Socioeconomic characterization and the agronomic practices that affect the use of pineapple waste to enhance soil fertility in Kayunga District, Uganda

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Abstract: Soil exhaustion and nutrient depletion are major constraints to pineapple farming in Uganda. This study explored potential for using on-farm waste from pineapple farming to conserve soil fertility and enhance agricultural productivity. Data collection was done using key informant interviews, focus group discussions, and a semi structured survey questionnaire administered to 109 randomly selected pineapple farmers and processors. The data was analyzed in SPSS to generate descriptive statistics for selected variables followed by cross tabulation to explore linkages between the variables. Results indicate that farmers engaged in pineapple farming, have diverse socioeconomic backgrounds but activities engaged in are not significantly associated with socioeconomic variables examined except farming experience and gender. The major challenges faced by the farmers included soil exhaustion, lack of appropriate technologies, inappropriate pineapple waste management and decline in yield. It was noted that strategies used by farmers employing use of on-farm waste have not yielded significant contribution and as such farmers resort to use of off-farm manure which is expensive and increasingly hard to secure. It was recommended that a sustainable technology harnessing the abundant but underutilized on-farm biomass waste be developed to produce a highly nutrient-rich soil conditioner to enhance pineapple yield and as such empower the farmers.

Keywords: pineapple waste, nutrient depletion, manure, soil fertility, fertilisers, yields

Citation: Zziwa, A., K. R. Kyeyune, K. Allan, K. Nicholas, M. G. John, and K. Florence. 2017. Socioeconomic characterization and the agronomic practices that affect the use of pineapple waste to enhance soil fertility in Kayunga District, Uganda. Agricultural Engineering International: CIGR Journal, 19(2): 12–21.

1 Introduction

Agriculture continues to play a significant role in the economic development of Uganda contributing 22.6% to national GDP while 72% of the working population is employed in the agricultural sector and 43.3% of the workforce is engaged in subsistence agricultural production (UBOS, 2007). There has been tremendous interest and increase in horticultural crop production in Uganda with the horticulture subsector envisaged to support rural development, poverty reduction and increased foreign exchange earnings. Pineapples in particular are among the fruits that have been selected for export diversification and enhancement of household incomes but Uganda is still unable to produce enough pineapples to meet the export demand (Bonabana-Wabbi et al., 2013; Chongtham et al., 2010). Total production of pineapples in Uganda is estimated at 3,265 tonnes per annum (FAOSTAT, 2009). However, according to EATH (2013), FAOSTAT data significantly understates Uganda's actual production. Pineapples are mainly grown

Received date: 2016-06-29 **Accepted date:** 2016-12-16

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south of Lake Kyoga and in western Uganda (Bua et al., 2013; Muyanja and Turyagyenda, 2006). In Kayunga, the main pineapple growing area in the country, pineapples are the main income generating enterprise for many farmers (Kiggundu et al., 2014). A study conducted by Baseke (2009) in Kayunga district demonstrated that pineapple production is profitable and can enhance incomes among rural households. However, it should be noted that pineapple farming in Uganda just like in other developing countries is linked with soil nutrient depletion (Conley and Udry, 2010; Nalubwama et al., 2014). Consequently, pineapple yields fluctuate, making it difficult for the farmers to get sustainable incomes from their farming efforts. This is worsened by limited entrepreneurial capacity of farmers to utilize abundant agricultural wastes on their farms.

Furthermore, soil degradation is widespread in Uganda mainly due to loss of soil nutrients from fields with no or minimal replenishment (Mubiru et al., 2007). Nutrient depletion in Uganda is estimated at 66 kg ha^{-1} per annum (Omotayo and Chukwuka, 2009; Nkonya et al., 2005). Consequently, farmers obtain low crop yields and sometimes experience crop failure. Findings by Kwikiriza et al. (2016) indicated that soil amendments used by pineapple farmers such as coffee husks and livestock manure are prohibitively costly to most farmers because in addition to paying for the materials, farmers have to incur additional costs to transport the bulk materials to their farms. It is well-documented that limited use of soil amendments leads to declining soil fertility, which is highly linked to the shorter life span of the pineapple crop to less than four years. Attempts to use land fallowing and on-farm animal manure have yielded minimal results due to the large manure volumes required to meet the necessary nutrient demand. However, in many parts of the country, particularly pineapple growing areas, biomass wastes are available in large quantities but are currently underutilized or discarded (Komakech et al., 2014). Moreover, these wastes contain vital crop nutrients which if exploited have a potential of increasing crop yields (Lleó et al., 2013). Therefore, this paper set out to explore the potential for use of pineapple waste for enhancement of soil fertility among small-holder pineapple growers in Uganda. The paper seeks to establish the socioeconomic background and existing practices of the target communities; explore existing initiatives in support of soil conservation; and to determine the factors that influence uptake and use of compost technologies for soil conservation.

2 Methods

Primary data was collected using key informant interviews, focus group discussions and a survey questionnaire. A preliminary survey with purposively selected stakeholders from Kangulumira sub-country located in central Uganda was conducted to pre-test the questionnaire. This was followed by interviews with 109 randomly selected pineapple farmers and processors using a refined questionnaire in the same area. The interviews were conducted from November to December 2015. The questionnaires were checked for completeness and consistency, open responses coded and thereafter data were entered in SPSS (Version 16) for analysis. Descriptive statistics for key variables were used to summarize the data and cross-tabulations used to explore the association between variables. Desk review of extant literature and secondary data were conducted to corroborate and contextualize primary data with a focus on factors that affect the demand for and ability to invest in composting of pineapple waste for soil conservation.

3 Results and discussion

3.1 Socioeconomic characteristics of respondents

Majority (67.9%) of respondents indicated that they engage in pineapple farming while processing of pineapples had the least percentage of respondents. About 20% of the respondents engage in both, farming and processing. Most of the respondents were males aged between 30 and 50 years and are married. About 25% of the respondents are aged below 30 years, pointing to active engagement of youth in pineapple farming and processing. However, with regard to formal education, majority (60.6%) of respondents have only received primary level education. Most of the respondents have appreciable pineapple farming experience with over 70% of them having more than ten years of engagement.

Family size is generally large with majority of families (66.1%) having between five to 10 members (Table 1). This implies availability of labor in the district.

Table 1 Socioeconomic characteristics of respondents

Variable	Percentage response (*n*=109)
Respondent Category	
Farmer	67.9
Farmer and Processor	20.2
Processor	11.9
Gender	
Male	67.9
Female	32.1
Marital status	
Married	81.7
Not Married	18.3
Age Category (years)	
Below 30	25.0
30 to below 50	49.1
50 and above	25.9
Years of Formal Schooling	
0-7	60.6
8-12	31.2
>12	8.2
Years of Farming	
<10	29.4
10- <30	58.7
>30	11.9
Household size	
<5	18.3
5-10	66.1
>10	15.6

To examine whether respondent categories were associated with other socioeconomic variables, the former was cross-tabulated with other socioeconomic variables. Results indicated that there was a significant association between respondent category and gender as well as years of farming only. Majority (78.4%) of respondents in the farmer category are male while females are dominant (76.9%) among the processor category. On the other hand, respondents with 10-30 years farming experience dominated the farmer and farmer/processor categories while processing was dominated by respondents with less than a decade of farming experience.

3.2 Group membership dynamics

Majority of respondents have membership in farmer groups but most of them have been in these groups for less than five years. The groups were formed primarily for promoting value addition and marketing, agricultural production, and for savings and credit services to their membership. Respondents indicated that the groups benefited them through marketing of their produce, acquisition of farming skills, savings and credit services and access to inputs. Respondents who did not belong to farmer groups cited lack of awareness and interest as the major reason preventing them from seeking group membership (Table 2).

Table 2 Membership to farmer groups

Variable	Percentage response (*n*=109)
Member to Farmer Group	
Yes	61.5
No	38.5
Period in Group (years)	
<5	55.2
5-10	31.4
>10	13.4
Major Group Function	
Value Addition and Marketing	43.8
Agricultural Production	21.9
Savings and Credit	14.0
Others	20.3
Benefits to Farmer	
Marketing	35.4
Skills Acquisition	24.6
Savings and Credit	16.9
Access to Inputs	7.7
Others	15.4

Cross-tabulation between group membership and socioeconomic variables indicated a significant association between group membership and education level as well as category of respondent only. While majority of respondents in all education level categories belonged to farmer groups, the proportion of respondents who are members increased from 54.5% in the lower education level category to 100% in the higher education level category. Similarly, majority of respondents in the farmer category (55.4%) a to farmer groups while over 92% of respondents in the other categories have membership to farmer groups. Cross-tabulation of period in group with socioeconomic variables confirms the expectation that older and more experienced respondents are associated with more years of group membership.

3.3 Cropping system

Majority of respondents owned up to one hectare of land with less than 14% owning more than two hectares. Consequently, majority of respondents hire land but most of them hire one hectare or less (Table 3). Farmers use

this land for both crop and livestock production. Pineapple farmers with relatively large pieces of land (>two hectares) allocate up to 70% of their land to pineapples and the rest is used for food crops. On the other hand, farmers with smaller pieces of land allocate only a small area of their land to growing of pineapples. The major crops grown for both food and cash generation include pineapples, banana, maize and beans (Table 4). Pineapples were ranked as the major cash crop but also feature among food crops while bananas were ranked as the major food crop and the number two cash crop. Other crops grown include maize, beans, coffee, and tomatoes. Most farmers keep livestock, mainly goats, cattle, poultry and pigs (Table 3).

Table 3 Pineapple cropping system

Variable	Percentage response (*n*=109)
Farmland owned (acres)	
0	16.5
>0-2.5	41.8
>2.5-5.0	28.1
>5.0	13.6
Farmland hired (acres)	
0	44.1
>0-2.5	42.2
>2.5	13.7
Major Livestock kept	
Goats	33.9
Cattle	27.5
Poultry	11.0
Others	27.6
Major reason for keeping Livestock	
Income	81.2
Food	18.2
Use of livestock waste	
Manure	92.2
Throw or give away	7.8

Table 4 Ranking of major crops grown

Crop	Rank as cash crop	Rank as food crop
Pineapples	1st	4th
Bananas	2nd	1st
Maize	3rd	3rd
Beans	4th	2nd

The livestock is mainly kept as a source of income and food but is also a source of manure which is critical to the success of pineapple farming enterprises and is also used in vegetable fields for soil fertility enhancement (Table 3). Cross-tabulation of owned with hired land size indicates that there is a significant association between the two Respondents without their own land dominate those who hire land with 88.3% hiring compared to 59.5% for those owning up to one hectare, 41.4% for those owning one to two hectares and only 35.7% for those owning more than two hectares. However, those owning land were dominant among those who hired relatively larger land pieces, particularly those owning up to two hectares, an indication of the fact that they are relatively large scale pineapple growers. There was no significant association between land size owned or hired with socioeconomic variables.

3.4 Pineapple production practices

Majority of respondents (89%) participate in pineapple growing with a major aim of income generation. Most of these farmers have been involved in pineapple growing for more than 20 years but an appreciable percentage (25.8%) is relatively new to pineapple farming enterprise having joined in the last five years (Table 5). Participation in pineapple growing was significantly associated with gender, age, farming experience, and membership to a farmer group. About 73.2% of respondents participating were male while 75.0% of those not participating were female. Similarly, majority (53.1%) of those participating was in the age category 30-50 years while majority (58.3%) of those not participating were below 30 years of age, indicating that the youth are not highly attracted to and involved in pineapple growing enterprise. Conversely, majority of respondents (64.9%) who participated in pineapple growing had a farming experience of 10-30 years while majority (83.3%) of those who did not participate had less than 10 years of farming experience.

The pineapple farm size for majority of respondents ranges between one to two acres (Table 5). The size of pineapple garden is a significantly associated with pineapple farming experience and land size (both owned and hired). Majority of respondents (50%) with less than an acre of pineapples had a farming experience of less than five years while majority (80%) of respondents with more than two acres had a farming experience for pineapples of 10-20 years. Similarly, majority (74.1%) of respondents who had less than an acre of pineapples did not hire any land while majority (50%) of respondents

who had more than two acres of pineapples did hire one or more hectares of land. The major input used other than the seed include organic and inorganic fertilizers and hired labor (Table 4). A section of farmers believe that it is impossible to successfully grow pineapples without the use of inorganic chemicals and as such use inorganic fertilizers and herbicides but others believe that it is possible to do organic farming if manure is used. Chongtham et al. (2010) reported that Ugandan organic fruit farmers participate in organic fruit production schemes because they have appreciated the fact that it is appropriate for the environment. It was reported by several respondents that organic growing of pineapples is a necessity for farmers who intend to add value through drying of pineapples because most of the dried pineapples are exported to markets that require organically certified products (Jumba and Freyer, 2016).

Table 5 Participation, inputs and challenges in pineapple growing

Variable	Percentage response (*n*=109)
Participation in pineapple growing	
Yes	89.0
No	11.0
Major reason for pineapple growing	
Income generation	99.0
Other	1.0
Area of pineapple garden (acres)	
<1.0	12.1
1.0-2.0	72.7
>2.0	15.2
Experience in pineapple farming (years)	
<5.0	25.8
5.0-<10.0	21.6
10.0-<20.0	38.2
>20.0	14.4
Major inputs (other than seed)	
Organic fertilisers	56.8
Inorganic inputs	34.7
Hired labor	8.5
Main source of planting materials	
Fellow farmers	49.3
Own saved seed	41.4
Market	9.3
Challenges in accessing planting materials	
Availability of planting materials	52.2
Inferior planting materials	27.8
High transport costs	20.0

Planting materials are mainly obtained from own saved seed and from fellow farmers. The major challenges faced in acquisition of planting material include their scarcity and poor quality. Farmers indicated that they categories planting materials into two, good and bad quality. It was reported by several respondents that the poor quality cultivars have very poor “secondary” yields. However, respondents expressed difficulty in distinguishing between the two from visual inspection of suckers only; those able to make the distinction can only do so from the crop in the field. A typical pineapple production cycle involves land preparation usually with a tractor followed by planting suckers that are either purchased at USD 0.02-0.05 each or obtained from fellow farmers or own seed. Each acre requires about 10,000 suckers implying that planting material can cost between USD 200-500 per acre. Coffee husks are applied three months after planting to enhance soil fertility because before that the pineapple would not have developed roots. Most of the pineapple growers intercrop with bananas and these provide an extra source of income during the production cycle. It takes between 18-24 months to make the first harvest depending on how well the pineapples were tended; subsequent harvests are done at seven-month intervals up to seven years by which time the soil would be exhausted. The first harvest is always the most productive but yields decline considerably after five years although bananas continue to provide yields up to the end of the seven-year production cycle. The land is then given a two-year fallow period, before it is replanted with pineapples.

3.5 Access to information and training services

Pineapple farmers obtain information mainly from fellow farmers and farmer groups. Majority of farmers (57.8%) participate in training organized by extension workers, buyer of processed pineapples, and farmer groups. Training normally focuses on agronomic practices and postharvest handling. Respondents who have not participated in training cite lack of awareness or interest as the major cause (Table 6). Participation in training on pineapple growing is significantly associated with group membership and respondent category. Respondents with membership to groups were majority (77.8%) among those who received training while those who do not belong to groups were dominant (73.8%)

among respondents who do not receive training on growing of pineapples. Similarly, respondents in the "farmer and processor" category had majority (90.9%) of respondents who received training while respondents in the farmer category were majority (80.4%) among respondents who did not receive training on pineapple growing.

Generally, pineapple farmers have limited access to agricultural extension services at the grass root level. Consequently, extension services including information provision are provided though non-traditional sources including farmers' associations, research institutions and trading companies that buy farmers' pineapples. Respondents indicated that it is through these sources that they have been able to receive training on pineapple agronomic practices and manure compositing from pineapple wastes (Medina and Garcia, 2005). Generally, information flow is poor and the availability of this information to the local farmer is low. Respondents indicated that extension agents focus work only at district level resulting in services not being received at the grass root level because most farmers don't get a chance of getting involved. Thus there is heavy dependence on non-technical community extension workers that are trained by private organizations.

Table 6 Access to information and services

Variable	Percentage response
Sources of information	
Fellow farmers	53.5
Farmer group	23.6
Fruits of the Nile	13.9
Extension workers	7.6
Mass media	1.4
Participation in training on growing	
Yes	57.8
No	42.2
Training provider	
Extension workers	29.5
Fruits of the Nile	27.9
Farmer group	23.0
Fellow farmers	13.1
Don't know	6.5
Focus of training	
Agronomic practices	63.9
Post harvest handling	20.8
Other	15.3

3.6 Constraints and coping strategies

The major constraint faced by pineapple farmers is access to organic mulches/fertilizers (Table 7). Respondents indicated that land has become so infertile making it infeasible to grow pineapples without the use fertilizers. Organic fertilizers such as coffee husks and chicken litter are the preferred option due to their long term effect (Omotayo and Chukwuka, 2009); but they are quite scarce and expensive with an acre requiring USD 441 on average. However, the cost and quantity per acre of coffee husks varied widely among farm farmers, pointing to a need to guide farmers with regard to the amount of fertilizer applied per unit area to ensure profitability of pineapple farming enterprise (Baruwa, 2013; Larney et al., 2006). Coffee husks are more expensive and take long to produce results but serve for a longer period; on the other hand, chicken litter is relatively cheap and produces quick results but also serves for a short period. The other challenges include limited land for pineapple growing, soil infertility and inaccessibility to mechanization services (Table 7). Respondents indicated that the growing of pineapples requires a relatively large piece of land for one to benefit but such land is increasingly becoming difficult to secure. Consequently, several farmers are shifting to other areas to expand their pineapple growing enterprises.

Table 7 Constraints and challenges to pineapple production and processing

Variable	Percentage response
Constraints to pineapple production	
Access to organic mulches	39.1
Land shortage	22.4
Access to mechanisation services	13.5
Soil infertility	12.2
Others	12.8
Gender related constraints	
Yes	12.0
No	88.0
Land tenure challenges	
Yes	37.6
No	62.4

Both men and women participate freely in growing of pineapples much as men dominate. Limited engagement of women in farming was partly attributed to the fact that they do not own land making it hard to do the farming, which requires substantial sizes of land solely dedicated to pineapple farming for at least five years. Only 12% of the respondents indicated to be facing gender-related

constraints such as labor-intensive activities and the skin-damaging weeding operations. Similarly, about 38% of the respondents faced land tenure challenges such as bleach of land hire agreements, unfavorable terms of land hire, and possession of large chunks of land by a few people (Table 8). Pineapple farmers who hire land for farming indicated that they pay an average of USD 30 per acre per year upfront for up to seven years. However, some landlords, particularly the relatively young, are unscrupulous and want to disown the agreements prior to elapse of the rental agreements. To cope with these constraints, respondents indicated that they employ a range of strategies. Farmers who do not own sufficient land enter into agreements with land lords, witnessed and approved by the area Local Council Authorities. Other farmers have bought land in other areas at relatively cheaper rates for expansion of their pineapple growing activities.

3.7 Labor dynamics

Most of the labor used for pineapple production is provided by family members but hired labor makes a significant contribution too. Family labor is dominant for sensitive tasks such as acquisition of planting materials. On the other hand, hired labor is mostly used for labor-intensive and demanding activities such as land clearing, planting and manure application. There is a wide variability in the labor charge rates for different activities among farmers. However, on average, if all farming activities other than harvesting were to be carried out using hired labor, a farmer would spend USD 500 per hectare to raise pineapples per season. Harvesting is excluded because it is a continuous activity once the pineapples have matured and normally paid for by the buyer as opposed to the farmer.

Table 8 Sources and cost of farm labor

Activity	Family labor, %			Hired labor, %	Hired labor Cost, $./acre
	Men	Women	Children		
Land clearing	38.1	4.2	3.1	54.6	40
Planting material acquisition	50.5	4.3	4.3	40.9	41
Planting	36.1	8.2	5.2	50.5	45
Weeding	42.3	14.4	3.1	40.2	22
Disease control	55.6	4.8	4.7	34.9	12
Manure application	35.1	7.4	1.1	56.4	50
Harvesting	52.5	2.5	2.5	42.5	12

3.8 Soil conservation and productivity

Majority of farmers use coffee husks to enhance soil productivity; since these are generated off-farm, they are a major constraint. An appreciable percentage of farmers use crop rotation while a small section makes use of inorganic inputs as a remedy. Fewer farmers make use of on-farm waste including pineapple and livestock waste to enhance productivity of their farms, most of them preferring to use coffee husks. The animal waste includes dung and droppings, but these are also limited to a few farms engaged in animal husbandry. Less than 10% of the respondents have heard about vermi-composting (Table 9), a technology that has the potential of converting on-farm waste to high-value organic fertilizers. However, they were optimistic when the idea was explained to them because the options being used at the moment are relatively expensive.

Table 9 Measures to improve productivity and production

Variable	Percentage response
Productivity enhancement measures	
Use of coffee husks	45.5
Crop rotation	29.3
Use of on-farm waste	17.3
Use of inorganic fertilizers	7.9
Knowledge of vermi-compositing	
Yes	9.2
No	90.8
Suggestions to improve pineapple production	
Yes	67.0
No	33.0

3.9 Existing manure technologies

Manure is critical to success of pineapple farming activities. Farmers perceive pineapples to be a booming business and highly profitable but constrained by declining soil fertility. While soils are well-suited to pineapple growing and there is a ready market for fresh pineapples, it is no longer feasible to grow pineapples without extensive use of organic manures. Currently, farmers use coffee husks as the major manure for their gardens; other alternatives include chicken litter and on-farm wastes from their crop and livestock enterprises. Coffee husks are preferred to other manure such as chicken litter because of their long-term effect (Nguyen et al., 2013). Information from farmers indicates that while coffee husks take long for their effect to become evident,

they continue to release nutrients over a longer period of time compared to chicken litter whose effects become evident over a long period of time but release nutrients over a shorter term. Other alternatives such as on-farm manure do not seem to make a significant contribution towards enhancing soil fertility (Gale et al., 2006). This can be attributed to the quantity of manure applied per unit area. Apparently, farmers do not seem to have a definite manure application rate, making specification in terms of number of vehicles/trucks per unit area. What appears to be certain is that this level of manure volume is quite difficult to sustainably generate on-farm without a dedicated manure production system. Vermi-composting technology is one such a possibility with potential to remedy the situation (Garg et al., 2006); although majority of farmers are not aware of the technology.

3.10 Factors affecting uptake of existing technologies

As articulated above, farmers have no choice with regard to the use of organic manures for growing pineapples. However, two key issues seem to inform their choice of manure to use namely: availability of bulk quantities and ability to provide long term effect. Farmers use a considerable amount of manure per unit area which can be attributed to the long production cycle for pineapples. Farmers need fertilizers that can release nutrients slowly over a long period of time that matches the production cycle of pineapples which is about five years. This partly explains farmers' preference of coffee husks over chicken litter; as farmers indicated, the former takes long to provide results but has long term effect while the later has an almost instant effect but also depletes very fast. This is a factor to which attention has to be paid as alternative manures are explored. The other aspect that came up as a challenge for the farmers is the cost associated with these manures. This is in agreement with findings of Chongtham et al. (2010) who indicated that 50% of farmers interested in pineapple growing could not afford to buy coffee husks making soil amendments the most important constraint for growing pineapple. Owing to their scarcity and quantity applied per unit area, the cost of manures in current use is relatively high. Farmers indicated that the cost per hectare can range between USD 364 and 455 per acre during the year of establishment which is relatively high for a rural farmer.

3.11 Entrepreneurial capacity of surveyed farmers

Entrepreneurial capacity can be defined as the ability and willingness to envisage, plan and execute an innovation process resulting in a sustainable value-creating outcome (Kurniati, 2015). According to Gibb (2007), entrepreneurship is defined in terms of sets of behaviors, attributes and skills that allow individuals and groups to create change and innovation. It entails developing, organizing and managing a business venture along with associated risks in order to make a profit. In this regard, the surveyed community in Kangulumira area can be objectively judged to have a certain level of entrepreneurial capacity because over the past three or more decades, the community identified pineapple growing as a viable enterprise for the area and they have successfully carried out this activity. However, successful entrepreneurship necessitates continuous change with the ever changing and complex business environment. This study reveals that continuous change and innovation are still missing links in the pineapple production enterprise. Farmers have attempted to innovate with regard to the challenge of declining soil fertility but there is still a lot that needs to be done, particularly with regard to soil conservation. Building the entrepreneurial capacity will require behavior change and this cannot occur overnight; specific attention needs to be paid to willingness of farmers to cooperate with each other in an effort to overcome the barriers that stand between them and better benefits from their pineapple farming enterprises.

4 Conclusions

Farmers engaged in pineapple farming have diverse socioeconomic backgrounds typical of a rural setting including male dominance, low education level and large family size. Pineapple growing and processing is mostly carried out by small scale entrepreneurs with most of them focusing on farming. Farming is perceived to be profitable but also costly. Soil conservation practices include use of organic manures and crop rotation. The major factors influencing uptake of new technologies include scale of operation, availability of capital and

perception of the ability of the technology to overcome current challenges. Proposed interventions to enhance agricultural productivity among smallholder farmers in the study area should pay attention to the socioeconomic diversity in the area. Initiatives to support pineapple farming enterprises are necessary to overcome challenges faced by entrepreneurs and enhance profitability of these enterprises. Existing initiatives in support of post-harvest processing have unacceptable weaknesses that need to be addressed through improved and optimized solar dryer designs to improve performance. Alternative options to existing organic manures need to be explored because of the high cost and relatively large volumes required. The proposed options should however take into account desirable characteristics of existing technology. However, new technologies developed should be able to overcome current challenges but also be cost-effective because availability of capital to acquire the technologies is a key factor influencing their adoption.

Acknowledgement

Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) is acknowledged for funding the study.

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