < 0.001$), while there was no significant difference in scores between the nutrition *vs* combined groups and between the comparison vs reproduction groups ($p > 0.05$).

Focus group discussion

From the intervention and comparison groups, 20 farmers (67% women) participated in the focus group discussions. Farmers unanimously reported that dairy production was the main source of livelihood in the area and indicated that they would not substitute it with any other form of farming. Some farmers said, "Dairy farming is the backbone of our households". Some of the benefits farmers reported to have accrued from dairy production, especially with improved milk production, included: better nutrition through drinking fresh milk/yoghurt; a source of family income through milk sales, and thus it was a major pathway from poverty; collateral for credit acquisition; a source of school fees for the children through milk sales; cattle as a form of savings for future liquidation, if necessary; livelihoods security that allowed farmers to diversify into other kinds of farming; a source of manure for sale and use on farms for better crop yields and animal feed production; beverages (milk/tea) for hosting social functions for visitors; and use of cows/heifers for dowry payment. Given the extent of the role of dairy production, farmers were positive that any improvement in the productivity of their enterprises would be of great benefit to their households.

The nutrition and combined groups (those who received shrubs and education) unanimously reported that they had seen some improvement in returns from their dairy enterprises since they began participating in this trial. The comparison and reproduction groups (those who did not receive shrubs) indicated that they had seen a slight improvement but would wish to have made more improvement. Although the comparison group did not receive any direct intervention, farmers cited the informal advice offered during the farm visits and from other farmers to have contributed to the improvements observed. Some farmers within the comparison group reported that their friends in the nutrition-related intervention groups had shared seeds of the *C. calothyrsus*/*S. sesban* shrubs with them and they had started some nurseries of their own on their farms.

The most important challenge raised by the farmers in both the intervention and comparison groups was low milk production during the dry season and early rainy season due to inadequate quality and quantity of feed. This low milk production was mentioned as a more serious constraint in the comparison groups than it was in the intervention groups who reported, "Milk production has not reduced much in the last dry season as it has been in other years". Some farmers said that since they started using the shrubs, they no longer used dairy meal on their farms and instead used the shrub foliage with wheat bran and that milk production was still good. Although farmers in both groups knew about silage-making, the largest hindrance for this form of feed conservation was the costs involved.

Farmers in the intervention groups unanimously reported that they would recommend these shrubs to other farmers saying, "Because they increase milk production!". As a result, the women reported they had shared this information in different women's groups, and some women had been requested to supply seeds to the women groups while others had managed to convince new members to join NDFCS to benefit from such interventions in the future. Male farmers indicated that although they did not share the knowledge about the shrubs in men groups/gatherings, they had shared their knowledge with neighbors and managed to convince their neighbors to attempt using these shrubs on their farms.

DISCUSSION

From the partial budget analysis, it was evident that there were significant changes in monthly milk production and profit/cow between the first 6 months and last 6 months of the trial. These time periods were selected purposively because it was expected that at the beginning of the trial, the shrubs were not evenly mature to provide constant foliage to the cows enough to significantly affect milk production. Additionally, replacement of dead seedlings was also done during the middle of the trial period. During the last six months of the trial, it was assumed that all shrubs in the nutrition and combined farms were evenly mature and were being used on all the farms, providing a basis for comparison between farms that had shrubs and those who had not received any shrubs.

The 68.8% increase in monthly profits/cow in the nutrition group (Table 5) was associated with a significant improvement in average monthly milk production/cow (Table 3). This increase in milk production would be largely attributed to the nutritional interventions (feeding shrubs and farmer education) implemented on farms in these groups. Better nutritional management and feeding of higher amounts of CP to cows would lead to an increase in the amount of milk produced by lactating cows. Farmers feeding these shrubs to cows could also reduce the amount of dairy meal fed and still maintain a good level of production. Similar observations have been made after adoption of different feeding interventions in SDFs in Kenya and other African countries (Omore et al., 2004; Van Leeuwen et al., 2012; Trees for the Future, 2016). With an average of more than 50% of household income in SDFs typically attributed to dairy production (Van Leeuwen et al., 2012), this increase would undoubtedly translate to better livelihoods.

The cost for *C. calothyrsus* and *S. sesban* seedlings at the time of publication in Kenya was approximately KES 25, therefore 300 seedlings would total KES 7,500. Assuming the seedlings were purchased at this price, with the nutrition group having increased its monthly profit by over KES 2,300, the return on the investment would only take 3.5 months, after which time, the additional profit would be available for other expenditures.

The average monthly feeding expenses decreased for farms in all groups. The decrease was significant for all groups except the nutrition group; probably because they had already started feeding the shrubs around the baseline period and already made some adjustments to their feeding practices. These farmers may also have felt that with the additional CP from shrubs, they needed to maintain energy to enhance milk production and reproduction. Some of the reduction in feeding expenses attributable to maize silage could be because farmers were running low on amounts of silage. However, there were no significant changes in monthly profits for SDFs in the combined group, primarily due to a decrease in milk production (Tables 3 and 5). This decrease in milk production could be attributed to farmers in the combined and reproduction groups focusing more on getting their cows pregnant (the primary objective of reproduction interventions). For example, in the reproduction group, farmers were observed to reduce their milking frequency when cows seemed to be losing body condition and taking a long time to come in heat, especially when there were feed shortages. These farmers' rationale was that reduced milk production would counter the negative energy balance experienced during suboptimal feeding.

Farmers in the nutrition and combined groups were significantly more knowledgeable and aware of good dairy nutrition practices compared to the comparison and reproduction groups (Figure 2 and Table 7), which demonstrates a benefit of the nutrition intervention. Better knowledge of dairy nutrition would promote better on-farm and off-farm decision-making, thus resulting in more efficient farm management and increased profits, leading to improved livelihoods (Chapman et al., 2003; Mtega, 2017). Moreover, farmers in the nutrition and combined groups reported that agroforestry could be a sustainable land use system (Table 7). Generally, SDFs in this area, as is common in other parts of Kenya, are on relatively small acreages (Richards, 2017; Maina et al., 2018). Adoption of agroforestry would reduce vulnerability to, and effects of, feed shortages on household income and economies, translating to improved and sustainable livelihoods (Kiptot et al., 2014; General Secretariat of the Organization of American States, 2015). Franzel et al. (2013) cited similar impacts and benefits on farmer livelihoods in Zimbabwe, Ethiopia and Uganda after planting and using fodder trees on their farms.

Farmers in the nutrition and combined groups felt more empowered and were significantly more confident about general dairy nutrition and raising calves and heifers for earlier age at first calving (Table 7 and Figure 3). The average AFC of heifers in SDFs in Kenya was estimated at 34 months but could be up to 40 months (Menjo et al., 2009). A reduction in AFC would subsequently translate to high returns resulting from higher lactation days per lifetime (Krpálková et al., 2014) which would lead to improved livelihoods. Moreover, increased empowerment and confidence observed among farmers in the nutrition and combined groups was likely indicative of intangible impacts of the interventions towards improved livelihoods (Ashley and Hussein, 2000; Oxfam, 2014; Horsley et al., 2015). These farmers would most likely be able to make effective decisions on farm management, leading to more efficient production and increased returns.

It was encouraging to get positive responses from the farmers during the FGDs regarding the agroforestry systems offered in the trial and how the leguminous shrubs helped mitigate the effects of feed shortage in milk production. Given the central role of dairy farming in this community, it was clear that any benefits in productivity and profit observed on the farms translated into better livelihoods for the household. Similar findings were observed in a longer study that integrated a suite of interventions to improve SDFs production in rural Kenya, including nutrition, reproduction, cow comfort, deworming and mastitis control (Van Leeuwen et al., 2012). Farmers who fed cows on leguminous shrubs in Ethiopia, Zimbabwe, Uganda and Kenya also reported benefits through increased milk production and reduction in feeding costs (reduced dairy meal use) (Cook et al., 2005; Franzel et al., 2013; Richards, 2017).

Farmers in the study had participated in different knowledge transfer activities within their circle of friends and neighbors, resulting in increased membership to the NDFCS. Such indirect benefits of the intervention are encouraging. Growth in NDFCS would translate into other socioeconomic benefits to the Naari area since the Dairy also supplied basic foods and household amenities to the community, and availed a credit facility to active members who shipped milk to the NDFCS, as was observed in Nyeri County, Kenya (Van Leeuwen et al., 2012).

Among the limitations of this study, farmers in this trial were not able to accurately indicate how much time they used to plant and manage the shrubs. There were no reports of any additional hired labor since most of the farms were generally worked with household members whose primary occupation was farming. Lack of that additional information limited the quantification of indirect costs and opportunity costs of having the shrubs on the farm. These potential costs were not factored into the partial budget. However, the labor to manage the shrubs beyond the first few months when the shrubs were establishing their roots would be minimal and would be similar to the management of other forage crops in terms of tending, fertilizing, and harvesting the forage crops.

Another limitation to the study was that the random allocation did not lead to completely equal farm and animal demographics and management, due to the small size of the farms and that there were just 20 farms in each group. For example, breed, DIM, the prevalence of subclinical mastitis, and pregnancy status were significantly different between groups, and the number of cow observations during the wet season was not the same among the four trial groups at baseline (Table 1). Some of these factors could have also had an impact on the changes in milk production and feed costs, and therefore changes in profit. However, factors such as pregnancy and DIM would be less likely to affect profit since farmers would likely reduce purchased feeds provided to pregnant cows and those with high DIM, coinciding with their lower milk production.

Notwithstanding these possible confounding factors on milk production and profit, the estimates of improvements to these outcomes from the nutritional interventions are likely conservative for a couple of reasons. The initial 6 months was a quasi-baseline in the sense that there were already nutritional interventions in the form of nutritional advice provided to the farmers during this time. A monitoring period prior to this time frame was not possible for logistical reasons. Secondly, the research team noticed that on a minority of farms with leguminous shrubs, the shrubs were already being harvested and fed to the cows during this first six months of baseline. Both of these circumstances likely led to a baseline level of milk production that was potentially higher than if neither of these situations happened, suggesting that the impacts on milk production and dairy net income were possibly underestimated.

As a third limitation, due to the close geographical placement of the intervention and comparison farms, it was likely that some level of unintentional information transfer to the comparison farmers from the intervention farmers occurred. This information transfer could bias the responses and practices of those comparison group farmers and the measurements of their cows. However, the farmers in the comparison group did not have leguminous shrubs on their farms, except perhaps from neighbors at the very end of the study, reducing this possible bias. If anything, this bias would only make the estimates in the differences in profits between groups more conservative than they really are. However, from a livelihood development perspective, this spread of leguminous shrubs would be a ‘good problem’ to have. The natural spread of this land management model could have extensive benefits to the incomes and livelihoods of the community and SDFs.

Conclusion

The nutritional interventions (education and *C. calothyrsus and S. sesban* shrubs) with and without reproductive interventions had positive financial, knowledge, and practice impact on the livelihoods of farmers. Agroforestry, using *C. calothyrsus* / *S. sesban*, with supportive education/training, can improve dairy farm household incomes and livelihoods if adopted by SDFs in Kenya, where agroecologically appropriate.

RECOMMENDATIONS

Use of *C. calothyrsus and S. sesban* in an agroforestry land management system has many benefits (tangible and intangible) not only to the farmer but to the environment as well. Adoption of this land management system by farmers would be optimized with adequate infrastructural and extension support by relevant authorities. A more detailed study on the impact of intercropping these shrubs with food crops and using them in the long-term sustainability of agricultural ecosystems would elucidate other benefits not explored in these analyses.

With the increasing human population and land fragmentation, leading to shrinking land available to individual dairy farmers, there is need for more intensive but sustainable farming methods. Smallholder dairy farms should adopt an agroforestry land management model for more intensive and sustainable production and more stable incomes from their dairy cows.

From our findings and other cited research, use of leguminous shrubs has the potential to reduce production costs while improving milk production in dairy cows. These two factors are directly related with better incomes. Stable household incomes, prevailing weather notwithstanding, would contribute to less vulnerable household economies and more sustainable livelihoods.

Ethical approval

This study was approved by the Research Ethics Board and the Animal Care Committee of UPEI, NDFCS, and FHF, a partner non-governmental organization. Consent of all participants was obtained after the study was fully explained.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Factors affecting the technical efficiency of oil palm fruit processing units in South-East Benin

Jean Adanguidi

Food and Agriculture Organization (FAO), BP 1327, Cotonou, Bénin.

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As the independent Benin's first export crop, oil palm continues to play an important role in the Beninese economy and society despite the decline in its production that has begun since the 1970s. It is present in most cropping systems throughout southern Benin. The objective of this article is, on the one hand, to assess the level of technical efficiency of oil palm fruit processing units in South-East Benin and, on the other hand, to analyze the determinants of this technical efficiency. The so-called "two-step" method was used, which consists of using a Data Envelopment Analysis (DEA) model for the analysis of technical efficiency scores followed by a Tobit regression model to analyze the determinants of technical efficiency. The data used were collected in 2018 within the Adja-Ouèrè municipality. The results obtained show that the average technical efficiency score of the processing units is 0.891, which means that it is still possible to improve the production. The analysis of the determinants of technical efficiency showed that variables such as membership to an agricultural producer organization and the number of direct relatives involved in the processing activity improve the technical efficiency of oil palm fruit processing units.

Key words: Oil palm fruit processing, the so-called "two-step" method, data envelopment analysis, Tobit model, Benin.

INTRODUCTION

The introduction of oil palm (*Elaeis guineensis*) in Dahomey (present-day Benin) goes as far back as two centuries ago. The expansion of its production was encouraged by King Guezo (1818-1858) (Dissou, 1972; Soumonni, 1995). Until 1960, the colonial administration favoured mainly the trade of export crops. From 1960 to 1970, rural development policy focused on the promotion of oil palm with the creation of the National Society for Rural Development (SONADER). Oil palm production increased from 6,000 tonnes in 1966 to 14,300 tonnes in 1970 (Beck, 1995). But over the last fifty years, several problems have hindered the development of oil palm production in Benin. They can be grouped into three categories:

(a) The decrease in production and yields due to:
(i) Declining rainfall: Oil palm suffered from the rainfall recessions recorded between 1963 and 1983. Annual

E-mail: a60j60@gmail.com.

rainfall is estimated at an average of 1200 mn of water per year. However, according to Hartley (1977), it takes about 2000 mm of rainfall well distributed throughout the year, preferably with three months of rainfall of less than 100 mm for the proper development of oil palm. However, the rainfall patterns of Benin's stations show a one-to-three-month recession sometimes between July and September and often rainfall of less than 100 mm, reaching 50 mm and less in some years.
(ii) Low availability of specific fertilizers;
(iii) Low availability of quality seeds: Good quality young palm plants are not available and/or accessible;
(iv) Ageing of plantations;
(v) Lack of access to adequate credit.

(b) The marketing problem: Strong competition from imported oils;
(c) The problem related to post-harvest processing mainly to the processing of palm nuts fruit into palm oil:

(i) The low yield of palm oil extraction using traditional processing methods because of the predominance of a very poorly mechanized artisanal sector (Fournier et al., 2000);
(ii) The poor access to credit adapted to the processing of palm nuts into red oil.

In a study on the artisanal processing of palm oil in Benin and Nigeria, Fournier et al. (2001) pointed out that:

(i) The high dispersion of palm oil extraction activities among the population of South Benin;
(ii) A strong competition between women palm oil processors, which hinders cooperation between them; and
(iii) The existence of collective innovation dynamics resulting in local product qualification processes in some regions, and in improvements in process productivity in other regions.

To date, no studies on the efficiency of traditional oil palm fruit processing units have been carried out in Benin. However, such a study is essential to see whether it is possible to improve the productivity of processing units without increasing the use of productive resources.

Despite this decline, oil palm is and remains the oil plant that supplies the most oil per hectare (Aholoukpè et al., 2013). That is why the people of southern Benin are so attached to it economically, socially, culturally and environmentally (Fournier et al., 2002). The traditional processing of palm nuts into red oil is largely dominant and provides a significant source of income for those who engage in it (SNV, 2016). Better still, the Strategic Plan for the Revival of the Agricultural Sector (PSRSA 2011-2015) had already targeted oil palm as a promising sector for Benin. The Government's Action Programme (PAG 2016-2021) has also targeted oil palm in three Agricultural Development Poles.

In view of the renewed interest in oil palm in recent years, it is necessary to analyze the performance of traditional processing units of palm nut in order to make relevant recommendations for reviving this sector. The objective of this article is, on one hand, to assess the level of technical efficiency of oil palm fruit processing units in South-East Benin and, on the other hand, to analyze the determinants of this technical efficiency.

METHODOLOGY

Study areas and data collection

For this research, the Commune of Adja-Ouèrè in the plateau department of South-East Benin as selected. Covering an area of 550 km^2, the Commune of Adja-Ouèrè enjoys a sub-equatorial climate with two dry seasons that alternate with two rainy seasons. Rainfall amounts to 1100 to 1200 mm per year. The presence of the Oil Palm Research Station in Pobè (neighbouring municipality) has long created a dynamic favourable to palm cultivation in this municipality, which has large oil palm plantations covering thousands of hectares and managed by cooperatives, interest groups, farming companies and individual producers (Fournier et al., 2001; PADECOM/Afrique Conseil, 2006).

A sample of 60 oil palm fruit processing units was selected for the in-depth investigation. The sample size was calculated using the following formula (Rea and Parker, 2014):

$$\boldsymbol{TE} = \frac{\boldsymbol{T_p^2 * P * (1-P) * N}}{\boldsymbol{T_p^2 * P * (1-P) + (N-1) * Y^2}}$$

Where:
TE = Sample size.
N = Number of agricultural households in the Commune of Adja-Ouèrè. According to the 2013 RGPH3 data, the number of agricultural households in Adja-Ouèrè Municipality is 9427. In 2018, the number of agricultural households is estimated at 11,196.
P = Proportion of agricultural households with a traditional unit for processing palm nuts into red oil in the Commune of Adja-Ouèrè. It is estimated at about 19.5%.
Tp = Sampling confidence interval. For a 95% confidence interval, the value of Tp = 1.96.
Y = Margin sampling error. We have taken here a margin error of 10%.

A questionnaire was designed, tested and administered to the 60 processing units. Data on quantities and prices of inputs used, including palm nuts, water and fuelwood, were collected. Information on the quantity and cost of labor throughout the processing process, in particular the cooking of the palm nuts, mixing, dilution up to settling of the oil and its packaging were collected. Some socio-economic characteristics of the people in charge of the processing units were also collected.

Data analysis

Two approaches are commonly used to measure technical effectiveness: the parametric approach (Aigner and Chu, 1968; Aigner et al., 1977; Meeusen and Van Den Broeck, 1977) and the non-parametric approach (Farrell, 1957; Farrell and Fieldhouse, 1962; Charnes et al., 1978; Banker et al., 1984; Seiford and Thrall, 1990; Seiford, 1996; Lovell, 1993; Charnes et al., 2013; Badillo and Paradi, 1999; Seiford, 1999; Amara and Romain, 2000; Borodak, 2007; Latruffe, 2010).

The parametric approach is based on a functional form for specifying the production boundary and profit function from econometric tools. The non-parametric approach, on the other hand, is not based on a predetermined functional form. It is based on linear programming and consists of determining the distance between a given observation and the target to be reached.

In this study, the so-called "two-step" method (Coelli et al., 2005; Pastor, 2002) was used. The "two-step" method combines a DEA model and regression analysis. In the first step, a traditional DEA model was built that includes only discretionary variables (inputs and outputs). In the second step, efficiency scores are regressed on environmental variables using Tobit regression model (Idris et al., 2013; Bravo-Ureta et al., 2007; Chavas and Aliber, 1993; Featherstone et al., 1997; Fried et al., 1999; Rowland et al., 1998).

Data envelopment analysis (DEA)

In practice, the DEA model can be given an input or output orientation. In the case of an input orientation, the model minimizes the inputs for a given level of outputs, that is, it indicates how much a Decision Making Unit (DMU) can reduce its inputs while producing the same level of outputs. In an output orientation, however, the model maximizes outputs for a given level of inputs, that is, it indicates by how much an MISP can increase its outputs with the same level of inputs.

The choice of the type of orientation of the model depends on the variables (inputs or outputs) on which the decision-makers exercise the greatest management power. If we make the hypothesis that no constraints are imposed on decision-makers and that they exercise management power over both resources (inputs) and outputs (outputs), and the hypothesis that the processing units studied evolve in a situation of Variable Returns to Scale (VRS), that is, they do not operate at their optimal size, we can use the DEA model in this study under the assumption of output-oriented variable scale return (Huguenin, 2013).

Technical efficiency is a global measure of an organization's performance. However, it does not indicate the source of the inefficiencies found, which could be twofold:

(i) First of all, the organization may be inefficient because its management can be improved (not to say deficient);
(ii) Second, the organization may be inefficient because it has not reached its optimal size.

The DEA method allows technical efficiency to be decomposed to reflect these two sources of inefficiency:

(i) The notion of pure technical efficiency refers to the inefficiency associated with perfectible management;
(ii) The notion of scale efficiency refers to the inefficiency associated with a sub-optimal size designated by:

Q_{rk} : the quantity of the output r produced by the processing unit k;
X_{ik} : the quantity of input i consumed by the processing unit k;
E_r *: the weight of the output r ;*
L_i *: the weight of the input i;*
n : the number of processing units to be evaluated;
s : the number of outputs;
m : the number of inputs;
s_r and s_i : the slacks.

i) Primal equation:

Minimize $\sum_{r=1}^{s} L_i X_{ik} - c_k$

Under constraints $\sum_{i=1}^{m} L_i X_{ij} - \sum_{r=1}^{s} E_r Q_{rj} - c_k \geq 0$ j=1,…,n

$$\sum_{r=1}^{s} E_r Q_{rk} = 1$$

$$E_r, L_i > 0 \qquad \forall r = 1, \ldots, s;\ i = 1, \ldots, m$$

ii) Dual equation:

Maximize $\emptyset_k$

Under constraints $\emptyset_k Q_{rk} - \sum_{j=1}^{n} \lambda_j Q_{rj} \leq 0$ r =1, …, s

$$X_{ik} - \sum_{j=1}^{n} \lambda_j X_{ij} \geq 0 \qquad \text{i = 1, …, m}$$

$$\lambda_j \geq 0 \qquad \forall = 1, \ldots, n$$

Where: $1/\phi_k$ and θ_k represent the technical efficiency of the organization k; λ_j represents the weight associated with the outputs and inputs of organization j.

iii) Dual equation with slacks:

Maximize $\phi_k + \varepsilon \sum_{r=1}^{s} s_r + \varepsilon \sum_{i=1}^{m} s_i$

Under constraints $\emptyset_k Q_{rk} - \sum_{j=1}^{n} \lambda_j Q_{rj} = 0$ r =1, …, s

$$X_{ik} - \sum_{j=1}^{n} \lambda_j X_{ij} - s_i = 0 \qquad \text{i = 1, …, m}$$

$$\lambda_j, s_r, s_i \geq 0 \qquad \forall j = 1, \ldots, n;\ r = 1, \ldots, s;\ i = 1, \ldots, m$$

Based on this, the efficiency will then be adjusted to the environmental conditions.

Tobit regression

The Tobit model was developed by economist James Tobin in an article published in 1958. It is a model with a limited dependent variable, that is, a model for which the dependent variable is continuous but observable only over a time interval.

In our work, each processing unit has an efficiency coefficient in the closed range of 0 to 1. The technical efficiency scores calculated for each processing unit are regressed on the potential determinants of the environment.

If we designate y_i as the dependent variable that represents the technical efficiency score of processing unit i, the Tobit model will look like this:

$$\boldsymbol{y_i^* = x_i'\beta + \mu_i} \qquad \text{i = 1, 2, …., n}$$

Where the observed variable is:

$$\boldsymbol{y_i = \begin{cases} y_i^* & if\ y_i^* > 0 \\ 0 & otherwise \end{cases}}$$

According to the literature, certain factors are likely to have an impact on the technical efficiency level. For this study, we will use the following factors (Table 1):

(i) The age of the person in charge of the processing unit (X_{AGE}): Some authors believe that the relationship between age and technical efficiency may be negative (Coelli and Fleming, 2004; Jwanya et al., 2014). Other authors, however, believe that this relationship can be positive (Dube et al., 2018).

Table 1. Variables used in the tobit model.

Variable	Description
Dependent variable	
X_{SET}	Technical efficiency score
Independent variable	
X_{AGE}	Age of the person in charge of the processing unit, measured in years
X_{TAI}	Size of the household of the person in charge of the processing unit
X_{EXP}	Number of years of experience in palm nut processing, measured in years
X_{APP}	Membership of an agricultural producer organization. It is measured as a binary variable: 1 if the processor is a member of an agricultural producer group; 0 = other
X_{NPD}	Number of direct relatives who process palm nuts

(ii) The size of the household of the person in charge of the processing unit (X_{TAI}): Household size plays an important role in labour availability and can positively affect the level of technical efficiency (Ani et al., 2013; Nuama, 2006; Ayaz et al., 2010; Dube et al., 2018).
(iii) The number of direct relatives of the person in charge of the processing unit in the activity (X_{NPD}).
(iv) The number of years of experience in palm nut processing, measured in years (X_{EXP}): The number of years of experience could positively influence the level of technical efficiency (Ayaz et al., 2010).
(v) The fact that the person in charge of the processing unit belongs to an agricultural producer organization (X_{APP}): Membership of an economic interest group has a positive impact on technical efficiency (Helfand and Levine, 2004; Nuama, 2006; Idris et al., 2013).

The following equation was estimated, based on the primary data obtained:

$$X_{SET} = \beta_1+\beta_2 X_{AGE} + \beta_3 X_{TAI} + \beta_4 X_{EXP} + \beta_5 X_{APP} + \beta_6 X_{NPD} + \varepsilon$$

Where X_{SET} is the efficiency score of the processing units.

Here, the Stata software was used to estimate the Tobit model.

RESULTS AND DISCUSSION

Analysis of the technical efficiency of oil palm fruit processing units

The results of the model are presented in Appendix 1. The first column of the table shows the oil palm fruit processing units. The second column presents the efficiency scores generated by the model under the assumption of constant returns to scale technical efficiency (CRSTE), also called total efficiency, which is further broken down into two other types of efficiency: pure efficiency, which is variable returns to scale technical efficiency (VRSTE), presented in the third column, and scale efficiency, presented in the fourth column. The type of returns to scale (IRS, DRS, CRS) is presented in the last column: The processing units associated with IRS evolve in a situation of increasing returns to scale (economies of scale); those associated with DRS evolve in a situation of decreasing returns to scale (diseconomies of scale); and finally those associated with CRS evolve in a situation of constant returns to scale; each of these operate at their optimal size.

On average, the processing units studied obtained the following efficiency scores:

i) 86.6% for CRSTE: in total, the oil palm fruit processing units studied can increase all their outputs (red oil) by 13.4% with the same amount of inputs.
ii) 89.1% for VRSTE: a better management of oil palm fruit processing units makes it possible to increase the quantity of outputs (red oil) by 10.9% with the same quantity of inputs.
iii) 97.2% for SCALE: by adjusting their size, oil palm fruit processing units can increase their outputs (red oil) by 2.8% with the same amount of inputs.

Table 2 shows the frequency distribution and some descriptive statistics of the technical efficiency scores in terms of constant returns to scale, variable returns to scale and efficiency of scale. On average, the 60 processing units studied obtained the following efficiency scores (Table 2):

i) 20 processing units (that is, 33%) are efficient;
ii) 28 processing units (that is, 47%) have an efficiency score greater than or equal to 80% and less than 100%.
iii) 6 processing units (that is, 10%) have an efficiency score of 70% or more and less than 80%.
iv) 6 processing units (that is, 10%) have an efficiency score of 40% or more and less than 70%.

The analysis of the results in Table 3 shows that:

(i) 28% of the oil palm fruit processing units studied are in a situation of economies of scale, that is, they operate in a situation of increasing scale efficiency. This means that a 1% change in output production implies a less than 1%

Table 2. Frequency distribution of technical efficiency scores obtained with the DEA model.

Efficiency score	CRS	VRS	SE
1.00	28%	33%	38%
0.90 - 0.99	22%	20%	55%
0.80 - 0.89	20%	27%	3%
0.70 - 0.79	17%	10%	2%
0.60 - 0.69	7%	3%	2%
0.50 - 0.59	5%	5%	0%
0.40 - 0.49	2%	2%	0%
Average	*0.866*	*0.891*	*0.972*
Minimum	*0.499*	*0.499*	*0.682*
Maximum	*1.000*	*2.000*	*3.000*
Standard deviation	*0.142*	*0.133*	*0.058*

Table 3. Efficiency of oil palm fruit processing based on the production scale of processing plants.

Production scale	Frequency	%
Increase Return to Scale (IRS)	17	28
Constant Return to Scale (Optimal)	20	33
Decrease Return to Scale (DRS)	23	38
Total	**60**	**10**

change in input consumption. An organization in such a situation has not yet reached its optimal size. To improve its scale efficiency, it must increase its production. This is the case for processing unit 31, for example, which has a pure efficiency of 83.3% and a scale efficiency of 86.4%. It is evolving in a situation of increasing returns to scale (IRS). By improving the way the processing unit is managed, 16.7% (100% - 83.3%) of the inputs can be saved. By adjusting the size of the processing unit, input consumption can be reduced by 13.6% (100%- 86.4%).

(ii) 38% of the oil palm fruit processing units studied are in a situation of diseconomies of scale. A 1% change in output production implies a change in input consumption of more than 1%. An organization in such a situation has already exceeded its optimal size. To improve its scale efficiency, it must reduce its production. This is the case of processing unit 40, which has a pure efficiency of 88.5% and a scale efficiency of 91.3%. It operates in a situation of diminishing returns of scale (DRS). By improving the way the processing unit is managed, 11.5% (100% - 88.3%) of the inputs can be saved. By adjusting the size of the processing unit, input consumption can be reduced by 8.7% (100% - 91.3%).

(iii) 33% of the oil palm fruit processing units studied are in a situation of constant returns to scale. A 1% change in output production implies a 1% change in input consumption. The example to illustrate this case is processing unit 48, which has a pure efficiency of 97.2% and a scale efficiency of 100%. It operates in a situation of constant returns of scale, so it operates at its optimal size.

The result of this study reveals an average technical efficiency of 89%. This average technical efficiency is almost similar to what Wuraola et al. (2013) found in a study on the technical and allocative efficiency of palm oil processing in Benue State in Nigeria. By using stochastic production frontier model, they found that the average technical efficiency is 91% showing that the processors actually operate with a level of inefficiency (9%). The result of our study is however different from the one found by Abdulsalam et al. (2014) in their study on the technical efficiency differentials in oil palm fruit processing technologies in Cross River State, Nigeria. The results of their study revealed mean efficiency of 62% for traditional and 81% for improved technologies.

Technical efficiency determinants analysis

To analyze the determinants of technical efficiency, the technical efficiency scores on the demographic and environmental variables of the transformation units were regressed. The technical efficiency score was used as the dependent variable. As it varies between 0.499 and 1, ordinary least squares are no longer indicated. We then used a Tobit model. Table 4 presents the results of the model that examined the relationship between the technical efficiency score and the variables earlier mentioned.

The results of the model show that age (with a significance level of 10%), membership of an agricultural producer organization (with a significance level of 1%) and the number of direct relatives in the activity (with a significance level of 5%) have a significant effect on the effectiveness score.

Membership of an agricultural producer organization has a positive effect on the efficiency score of processing units. This is proof that the organization can offer opportunities for access to credit, labor and even new technologies. It can also provide an excellent framework for the exchange of experience between members. This result is consistent with that obtained by Helfand and Levine (2004), Nuama (2006) and Mohd et al. (2013).

The number of direct parents in the activity also has a positive effect on the effectiveness score. The presence of parents engaged in the same activity best facilitates the learning process of the trade while at the same time providing an excellent framework for the exchange of experience and the dissemination of new technologies. It could also make it possible to pool certain productive resources such as processing equipment and even sometimes labor.

Age, on the other hand, has a negative effect on the efficiency score. This will mean that increasing the age of the person in charge of the processing unit leads to a

Table 4. The Tobit regression model.

Variable	Coefficient	Standard error	t	P > |t|
X_{AGE}	-0.0057983	0.0032082	0.076	0.095
W_{TAI}	-0.0057861	0.0127837	0.653	0.744
X_{EXP}	0.0027225	0.0035748	0.450	0.448
W_{XAPP}	0.1301798	0.0499905	0.012	0.009
X_{CPS}	0.0682071	0.0159002	0.000	0.045
_CONS	0.9600276	0.1299998	0.000	0.000

decrease in her technical efficiency score. It is therefore possible that the increase in the processor's age will further plunge her into a state of conservatism that is detrimental to the adoption of new technologies. This result is consistent with those obtained by Adesina and Baidu-Forson (1995), Coelli and Fleming (2004), Onyenweaku et al. (2004), Chirwa (2005), Alene and Manyong (2006), Chong (2013) and Mohd et al. (2013).

The number of years of experience in oil palm fruit processing has a positive but not significant impact on the efficiency score. These results are consistent with those obtained by Idiong (2007) and Rahman and Umar (2009).

The size of the household of the head of the processing unit has a negative and insignificant impact on the efficiency score. These results are consistent with those obtained by Alene and Manyong (2006) and Croppensted et al. (2003).

CONCLUSION AND RECOMMENDATIONS

The objective of this article is, on one hand, to assess the level of technical efficiency of oil palm fruit processing units in South-East Benin and, on the other hand, to analyze the determinants of this technical efficiency. The estimation of the DEA model showed that the average technical efficiency score of the processing units is 0.891, which means that it is still possible to improve the production.

Analysis of the determinants of technical efficiency showed that variables such as membership of an agricultural producer organization and the number of direct relatives in the activity improve the technical efficiency of oil palm fruit processing units.

In order to improve the technical efficiency of oil palm fruit processing units, we can make the following recommendations at the end of this study:

(i) Encourage owners of the oil palm fruit processing units to group themselves into associations with regard to the OHADA Uniform Act of 15 December 2010 on the rights of cooperative societies. The Territorial Agencies for Agricultural Development, which today constitute the operational arm of the Ministry of Agriculture, Livestock and Fisheries, which provide agricultural extension services, should encourage the heads of oil palm fruit processing units to form associations in order to facilitate their access to new technologies, credits and labour. Non-governmental organizations and the National Platform of Farmers' and Agricultural Producers' Organizations of Benin (PNOPPA-Benin) and the Federation of Producers' Unions of Benin (FUPRO-Benin) could play a major role in promoting professional agricultural organizations among oil palm fruit processing units owners.

ii) Share the experience of the oil palm fruit processing units run by young people with those run by the elderly in order to improve the technical efficiency of the whole sector; this could be done through experience exchange visits.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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Appendix 1. Presentation of the model results.

Oil palm fruit processing unit	CRSTE	VRSTE	SCALE	Type of scale returns
DMU1	1.000	1.000	1.000	CRS
DMU2	0.844	0.852	0.991	IRS
DMU3	0.741	0.784	0.945	DRS
DMU4	1.000	1.000	1.000	CRS
DMU5	0.735	0.982	0.748	DRS
DMU6	0.955	0.983	0.971	DRS
DMU7	0.682	1.000	0.682	IRS
DMU8	1.000	1.000	1.000	CRS
DMU9	0.955	0.956	0.999	IRS
DMU10	0.823	0.825	0.998	IRS
DMU11	1.000	1.000	1.000	CRS
DMU12	0.540	0.548	0.986	IRS
DMU13	0.621	0.627	0.990	IRS
DMU14	0.976	0.976	1.000	CRS
DMU15	0.998	0.998	1.000	CRS
DMU16	0.842	0.896	0.939	DRS
DMU17	0.795	0.795	1.000	CRS
DMU18	0.730	0.884	0.827	DRS
DMU19	0.549	0.560	0.981	DRS
DMU20	0.981	0.982	0.999	IRS
DMU21	0.796	0.822	0.968	DRS
DMU22	0.815	0.835	0.976	DRS
DMU23	0.887	0.889	0.998	IRS
DMU24	1.000	1.000	1.000	CRS
DMU25	1.000	1.000	1.000	CRS
DMU26	0.741	0.784	0.945	DRS
DMU27	0.671	0.719	0.934	DRS
DMU28	0.741	0.784	0.945	DRS
DMU29	0.621	0.621	1.000	CRS
DMU30	1.000	1.000	1.000	CRS
DMU31	0.719	0.833	0.864	IRS
DMU32	1.000	1.000	1.000	CRS
DMU33	1.000	1.000	1.000	CRS
DMU34	1.000	1.000	1.000	CRS
DMU35	0.580	0.582	0.996	IRS
DMU36	1.000	1.000	1.000	CRS
DMU37	0.909	0.913	0.995	IRS
DMU38	0.894	0.898	0.996	DRS
DMU39	0.974	0.979	0.995	DRS
DMU40	0.808	0.885	0.913	DRS
DMU41	0.793	0.818	0.969	DRS
DMU42	0.885	0.886	0.998	IRS
DMU43	0.736	0.761	0.967	DRS
DMU44	0.814	0.816	0.998	IRS
DMU45	0.499	0.499	1.000	CRS
DMU46	1.000	1.000	1.000	CRS
DMU47	0.940	1.000	0.940	DRS
DMU48	0.971	0.972	1.000	CRS
DMU49	0.807	0.862	0.936	DRS
DMU50	1.000	1.000	1.000	CRS
DMU51	0.815	0.823	0.991	DRS

Appendix 1. Contd.

DMU52	0.969	0.988	0.981	IRS
DMU53	0.887	0.898	0.987	DRS
DMU54	0.999	1.000	0.999	IRS
DMU55	0.934	0.953	0.980	IRS
DMU56	1.000	1.000	1.000	CRS
DMU57	1.000	1.000	1.000	CRS
DMU58	1.000	1.000	1.000	CRS
DMU59	1.000	1.000	1.000	CRS
DMU60	0.975	0.981	0.995	IRS
Average	**0.866**	**0.891**	**0 .995**	

DMU = Decision Making Unit; IRS = Increasing Returns to Scale; DRS = Decreasing Returns to Scale; CRS = Constant Return to Scale.

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Micro-financing and rural poverty reduction: A case of Rima Microfinance Bank in Goronyo Local Government Area, Sokoto State, Nigeria

M. B. Mustapha[1*], B. I. Yusuf[2] and A. N. Abdullahi[3]

[1]Department of Economics, Shehu Shagari College of Education, Sokoto, Nigeria.
[2]Sokoto State Fadama III AF Coordination Office, Sokoto, Nigeria.
[3]Department of Agricultural Economics, Usmanu Danfodio University, Sokoto, Nigeria.

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Microfinance is proposed to be an efficient and viable means to poverty alleviation in the developing world, but there has been little empirical study on the impacts of microfinance banks. This study examines the impact of Rima Microfinance Bank on beneficiaries' income and poverty in Goronyo Local Government Area of Sokoto State, Nigeria. A multistage-sampling technique was used to draw the sample and a structured questionnaire was used for data collection. The data was analysed using descriptive statistics (means, frequency, and percentages) and Foster, Greer and Thorbecke (FGT) poverty index. The result revealed that the beneficiaries had a mean per capita income of ₦47,489.19 before and ₦115,678 after using the Rima Microfinance credit facility. The result of the FGT poverty incidence reduces by 6%. This is reflected by the reduction in poverty depth and severity significantly after the Rima microfinance intervention in the form of agricultural input credit facilities. The study recommends a microfinance policy that will ease more access to credit as well as ensuring efficient utilization of acquired inputs through effective monitoring for better productivity, income and poverty reduction among rural dwellers.

Key words: Rima-Microfinace, impact, income, poverty, beneficiaries.

INTRODUCTION

Poverty adversely affects individuals, groups, nations and the world at large. However, the growing inequality between the rich and poor has long been a source of concern and a big challenge for nations, especially those with high rates of poverty. Poverty threatens the survival of mankind and as such the United Nations, together with support of other International Development Organizations such as the UNDP, World Bank, and the CGAP, declared 1996 as the international year of poverty reduction (Nnanna, 2001). This led to the adoption of the Millennium Development Goals (MDGs) in September, 2000, with much emphasis placed by the United Nations

*Corresponding author. E-mail: angaski1@gmail.com.

on poverty eradication. In line with these developments, successive Governments in Nigeria had taken several measures aimed at reducing poverty in the country. Over the years, a number of microfinance strategies have been implemented in order to expose the Nigerian poor to banking habits and to provide credit support. These strategies include community and people's banks, collaboration and services of the International Development Partners, and different policy frameworks, such as the rural banking scheme. However, these strategies have met with little or no success (Harper, 2005; Okafor, 2016).

The roles played by microfinance both as a poverty alleviation strategy and a vehicle for providing financial services to the poor have continued to gain prominence (Yunus, 2000; Okafor, 2016). This is because a broad base of micro-entrepreneurs, with access to resources, is essential to the sustenance of growth and development processes in any economy. The term 'microfinance' is more general in nature and covers all aspect of small credits and finance, assistance, grants savings and insurance (Akanji, 2001). Microfinance banks are institutions that are established to provide financial services to the active poor. The Central Bank of Nigeria (2005) observed that microfinance is about providing financial services to the poor who traditionally are not served, or are under served by the conventional financial system, owing to their inability to provide collateral. Microfinance institutions can be non-governmental organizations, savings and loan cooperatives, credit unions, government banks, commercial banks, or non-bank financial institutions. A policy based on microfinance seeks to make financial service available, on a sustainable basis, to the economically active poor, low income earners and micro small, small and medium enterprise through privately owned banks (Ledgerwood et al., 2010). Three features distinguish microfinance from other formal financial products. Microfinance is characterized by the small size of loans advanced and/or savings collected; the absence of asset-based collateral, and the simplicity of operations (CBN, 2005). Microfinance is therefore seen as the provision of financial services, such as credit (loans), savings, micro-leasing, micro-insurance and payment transfers to economically active poor and low income households to enable them to engage in income generating activities or to expand their small businesses.

Rima Community Bank, Goronyo was established in the year 1993 under the National Board for Community Banks (NBCB) with Registration No. 0442 and licensed by the Central Bank of Nigeria under the provision of Banks and Other Financial Institution Act. No.25 of 1991 as amended. Rima Community Bank is a registered microfinance bank with Corporate Affairs Commission and allowed to operate as Microfinance Bank by Central Bank of Nigeria in the year 2009. The bank collects of deposits through current and savings accounts, target savings, fixed deposit account, as well as grants loan to individual, group and corporate. The bank equally grants special agricultural loans to farmers for rain fed and irrigated crop production as well as micro loans to rural women for small and medium businesses. It is in line with this development that this paper seeks to revisit the Rima microfinance Bank in Goronyo local government area of Sokoto State, with a view to assessing its impact on beneficiaries' household income and poverty. This would provide inputs for designing policies for future agricultural rural financing initiatives in Nigeria.

REVIEW OF RELATED LITERATURE

Microfinance has evolved as an economic development approach intended to benefit the low-income part of a given society (Soludo, 2005). According to the World Bank definition, the term refers to 'provision of financial services' (including savings and credit) to 'the poor'. Micro finance banks are institutions that are established to provide financial services to the active poor. Microfinance institutions can be non-governmental organizations, savings and loan cooperatives, credit unions, government banks, commercial banks, or non-bank financial institutions. This policy seeks to make financial service available on a sustainable basis to the economically active poor, low income earners and micro small, small and medium enterprise through privately owned banks (Ledgerwood et al., 2010)

Poverty is defined as an income (or more broadly welfare) level below a socially acceptable minimum and microfinance is one of the range of innovative financial arrangements designed to attract the poor as either borrowers or savers. In principle, microfinance can relate to the chronic (non-destitute) poor and to the transitory poor in different ways. According to World Bank (2009), the condition of poverty has been interpreted conventionally as one of lack of access by poor households to the assets necessary for a higher standard of income or welfare, whether assets are thought of as human (access to education), natural (access to land), physical (access to infrastructure), social (access to networks of obligations) or financial (access to credit).

Source of credit to farmers is of vital importance for poverty reduction and agricultural development of any country. Availability of funds to farmers strengthens the farming business and enhances the productivity of other resources. The low level of loan utilization by farmers and traders alike may be due to the absence of micro-finance institutions and loan-awarding banks coupled with the administrative bottleneck associated with loan accessibility. Oludimu and Olufemi (2003) observed that rural farmers' savings are very low and were unable to purchase new technology because of insufficient use of credit. Given the farmers' poor resource endowments base and the huge requirements of finance in production, very few rural dwellers have enough capital to invest. This fact really constitutes a big hitch to agricultural development and to poverty reduction in Nigeria. The low use of government/bank loan by the rural residents could also be explained by the findings of Subba-Reddy et al. (2004), who earlier highlighted the problems of agricultural credit such as illiteracy, diversion of production loans, high-interest rates, mismanagement, lack of collateral, etc. Harper (2005) stipulated that despite these short comings, agricultural credits remain one of the most valuable instruments for agricultural transformation, and invariably for alleviating poverty among rural farmers.

Lack of access to credit is readily understandable in terms of the absence of collateral that the poor can offer conventional financial institutions, in addition to the various complexities and high costs involved in dealing with large numbers of small, often illiterate, borrowers. Thus, the poor have to rely on loans from either moneylenders at high interest rates or friends and family, whose supply of funds are limited. Microfinance institutions attempt to overcome these barriers through innovative measures such as group lending and regular savings schemes, as well as the establishment of close links between poor clients and staff of the institutions concerned. The range of possible relationships and the mechanisms employed are very wide. The case for microfinance as a mechanism for poverty reduction is simple. If access to credit can be improved, it is argued, the poor can finance productive activities that will allow income growth, provided there are no other binding constraints. For the transitory poor, who are vulnerable to fluctuations in income that bring them close to or below poverty line, microfinance provides the possibility of credit at times of need and in some schemes the opportunity of regular savings by a household itself that can be drawn on. The avoidance of sharp declines in family expenditures by drawing on such credit or savings allows ‘consumption smoothing’ (Okafor, 2015).

One of the most interesting generalizations to emerge from the microfinance and poverty literature is that the poorest of the chronic poor (the core poor) borrow essentially for protection purposes, given both the low and irregular nature of their income. This group, as suggested, is too risk averse to borrow for promotional measures (that is for investment in the future) and therefore is a very limited beneficiary of microfinance schemes (Toby and Akani, 2014)

The Foster-Greer-Thorbecke (FGT) indices are a family poverty metrics, the most commonly used and combined measure of poverty and income inequality and a popular choice within development economics. The FGT class of decomposable poverty measures was introduced in the year 1984 and the indices measures poverty incidence, depth and severity. Poverty incidence or poverty rate is the share of the population whose consumption (or income) is below the poverty line. This measure quantifies the share of the population that cannot afford to buy a basket of goods (Aguirregabiria, 2003). In this respect, the poverty incidence provides an estimate of the number of beneficiaries’ households living below the poverty line. The poverty severity measures an average of overall people to the proportionate gap between poor people living standard and the poverty line. Poverty gap measures the degree to which the mean income of the poor differs from established poverty line. According to Aguirregabiria (2003), an advantage of the poverty depth is that it reflects the average shortfall of poor people, thereby giving a better understanding of the depth of poverty and further shows how much would have to be transferred to the poor to bring their expenditure or income up to the poverty line or the amount of income necessary to bring every beneficiary in poverty up to the poverty line, divided by the total population. This can be thought of as the amount that an average person in the economy would have to contribute in order for poverty to be just barely eliminated. The squared poverty gap is the average of the squared relative gaps. It captures differences in income levels among the poor and it takes into account not only the distance separating the poor from the poverty line but also the inequality among the poor (Aguirregabiria, 2003).

METHODOLOGY

Description of the study area

The study was conducted in the Goronyo Local Government Area (LGA) of Sokoto State, Nigeria. Goronyo LGA has a population of approximately 220,000 people and has an area of 1,444,369 km^2. It shares boundaries with Sabon Birni LGA in the East, Wurno LGA in the West, Gada LGA in the North and Rabah LGA in the South (SOSG, 2009). The Local Government consists of Hausa, Fulani and Bugaje tribes. The major occupations of the people in the area are farming (both in raining and dry seasons), trading, livestock rearing and fishing. The major crops cultivated in the area include millet, Guinea corn, wheat, rice, beans, onions and garlic. Goronyo LGA is one of the largest garlic and onion producing areas in Nigeria (SOSG, 2009).

The study used both primary and secondary data. Primary data were collected using a designed interview schedule while secondary data were sourced from text books, journals, past project works, and other relevant materials.

Sampling

A Multistage sampling technique was used to get the sample. The first stage involved a purposive selection of the two major districts in the Goronyo LGA: Goronyo and Shinaka districts. The second stage involved a simple random selection of five villages from each of the two major districts. The third stage involved a selection of 16 beneficiaries from each of the 10 selected villages using proportionate quota sampling technique and simple random sampling procedure. A total of 160 beneficiaries of microfinance intervention were selected for the study. In this study, before and after option (Pitt and Kandker, 1998) was used, because of lack of information on non-users. The difference is used as a measure of the impact on the use of such intervention (Pitt and Kandker, 1998).

Analysis

The data were analysed using descriptive statistics (means, frequency, percentages) and the Foster, Greer and Thorbecke (FGT) poverty index measure. The poverty line was determined using the $1.25 and $1.50 levels to establish the poverty status of core poor, moderately poor and non-poor before and after the intervention programs. The Foster, Greer and Thorbecke-FGT (1984) weighted poverty index was used to determine the poverty profile of the beneficiaries. The FGT measure for the ith group (P_α) is specified as:

$$P_\alpha = n^{-1} \sum^{q}(Z - y_i / Z)^{\alpha}$$

where N = Total number of households, Z = Poverty line, y_i = Individual incomes, q = Number of poor (those with incomes at or below the poverty line, Z), α = Degree of poverty aversion (sensitivity parameter). When α = 0 gives the incidences of poverty (head count index, or the fraction of the respondents who live below the poverty line), α = 1 gives the depth of poverty, and α = 2 gives the severity of poverty (FGT, 1984).

RESULTS AND DISCUSSION

Socio-demographic characteristics of the beneficiaries

The socio-demographic characteristic of the beneficiaries is shown in Table 1. The result shows that majority (53%) of the beneficiaries in the study area were ageing males (36-50) years) (Table 1). By implication, youth involvement in rural activities is low as reported by Williams (1978), who reported that the average age of persons that engage in rural activities was 35 years in Nigeria. The absence of productive and energetic youth in farming activities could pose a threat to food supply and by extension lead to poverty.

The result (Table 2) shows that majority of the beneficiaries interviewed had a family size of between 1 and 10 members. This is in agreement with the findings of Baba and Wando (1998), Ndanitse (2005) and Idowu et al. (2009). The distribution depicts the usual Islamic religious doctrine, where emphasis is placed on the belief that a man should marry more than one wife and begets children both for pride and in accordance to Islamic injunction.

The results (Table 3) show that most beneficiaries had been involved in rural economic activities for quite some period of time, with 33.5% and 22.5% of the beneficiaries been involved in different economic activities for a period of 11 to 15 years and 16 to 20 years, respectively. The results (Table 4) further show that, although all the beneficiaries were either formally or informally literate, 63.1% of the beneficiaries had formal (primary, secondary or tertiary) education. This arbitrarily indicates beneficiaries with formal education desire information and new technologies that can enhance their productivity.

The result (Table 5) further shows that 67.5% of the beneficiaries practiced either farming only or farming and trade as their means of subsistence, and that 58.8% of the beneficiaries had a second income source (trade, civil service or both) that provides security in case of adverse events, such as crop failure. The result demonstrates that the study area is a typical rural setting where agriculture based occupation is the predominant activity among the populace (Olayide et al., 1981).

Structure of the beneficiaries' per capita income

The structures of the household per capita income before and after Rima microfinance intervention were obtained through the household level survey. The per capita household income is defined as the total household income divided by the household size. The distribution of per capita household income of the beneficiaries is shown in Table 6.

Table 6 shows that the majority (60.6%) of the beneficiaries had a per capita income of ₦1,333 to ₦41,110, and only 22.50% earned ₦41,111 to N80,889 before the Rima microfinance intervention (mean = ₦47,489.19). However, after being granted the Rima Microfinance credit facility, 75.6% of the beneficiaries realized a per capita income of ₦5,000 to ₦153,278 and 15% earned ₦154,279 to ₦300,556 per capita (mean = ₦115,678). The increase in the beneficiaries' mean per capita income, after benefiting from the services of the Rima microfinance Bank in the area under study, was therefore ₦68,188.81 (from ₦47,489.19 to ₦115,678.00).

The finding of the study on the impact of Rima microfinance on beneficiaries' income agrees with Jegede et al. (2011) and Okafor (2014). Okafor (2014) examined the empirical relationship between microfinance loan disbursement and poverty alleviation, and reported that there was a significant difference between those people who used microfinance institutions and those who do not use them. They further established a significant effect of microfinance institutions in poverty reduction through increasing income and changing economic status of those who patronize them. His study concludes that microfinance institution is indeed a potent strategy of poverty reduction and a viable tool for purveying credit to the poor. However, Jegede et al. (2011) as well as Toby and Akani (2014) observed that microfinance can be a more viable tool for sustainable poverty reduction if more is done on program outreach and depth than the present outreach. Conversely, Nwigwe et al. (2012) and Okafor, (2016) argued that, although the impact of microfinance on poverty reduction remains in doubt, it certainly plays an important role in providing a safety net and in consumption smoothening.

Poverty status of the beneficiaries' households

Poverty situation of the households is discussed under three poverty indicators: poverty incidence (p_0), poverty

Table 1. Distribution of beneficiaries by age.

Age (years)	Frequency	Percentage
20 - 35	56	35
36 - 50	84	53
51 - 65	17	11
66 - 80	3	1
Total	160	100

Table 2. Distribution of beneficiaries by household size.

Family size	Frequency	Percentage
1 - 10	130	81.25
11 - 20	26	16.25
21 - 30	4	2.50
30 and above	0	0.00

Table 3. Years of experience of the beneficiaries.

Experience	Frequency	Percentage
0 - 5	5	3.13
6 - 10	28	17.50
11 - 15	53	33.13
16 - 20	36	22.50
21 - 25	14	8.75
> 25	24	15.00
Total	160	100.00

Table 4. Distribution of beneficiaries by level of education.

Education level	Frequency	Percentage
Bachelor Degree/Higher National Diploma	5	3.13
Diploma/National Certificate of Education	20	12.50
Secondary education	34	21.25
Primary education	42	26.25
Arabic/Islamic education	59	36.88
Total	160	100

Table 5. Distribution of beneficiaries by their occupation.

Occupation	Frequency	%
Farming	64	40.00
Trading	1	0.63
Civil service	1	0.63
Farming and trading	48	30.00
Farming and civil service	37	23.12
Farming	9	5.62
Total	160	100

Table 6. Distribution of beneficiaries by mean per capita income before and after the intervention.

Mean per capita income (₦)	Frequency	Percentage
Before		
1333 - 41110	97	60.62
41111 - 80889	36	22.50
80890 - 120668	17	10.63
120669 - 60447	2	1.25
160448 - 00225	7	4.38
200226 - 40000	1	0.63
MPCHHINC*	₦ 47489.19	
After		
5000 - 153278	121	75.63
155279 - 300556	24	15.00
300557 - 455834	8	5.00
455835 - 606112	6	3.75
≥ 606113	1	0.63
MPCHHINC*	₦ 115678.00	

*Mean per capita household income.

Table 7. FGT poverty analysis and interventions impact.

Respondent type	Before			After			Percentage relative change		
	p_0	p_1	p_2	P_o	P_1	p_2	P_0	P_1	P_2
Rima	0.53	0.28	0.18	0.47	0.20	0.12	-11.76	-28.57	-33.33

depth (p_1), and poverty severity (p_2). These classifications are in line with the observations of Jenkins and Lambert (1997) that every poverty measure should be expressed as a function of the FGT three poverty indicators, showing the incidence, the intensity and the inequality among the people. The result of the FGT poverty index analysis is presented in Table 7. The result of the poverty incidence shows that 53% of the beneficiaries' households were poor before the Rima microfinance intervention and the incidence reduces 47% after benefiting from Rima microfinance credit facility. This could be translated to percentage change of the poverty incidence relative to the baseline to a reduction of 11.76 %. The FGT poverty depth index further shows the poor beneficiaries' households require an income transfer of 20% to lift to the poverty line, as against 28% that was required before the Rima microfinance intervention. The poverty severity index further shows that the beneficiaries had a poverty severity of 0.18 before and 0.12 after the Rima Microfinance intervention.

Poverty incidence

Poverty profile of the beneficiaries

The distribution of the poverty profile of the beneficiaries' households before and after the microfinance intervention is as shown in Figure 1.

Figure 1 shows that the result shows that 44.4, 27.5 and 28.1% of the beneficiaries were non-poor, moderately poor and core-poor, respectively before the intervention. However, after benefiting from the Rima microfinance credit facility, the result revealed that more than half (precisely 53.13%) were found to be non-poor while 25.62 and 21.25% were moderately poor and core-poor, respectively. The result revealed that Rima microfinance Bank increased the number of non-poor beneficiaries by 8.8% (from 44.4% before the intervention to 53.1% thereafter) and decreased the number of core-poor beneficiaries by 6.9% (from 28.1% before the intervention to 21.3% thereafter).

The finding implies that Rima microfinance had fairly assisted in minimizing the poverty situation of the beneficiaries' households in the study area. This finding agrees with the observations of Harper (2005); Ike (2012) and Okafor (2016) that, despite the short comings, microfinance remains one of the most valuable instruments for alleviating poverty among rural people. The findings of this study substantiates that Microfinance have proven to be an effective tool for poverty reduction, t as reported by Jegede et al. (2011), Harper (2005), Ike (2012), Oluyole (2012) and Okonkwo et al. (2015).

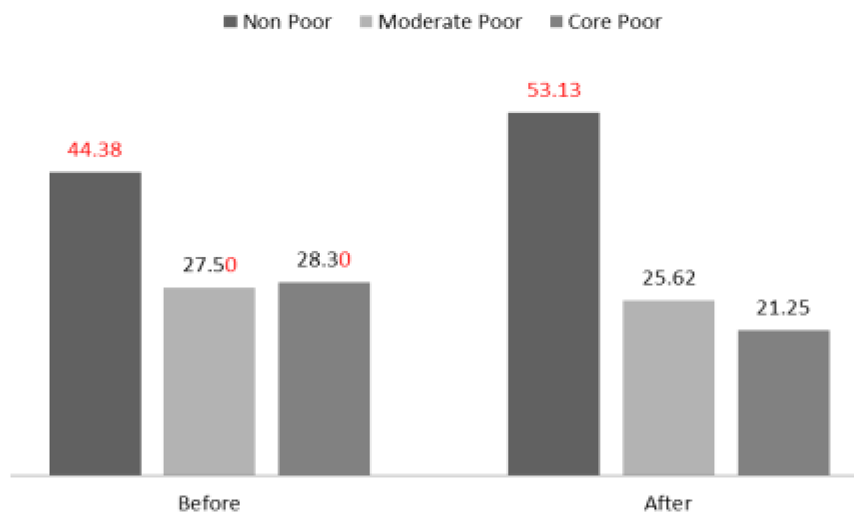

Figure 1. Poverty profile of beneficiaries.

Table 8. Distribution of respondents' perception on Rima Microfinance Bank.

Perception question	Likert scaling					
	SA	A	U	D	SD	Mean
Credit assisted you in meeting your farms demand	79 (49.69)	80 (50.31)	2 (0.63)	0 (0.00)	0 (0.00)	4.49 (0.506)
The credit intervention improved your living standard	71 (44.65)	84 (52.83)	4 (2.52)	0 (0.00)	0 (0.00)	4.42 (0,5441)
Your income increase as a result of the credit intervention	75 (46.37)	69 (43.67)	14 (8.86)	0 (0.00)	0 (0.00)	4.39 (0.6457)
The RMFB made significant effort in providing credit facility to households in the area	-	-	-	0 (0.00)	0 (0.00)	4.38 (0.6529)
The RMFB has recorded success in the area	76 (47.80)	60 (37.74)	23 (14.47)	0 (0.00)	0 (0.00)	4.33 (0.7175
Poor farming households have benefited from the credit	64 (40.00)	75 (46.88)	18 (11.25)	3 (1.88)	0 (0.00)	4.25 (0.7268)
The approach used for the poor farming households to benefit is not efficient enough	0 (0.00)	71 (44.38)	40 (25.00)	46 (28.75)	3 (1.88)	3.12 (0.8928)
RMFB officials are kind and tolerant	73 (45.63)	55 (34.38)	32 (20.00)	0 (0.00)	0 (0.00)	4.26 (0.7709)
The Monitoring methods of RMFB is inefficient	0 (0.00)	76 (47.50)	37 (23.13)	45 (28.13)	2 (1.25)	3.17 (0.8847)
The RMFB has sufficiently addressed the farming credit needs of households	78 (48.75)	67 (41.88)	14 (8.75)	1 (0.63)	0 (0.00)	4.39 (0.6728)

Perception of the beneficiaries on Rima Microfinance Bank intervention

The result (Table 8) of the study shows that 99% of the beneficiaries agreed that the policy interventions had assisted them in meeting their farming demands. Over 80% of the respondents further opined that the project had recorded success in addressing the farming needs of farming households in the study area. They stressed that this had enabled them to purchase the required inputs, such as improved variety of seeds, fertilizer, and pesticides, for their farming activities.

Values in parenthesis are percentage

Perceptions of the beneficiaries on the approach and monitoring methods used by Rima microfinance in implementing its objectives shows that the follow-up and monitoring visits methods were not regular and perceived to be inefficient. However, only 28% of the beneficiaries claimed that the follow up approach and monitoring visits by Rima microfinance official were efficient. To cap it up, almost all (93%) the beneficiaries reported that the intervention had made an appreciable effort at ensuring the participation of farming households in the study area. They further confided that the Bank's staffs were kind, understanding and tolerant.

Conclusion

The study examined the impact of Rima Microfinance intervention on income and poverty status of beneficiaries. The study used household level survey and adopted 'before and after' approach rather than the use of control and treatment groups, that is comparing the income and poverty status before the microfinance intervention and the current situation. The intervention results to a change in the mean per capita income increased from ₦47,489.19 to ₦115,678 after enjoying the Rima microfinance credit facility. The results of the poverty indices revealed that the intervention reduced poverty incidence by 6%; resulting to relative change in the incidence of 11.76%, the depth and severity of poverty among the poor beneficiary decreased by a relative change of -28.57 and -33.33 % respectively. The perception assessments by beneficiaries show that they agreed Rima micro-financing assisted them in meeting their farming demands, increased their income and improved their standards of living. The study recommends that government should establish agricultural policy that will ease access to finance through microfinance banks as well as ensure efficient utilisation of such loans on agriculture, through timely monitoring so as to enhance productivity, income and invariably reduction in poverty among rural dwellers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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