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Trends in livelihoods options over a five year period: A case of Murewa smallholder farmers

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Inter and intra seasonal trends in livelihoods options have been reported at country and rarely at ward level in Zimbabwe. Evidence based on local level trends in livelihoods options is rare. This study thus reviewed data on livelihoods activities based on the Agriculture Food Security Monitoring System (AFSMS) surveillance system. It was conducted by the Department of Crop and Livestock Production formerly Department of Agricultural Technical and Extension Services (AGRITEX) in four wards of Murewa District over 5 seasons from 2010 to 2014. It was done to document local trends in livelihoods options over time for improved food security. The review consulted AGRITEX records, secondary data from web and other public documents. The results showed that income generating activities and livelihoods options at local ward level fluctuate within the farming season and across seasons. However, contributing factors were not ascertained in this study. Casual labour and market gardening were major sources of livelihoods in the wards under study in contrast to generalised extension reports which indicate crop production as a major livelihood option in the study district. The paper provides local level evidence on trends of livelihoods options and argues for diversified livelihoods coping strategies and adoption of extension messages that go beyond crop and livestock production to include other non–farm (off –farm) based livelihoods options such as brick moulding, arts and crafts.

Key words: Trends in livelihoods, socio-economic, extension, income generation, food security, local level.

INTRODUCTION

The sources of livelihoods in rural communities of Southern Africa are mainly agriculture-related and therefore have a bearing on the socioeconomic status of most developing countries (Speranza, 2010; Brown et al., 2012) including Zimbabwe. According to Kandlinkar and Risbey (2000) more than 60% of the population in Sub-Saharan Africa is employed in agriculture with a contribution of 30% to the Gross Domestic Product. In Zimbabwe approximately 68% of the population in the country resides in the rural areas relying on agriculture for income, food security and general well-being of the household members (ZimStat, 2013). However, their livelihoods are threatened with risks associated with socio economic and environmental factors that need periodical monitoring to avoid disasters at national and household level. Socio-economic factors include the low

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returns from agricultural related income activities and the unfavourable economic environment that prevailed during the period 2000-2008, with the latter seriously eroding the purchasing power of rural communities (ZimStat, 2013).

The low agriculture-related incomes result in high poverty levels despite the fact that there is diversity in sources of income and food in rural livelihoods. The income generating activities that rural communities are involved in can either be on farm or off farm. On farm activities include crop sales either cash or food, livestock sales, horticultural sales and non-farm activities include thatching, mining, crafts, wild fruit sales and brick moulding (Alobo, 2016; ZimVac, 2014). These activities directly and indirectly contribute to income generation and food security by making food more accessible and affordable.

Food security analysis has always focused on determining the household’s situation of meeting the 210 kilocalories/person/day by looking at the four pillars; food availability, food access, food utilization and stability (ZimVac, 2017). This can be done using a number of tools depending on set objectives. For instance in Zimbabwe surveillance or food assessment tools can be used. In the case of Zimbabwe, surveillance or assessment is carried out by a consortium of organizations working under the Zimbabwe Vulnerability Assessment Committee carry out the assessment annually. Food security recommendations are then announced at national level. Unfortunately these rarely cascade to household level for household specific recommendations

Analysis has shown that in periods of food scarcity, affected households device coping strategies and in most cases they end up selling or consuming productive assets. Such coping strategies are categorized into stress, crisis and emergency livelihood coping strategies. Unfortunately, in most cases where such coping strategies involving the disposal of productive assets are implemented a households’ ability to recover is usually negatively affected (Scoones, 2009; CCDR, 2014). In some cases affected households resort to alternate livelihoods options which are usually not supported by existing agricultural extension services.

In 2018, the proportion of households adopting livelihood based coping strategies was 37% whilst 63% were not adopting coping strategies at country level (ZimVac, 2018). According to the same report, Mashonaland East province had the highest proportion of households in rural areas engaged in livelihood based coping strategies. Of these households, 16% are engaged in emergency livelihood based coping strategies; as such Mashonaland East province was targeted for this study. It is with this background that this paper seeks to analyse the trends in livelihoods options to enhance extension programming as agricultural extension is one of government’s support systems. The main objective of the study is to review the trends in livelihoods based options in the wards under study over a five year period (2010-2014) in Murewa district of Mashonaland East province targeting households at local level. The study reviewed data from the food surveillance system of the Department of Agricultural Technical and Extension Services (AGRITEX) 2010-2014, which had relatively consistent datasets on livelihoods in order to provide evidence on trends in livelihoods at local level.

**Institutional setting**

The Department of Crop and Livestock Production (AGRITEX) is mandated to provide technical and advisory services, to disseminate technologies and to provide market-oriented extension for sustainable farming and to ensure agricultural development in Zimbabwe (Ministry Strategic Plan, AGRITEX Vision and Statement) (AGRITEX, 2009). The department achieves its mandate through a number of extension approaches operated by different branches. One of the activities used to inform stakeholders on food security issues is carried out by the Crop Production Branch through its Food Security Surveillance System (FSSS), which has been in existence since the late 1990s. The system was set up to provide early warning information on the food security situation during a marketing year thereby assisting policy makers with information for timely decision making. Overall, the system attempts to monitor the livelihoods of rural communities particularly the impact of both government and partner agricultural interventions in addressing the challenges faced by the communities. The FSSS involves data collection by ward-based Officers in all wards of the country through questionnaires. Responses are subsequently submitted through the different levels within the organization (ward, district, provincial) for final compilation at national level. However, it needs to be highlighted that at each level, the analysis of data is recommended as a means of building ownership and quick actions to ward, district, provincial-based challenges.

**METHODOLOGY**

**Description of study site- Murewa District**

Murewa District is one of the nine administrative districts in Mashonaland East province of Zimbabwe. (Figure 1)

The district has 30 wards. However, the Agriculture Food Security Monitoring System (AFSMS) was conducted in randomly selected wards which are; Wards 2 (Cheunje), 9 (Tsokoto), 15(Kadzere) and 19 (Mukarakate West). Murewa District in the former agro-ecological regions Ila, Iib and III and receives an average annual rainfall of 650-1000 mm thereby making it favourable for agricultural production of both field and horticultural crops (ZimVac, 2011).

The district has two livelihood zones; Highland Prime Communal
and Resettlement (HPCR) covering Wards 23 and 29 and Highveld Prime Communal (HVPC) covering the bulk of the district. For this paper, more emphasis will be on the HVPC zone in which all the four sites lie. The HVPC livelihood zone contains some of the most productive communal areas in the country. According to the ZimVac (2011), although in some cases the agricultural potential is affected by the high population density and poor soils.

The district’s proximity to the capital city Harare and access to the country’s main road infrastructure has greatly influenced the marketing of agricultural produce by households in the area. This paper is based on the review of data from the Agriculture Food Security Monitoring System (AFSMS) from 2010-2014 for four wards of Murewa district. It discusses the proportion of households engaged in different livelihood options; the sources of income and the related proportion contribution to household needs and makes appropriate extension recommendations.

The surveillance system

The Agriculture and Food Security Monitoring System (AFSMS) is a surveillance system implemented by the Crop Production Branch of AGRITEX since 2007 for the provision of periodic updates on the agriculture and food security situation through data collected on agriculture and food security indicators from 226 wards covering 57 districts of Zimbabwe. The sites were selected based on the agro-ecological regions, livelihood zones and food insecurity levels. The AFSMS has been implemented in collaboration with several organizations over the years which included; the Food and Agriculture Organization (2007-2014), Action contre la Faim (2007), Famine Early Warning Systems Network (2009-2011) and Caritas Zimbabwe (2011-2012).

Since its inception in 2007, the AFSMS has expanded to cover 57 districts by 2014 from just 12 districts in the inception year. Agricultural Extension Workers (AEWs) in each of the 226 wards collect data on agriculture and food security indicators during the first week of the scheduled month in all sites in order to compare information generated over space and time. Quality control is managed through the respective Agricultural Extension Supervisors (AES) and District Agricultural Extension Officers (DAE0). Data are collected using a focus group discussions guide at three – five sites within the ward to enable the intra - ward variability to be captured. The data from the sites within the ward is then averaged to give a ward picture. A copy of the completed questionnaire from each site is submitted to Head Office for data entry and analysis whilst three copies are kept as records at ward, district and provincial levels.

Through the AFSMS, the Crop Production Branch produces various reports during the marketing year as a means of providing updates on the country’s food security situation. The reports generated from the various data sets are shared with relevant stakeholders whilst the remaining data is filed with little reference for development at local level. It is this data that was reviewed and informed the arguments in this paper.

The desk study

A desk study was conducted to review secondary data stored as hard copies in files for the trend analysis and this was supported by in-depth interviews with key informants from Murewa District. The study randomly selected and reviewed 60 completed questionnaires of data representing responses from 60 farmers. The questionnaires used for the trend analysis were for the period 2010 to 2014 for the months February, June and October. The sections on livelihoods options and income generating projects were analysed in SPSS and in Excel for frequencies. Emerging narrative statements from responses were grouped into themes and merged in the data analysis. Data was presented graphically and in tables.

RESULTS AND DISCUSSION

Livelihoods options

Casual labour and market gardening were the dominant sources of livelihoods for the communities in the four selected wards during the review period (Table 1). Households engaged in these two livelihoods generally recorded a decline in 2013 and 2014. Households were mostly active in non-farm based livelihoods options such as general trading and brick moulding during the off peak farming season June to October. The marketing window for field crop sales is normally June to September, and therefore the proportion of households engaged in field crop sales was expected to reach a peak during June but was not consistent. The majority of households, 25 and 22% were engaged in crop sales during the June period in 2011 and 2012 respectively. This could be attributed to favourable production and economic environment that prevailed during that farming season (ZimVac, 2012).

The decline in the proportion of households reporting market gardening as a livelihood source may be attributed to climate variability resulting in low levels of water for irrigation. Whilst more than 40% of respondents were engaged in market gardening during the 3rd period (October report) of 2010, 2011; and 2012, only 31% and 26% of respondents were engaged in the same livelihoods option in 2013 and 2014, respectively. The findings are in line with ZimVAC assessments, which

Figure 1. Mashonaland East Province in Zimbabwe.
Table 1. Proportion of households by % in Murewa District engaged in livelihoods options 2010-2014.

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<td>Field crop</td>
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<td>3</td>
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<td>0</td>
<td>0</td>
<td>5</td>
<td>25</td>
<td>22</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>25</td>
<td>15</td>
<td>0</td>
<td>0</td>
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<td>Market gardening</td>
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<td>30</td>
<td>35</td>
<td>25</td>
<td>24</td>
<td>38</td>
<td>41</td>
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<td>33</td>
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<td>45</td>
<td>46</td>
<td>44</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>Poultry Keeping</td>
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<td>7</td>
<td>9</td>
<td>10</td>
<td>6</td>
<td>8</td>
<td>8</td>
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<td>7</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Small stock</td>
<td>0</td>
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<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>11</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
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<td>Casual labour</td>
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<td>45</td>
<td>40</td>
<td>41</td>
<td>41</td>
<td>51</td>
<td>48</td>
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<td>32</td>
<td>32</td>
<td>41</td>
<td>35</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>General trading</td>
<td>20</td>
<td>16</td>
<td>17</td>
<td>10</td>
<td>22</td>
<td>18</td>
<td>17</td>
<td>21</td>
<td>18</td>
<td>25</td>
<td>24</td>
<td>10</td>
<td>12</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>Brick moulding</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>14</td>
<td>10</td>
<td>19</td>
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indicate that generally, casual labour tends to be a major livelihood source especially among the poor households (Table 1). The few households involved in small stock production during the five year period are in tandem with previous ZimVac assessments. Access to and engagement in small livestock production is low in the study area yet this could provide an alternate source of livelihoods for farmers. There is limited diversity in livelihood options and with those available tending to be seasonal. Therefore, this has a bearing on coping and adaptation strategies of the households. Since there is limited income generating activities, poor households are deprived of other means of survival except hiring out labour.

The Zimbabwe National Nutrition Survey -ZNNS (2018) reported rural development challenges related to limited livelihood options. Nationally, the report shows that only 37% of households are engaged in at least one livelihoods coping strategy. Vulnerable households are mostly exposed to shocks and weather-related stresses especially when there are few livelihoods options at their disposal (Zake et al., 2010; ZNNS, 2018).

**Trends in income generation activities as a source of livelihoods**

Extension agents consider income generation activities as activities that the households carry out in order to obtain extra income besides field crop enterprises. However, most of these; market gardening; poultry keeping, and small stock production are closely linked to field crop production and are on farm related. This narrow definition confines extension staff to consider only agricultural-based activities in contrast to the broader definition provided by (UNESCO, 1993) which includes non- farm based activities. In this study other income generating activities which are non-farm related were considered and these include brick moulding, general trading. These activities are employed as livelihood-based coping strategies in view of the socio-economic and environmental challenges faced by the communities (Brown et al., 2012).

Market gardening and casual labour are the major income generating activities reported in the assessment period. It is interesting to note that the average income to a household differ from period to period and from year to year. Average monthly income in US dollars from market gardening was always high during June coinciding with the peak period for market gardening in communal areas. The same trend was observed for casual labour except in 2014, where an increase was noted during February. Variations in income sources and levels were observed across the five years. This could be linked to the production levels, which are affected by the variability in the rainfall (Brazier, 2017).

**Contribution of income generating activities to total annual income**

Market gardening followed by casual labour had the highest contribution to total household income over the five years (Figure 2), since they are also the major income generating activities. The contribution to total household income remained relatively high from the two sources in the 5-year period with a slight decline in 2011 and 2013. Probably the cash for paying for casual labour was derived from marketing of garden produce.
This may be an indication of the interdependency of these sources of income at community level. Crop sales have shown a general decline in the contribution to total income since 2011 whilst that of general trading (petty trading) has been on the increase for the same period.

For the period 2010-2014 market gardening and casual labour contributed between 20 to 40% of annual and household income. However in 2011 field crop production contributed 18% which was an increase in comparison with other years, but at the same time less than nationally reported contributions. According to ZimVac (2011), the contribution to the total income from crop sales for the poor and better off wealth groups at country level was reported at 19-22 and 47%, respectively.

**Major livelihoods contributing to household income**

The major livelihoods contributors to household income are market gardening and casual labour. Trends in average income sources at household levels for the survey periods are shown in Figures 2 and 3. According to ZimVac (2011), the average income generated by households during a marketing year ranged from USD100 to USD700 giving a monthly range of 8-58 USD depending on the wealth status of the farmer, for all periods under assessment. From the two major income generating activities over the study period monthly income ranged from 18 USD to 48USD, which was within the national range. The lowest income was obtained in June 2010 and October 2013, probably due to unfavourable socio economic and political environment.

**CONCLUSION AND RECOMMENDATIONS**

Diversity in sources of livelihoods fluctuates from season to season and differs from household to household. Although this review did not focus on the factors contributing to these fluctuations, it is suffice to conclude that the fluctuations are major points of concern for both farmers and extension personnel. Most extension recommendations are blanket and generic and do not take into consideration farmer's circumstances and also extension does not consider non-farm livelihood coping strategies. There is need to promote alternate coping strategies which are non-farm based such as crafts, moulding bricks, petty trading and other income generating activities.

During the 5-year period, most households reported market gardening and casual labour as the main income sources. The two income sources provided most of the income throughout the study periods (February, June and October) for the 5 year period. This could have been attributed to the direct linkages between market gardening and labour requirements. Besides field crop production, households depended on other non-farm sources of income that vary within and across farming seasons and also at various degrees of implementation. As a result this should be considered at farmer level planning and in extension programming.

Contribution of the various livelihoods options to average
household income fluctuated over the years with non-farm based livelihoods options on the increase. In addition, the reliance on income from on-farm activities exposes communities to challenges related to climate change as they fail to cope and adapt. Other income sources such as remittances were not captured in the review since the focus was on income generating activities in which households were directly involved. This review indicated the need for diversification in livelihoods options not only across seasons but also within a season to cope with the ever increasing challenges faced by rural communities.

The study results show that casual labour as a source of income persistently contributed to household income for rural communities of Murewa in Zimbabwe, during intra and inter seasonal analysis. Casual labour as a source of income and its contribution to household incomes was on the increase in the study period as such it can contribute to a certain extent to raising the standards of living of the poor. Availability of casual labour in turn increases crop and livestock productivity and incomes of the better off households who provide with work to be done and at the same time incomes of poor households hiring out labour are increased. On the other hand the study provided evidence on inter and intra seasonal trends in livelihoods options and challenges the current blanket extension messages for improved livelihoods.

The need for inclusion of extension advisory services that go beyond crop and livestock production cannot be overemphasised. As such the study recommends a shift in extension programming to include livelihoods coping strategies which are non-farm based. In this regard non-farm related livelihoods options such as brick moulding, petty trading, and arts and crafts can be included as alternate livelihoods options in extension programming. However, additional skills within the extension services as well as approaches that are multidisciplinary are needed. In view of the limited non-farm livelihoods options, extension service providers from different disciplines are recommended to work together and collaborate on provision of a basketful of livelihoods based coping strategies.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

REFERENCES


Figure 3. Average income from market gardening and casual labour for the 5 year period.
Effects of soil organic resource management practices on crop productivity and household income in Chipata district of Zambia

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Received 9 September, 2020; Accepted 9 November, 2020

Soil organic resource management practices such as use of green manure, cover crops, improved fallows, mulch, animal manure, compost and residue retention are options that promote the environment and potentially increase farmer crop yields and income. However, there have been low levels of adoption of most of these practices, and their ability to improve crop yields and farmer income has come into question. The objective of this study was to estimate the effects of the aforementioned practices on maize yields and income in Chipata district of Zambia. Using Matching algorithm strategies on data from 303 households, the study observed that only cover crops and improved fallows, significantly increased maize productivity by 16 - 21 and 22 - 31%, respectively. Only green manure and improved fallows increased household income by 26 - 28 and 48 - 67%, respectively. Since green manure did not show any significant influence on the production of maize, this latter result could imply that the practice is expressing its significant effect on household income through cash crops such as cotton, soybean, tobacco and vegetables, which are common in the study area. The non-significance in the contribution of most of the practices to private benefits could be affecting the rates at which the practices are adopted. Since the significant contribution of the practices towards environmental sustainability is not debatable, there is need for payment of some mark-up to the adopters of the practices which could go towards compensation for production of environmental services through the practices. This will increase the private benefits accrued from adopting the practices, with the spill-over effects of increasing adoptability potential of the practices.

**Key words:** Maize yields, income, organic resource management, matching strategies, Zambia.

**INTRODUCTION**

Agriculture has been recognized as the economic backbone of most developing countries (Bargali et al., 2004, 2009; Vibhuti et al., 2015; Padalia et al., 2017). However, the decline in productivity of most farmlands due to land degradation has been recognized as a major threat and challenge to households who depend on
agriculture as the major source of economic livelihood (Bargali et al., 1993a, b, 2019; Manral et al., 2020). Le et al. (2014) observed that land degradation ‘hotspots’ stretch to about 29% of the total global land area. For Sub Saharan Africa, land degradation hotspots affect about 26% of land (Kirui and Mirzabaev, 2014). This shows that the problem of land degradation is more prevalent in developing countries like Zambia. Unfortunately, in these countries, agriculture is the major source of income for the majority of the citizenry (Clay and Reardon, 1994; Kabwe and Donovan, 2005; Thirwall, 2006). To ensure sustained crop production in these countries, there is need to continuously use external inputs.

The use of chemical fertilizers usually provides immediate crop yield increase response but this comes at the expense of land ecosystem pollution and exorbitant production costs. For this reason, and in recent times, there has been movement towards the promotion of sustainable agricultural practices involving soil organic resource management practices. Examples of soil organic resources promoted in Zambia and elsewhere in sub Saharan Africa include; field residue retention, improved fallows, green manures, animal manure and others. The importance of soil organic resource management for agricultural development, especially in Africa cannot be overemphasized. According to a Montpellier Panel Report on “No Ordinary Matter: Conserving, Restoring and Enhancing Africa’s Soils” authored in 2014, ‘healthy and fertile soils are the cornerstone of food security and rural livelihoods. Therefore conserving, restoring and enhancing soils through sustainable management practices could unleash Africa’s agricultural transformation towards a food secure economy with vibrant rural livelihoods’.

The promotion of sustainable soil management practices has been encouraged largely due to the potential of the practices to simultaneously provide farmer benefits in terms of increased crop yields and sustain the environment. However, it has been observed that in developing countries adoption of newer technologies initially is a difficult task spatially to the small land holders though gradually the adoption rate increases with the increase in time (Bargali et al., 2007; Pandey et al., 2011).

Notwithstanding this state of affairs, it is not in contention that there have been low levels of adoption of most sustainable agricultural practices (Ajayi, 2007; Kuntashula and Mungatana, 2015), but their ability to improve crop yields and farmer income has come into question. To what extent do soil organic resource management practices increase crop yields and farmer income in Zambia? This study attempted to provide answers to this question.

It is not so difficult to argue for environmental sustainability of soil organic resource management practices. However, when it comes to farmer welfare impacts in terms of increasing crop yields and household income, the practices might not be significantly increasing these welfare outcomes hence the low adoption rates. Most sustainable agriculture management practices increase soil organic matter content while improving soil fertility. This in turn ensures long term soil fertility benefits in crop production. Soil organic matter has been shown to maintain and improve land quality by protecting the soil from the various agents of erosion, nutrient depletion, loss of soil structure and general degradation (Lal and Stewart, 1995). Various experiments have also been conducted worldwide to demonstrate the potential benefits of cost effective and sustainable farming practices with special regard to organic resource management for soil fertility management. For example, in India, Satyanarayana et al. (2002) showed that the application of 10 ton ha⁻¹ of farm yard manure with three levels of chemical fertilizer, increased grain yield of rice by 25% over the no farm manure control plot. Further, studies on cover crops and living mulches conducted by Hartwig and Ammon (2002) showed the usefulness of these technologies in soil erosion control, weed pressure reduction and most of all, an increase in soil organic matter content. Despite these positive benefits, it has been reported elsewhere that suitable combinations of crop and other plants that deliver organic resources for soil fertility improvement which have been developed (Cannell et al., 1996) have failed to be implemented in farmers’ cropping systems on a large scale (Adesina and Chianu, 2002; Adesina et al., 2000) because of low farmer adoption rates.

There is evidence that points to the fact that some crops and practices recommended by research were not suitable to farmers’ needs or criteria (Nederlof and Dangbegnon, 2007). There is also a myriad of other factors affecting uptake of these practices such as the difficulty of producing sufficient amounts of organic matter (e.g. for mulching and/or composting) for meaningful crop production since machinery is rarely available to smallholders (Ouedraogo et al., 2001). The importance of using farming techniques that encourage organic matter build-up in the soil is non-debatable. However, farmer adoption of these practices has largely been very poor and often exists only on a project basis (Douthwaite et al., 2002). Kuntashula and Mungatana (2015) contend that the adoption of sustainable soil fertility practices in Zambia and most parts of sub-Saharan Africa has generally been low. This is despite the recognition by the same authors that most small scale farmers in the region are resource constrained and can barely afford chemical fertilizers. Kuntashula and Mungatana (2015) further observed that many estimates of the benefits associated with most sustainable agricultural management practices stem from either on-station experimental plots or researcher designed and farmer managed field experiments. This therefore puts doubts on the efficacy of the practices on non-experimental farmer fields. Farmers
face different socio-economic as well as biophysical conditions that may affect the performance of the practices and yet setting up experiments on all these farms could prove logistically impossible. The different factors affecting the farmers coupled with the fact that soil organic resource practices produce environmental benefits that transcend farmers’ boundaries, calls for more encompassing ways of estimating the benefits of these practices. In order to justify lobbying to other farmers to invest in these practices, whole encompassing meaningful or tangible impact estimates on crop yields and income needs to be explicitly spelt out. Usually, if the confounding factors are significantly different between the adopters and non-adopters of a technology, the use of rigorous techniques such as matching algorithms that account for selection bias due to these differences produces robust estimates (Kuntashula and Mungatan, 2015). Thus, this study adopts matching strategies which equalises the adopting and non-adopting groups in terms of confounding factors in estimating the effects of soil organic resource management practices on crop productivity and household income among farmers in eastern part of Zambia.

As a contribution to literature, this study is one of its kind that attempted to estimate in a more rigorous manner, the impact of several (seven) soil organic resource management practices on farmers’ crop yields and income. The objective of the study was to estimate the effects of soil organic resource management practices on farmer crop yields and income in Chipata district of Zambia. The practices assessed were green manure, cover crops, improved fallows, mulching, animal manure, composting and residue retention.

RESEARCH METHODOLOGY

Description of the study area and the study sample

The study was conducted in the Eastern Province of Zambia in Chipata district. Chipata is located at about 600 km east of Lusaka, the capital city of Zambia, and about 110 km west of Lilongwe, the capital city of Malawi. The district lies between latitude 13°38'43.0"S and longitude 32°38'47.0"E, with an average elevation of 1,181 m above sea level. The main vegetation in Chipata is the Brachystegia (Miombo) woodland and Munga vegetation types.

As of the 2010 Zambian Census, the district had a population of 455,783 people, the majority of whom are agriculturists. Chipata’s economy is based on agricultural trade and value addition activities. It sits at the termination of a dense corridor leading west to Lusaka around which agricultural production, trade and value addition activities have clustered. It also benefits from its location alongside the Malawian border with reports of illegal agricultural trade into higher value cross-border markets. Chipata district is highly productive, and a large producer of maize, groundnuts, cotton and tobacco.

The study sample selection

The provision of extension services by the government of Zambia is such that the province is subdivided into districts which are subdivided into agricultural blocks which are further divided into agricultural camps. Chipata district has eight agricultural blocks, namely Western, Southern, Eastern, Central, Chiparamba, Chitandika, Chanje and Chankhazwe. This study was conducted in Chisitu camp found in the Central Agricultural Block and in Kapita camp of Chiparamba Agricultural Block. The two camps were purposively chosen as focal points for a Soil Organic Resource Management for Soil Fertility Project experiments which commenced in 2015. This study was one of the many initial research activities which provided baseline data for the project. Chisitu agricultural camp had 2,546 registered farmer households according to the records held by the Camp Extension Officer. A total of 155 households were randomly selected from Chisitu to be part of this study. Similarly, Kapita camp had 2,858 households involved in farming form which a total of 155 were randomly selected, and participated in the study. However, due to unavailability of respondents (household heads) in some cases, only 303 (150 for Kapita camp) household questionnaires had complete information and thus were available for data analysis.

Household survey implementation and the data

This study inquired on agricultural production data based on the 2014/2015 farming season. The survey was implemented during the later parts of 2015 and beginning of 2016. The survey tool used was a structured household questionnaire which was designed and implemented, following informal interviews with the agricultural camp extension officers and some lead farmers in the study area. The informal interviews mainly covered issues surrounding on general agricultural and soil organic resource management activities being practiced in the area. These same themes were repeated in the structured household questionnaire. In addition, the data collected included the socioeconomic characteristics of the farmers and households such as age, gender, education household membership, etc. (Theoretical framework and Table 1). Farmers also estimated crop production and income levels for the 2014/2015 season.

Theoretical and analytical frameworks

The conceptual relationships between various confounding factors and adoption of the soil organic resource management practices are discussed in this section. The section concludes with the analytical framework used to estimate the effects of the practices on crop yields and income. The organic resource management practices studied were animal manure, improved fallows, green manure, cover crops, compost, residue retention, and mulching. Farmers were asked to state whether they used these practices during the 2014/2015 farming season. Therefore, notwithstanding the fact that adoption entailed the uptake of solely one of these practices, we also analyzed the effects of adopting at least one or more of the organic practices listed earlier. The adoption of one or more of these practices was hypothesized to increase crop (maize) productivity and/or household income. Therefore crop productivity and household income were used as outcome variables in this study. Farmers estimated how much of the crops they harvested in 2014/2015, and how much income from the different household activities they raised during the period of 12 months prior the survey.

Animal manure is the solid and liquid excrement from animals, mainly cattle, which are spread in field for use as agricultural inputs. Animal manure is a vital soil fertility replenishment component in mixed crop and livestock farming systems widely found in Southern Africa, including Zambia (Kuntashula et al., 2004). Improved fallows are deliberately planted fast-growing leguminous nitrogen-fixing woody trees or shrubs left to grow on a field for a minimum of 2 to 3 years for rapid replenishment of soil fertility. Improved fallows aim to
achieve objectives of natural fallows within a shorter time or a smaller area (Kuntashula and Mungatana, 2015). Some legume shrubs can also be used as green manures or cover crops. These are legume shrubs or crops such as velvet beans that are grown in rotation or simultaneously with mainly maize to improve the nitrogenous status of the soil (Mafongoya et al., 2006). In addition, the legumes cover the surface of the soil and reduce soil erosion. Compost is the collection and distribution of a range of organic compounds that may include soil, animal waste, plant material, food waste, and even doses of mineral fertilizers. Prior to application of compost onto the field, there is a period of incubation to decompose the materials. Crop residues are in situ utilization of crop residues which could be in the form of leaving residues on the surface or by cutting, chopping, and incorporating them into the soil. This operation is normally done during land preparation for the following season. In Zambia, the crop residue retention technology has been mostly promoted as one of the principles of Conservation Agriculture (CA). Mulching simply means covering the soil between plants with a layer of materials such as leaves, crop residues, etc. Mulch prevents water from evaporating. Less watering is therefore needed. It protects the soil from wind, rain and sun, and suppresses weed growth by blocking out sunlight.

In addition to consideration of the effects of the aforementioned soil organic resource management practices on crop productivity and income, this study is cognizance of the effects of other factors on the adoption of the practices. These other explanatory or confounding variables include: farmer and farm characteristics (age, gender, marital status and education level of the household head, household membership size and dominant soil type); social capital (membership to agricultural groups); access to extension services; and location (agricultural camp dummy).

The theoretical underpinnings of these explanatory variables as posited by various authors include that; the age of household head is likely to influence adoption of organic resource management practices and hence crop productivity and income. Older farmers usually gain experience in farming but younger farmers may be more innovative and have lower risk aversion behavior (Kuntashula and Mungatana, 2015) hence the relationship between age and productivity or household income through adoption of organic resource management practices may be ambiguous. Other farmer characteristics such as gender, marital status and level of education are also expected to affect the decision to adopt soil organic resource management practices such as improved fallows (Ajayi et al., 2003; Keil et al., 2005) leading to improvement in crop productivity and income.

Ajayi et al. (2003) postulated that households with female heads may respond less favourably to adoption of technologies than their male headed counter parts due to differences in resource endowments. Resource endowments differential effects in the improvement of crop productivity and income through adoption of technologies may also be reflected through divorced or single households who might have fewer resources for adopting such technologies. However, Kuntashula and Mungatana (2015) contended that the divorced or single household heads could also circumvent bureaucratic tendencies of consulting partners in arriving at decisions to adopt technologies. Thus marital status of household heads is expected to have an ambiguous effect on adoption of organic resource management practices. Expectations are that more knowledgeable household heads would embrace these agricultural practices. Therefore, level of education of the household head was expected to positively influence adoption of the practices. Generally, most soil resources management practices such as manure application, improved fallows, composting etc. are labour intensive, household’s labour availability is expected to positively affect the farm household’s decision to adopt the technologies.

Resource endowment can affect adoption of agricultural technologies in a direct way. Kuntashula et al. (2014) argued that it was common knowledge that relatively less resource endowed poorer farmers in rural communities were reluctant to invest in any untried innovations mainly due to their limited factors of production. Therefore assets such as farm sizes, livestock, bicycles, radios which are indicators of wealth in rural communities, are expected to enhance adoption of soil organic resource management practices. Riding on the premise that farmers associate sandy soils with low soil fertility (Kuntashula et al., 2018), farmers who perceive predominantly sandy soils on their farms were more likely to adopt soil organic management practices which improves the organic matter content of the soil.

Other factors such as access to extension, and belonging to agricultural groups are expected to increase the likelihood of adopting these practices since these are vital sources of agricultural information. Finally, the study sample came from two agricultural camps with varying distances to the main agricultural input and output market town of Chipata; therefore, the influence of geographical location would be also important in the adoption of the soil organic resource management practices.

All the discussed variables were controlled for, in the estimation of the effects of the organic resource management practices on crop productivity and household income.

**Propensity score matching technique analytical model**

The explanatory variables affecting adoption of the soil organic management practices may also impact farmers’ crop productivity and income levels hence isolating impact of the practices could become challenging. To account for this potential problem, matching techniques which equalized or balanced the explanatory variables between the adopters and the non-adopters of the practices were used. In matching, the central issue is that adoption of soil fertility organic management practices are a function of a wide range of observable characteristics. If comparison groups are statistically identical in these observable characteristics except the fact that one of them received the treatment (adopted), then the impact can be estimated as the mean difference in mean outcomes between the adopting and non-adopting groups (Kuntashula and Mungatana, 2015).

Adapting the causal inference potential outcome framework model discussed by Rubin (1974), the average adoption effect on those adopting the practices is:

\[
E(Y_1 - Y_0 | T = 1)
\]  

(1)

with \(E\) standing for the expectation in the difference in the crop or income outcome \((Y_1 - Y_0)\) between the adopters of the soil organic management practices, \(T = 1\) and the counter factual outcome if they had not adopted, \(T = 0\). Since we cannot observe the outcomes of the adopters in the non-adopting state, one assumption or possible identification strategy we can use is the Conditional Independent Assumption (CIA) that states that, given a set of observable covariates \(X\), the potential outcome in case of no adoption is independent of adoption assignment (Kuntashula and Mungatana, 2015), which can be given as:

\[
Y_{0,1} \perp (X)
\]  

(2)

Using CIA, the outcomes of the non-adopters, with similar adopter’s characteristics can be used. Besides this necessary condition, a sufficient requirement for identification is that for each adopting farmer there are non-adopting farmers with similar same observables (Kuntashula and Mungatana, 2015).

Matching adopters and non-adopters on singular observables
could lead to high dimensionality problems hence the use of the propensity score. The propensity score is the conditional probability of adopting a technology or practice. The probability is conditional on the observable characteristics. Mathematically, the propensity score can be expressed as:

\[ e(x) = \Pr(W_i = 1 \mid X_i = x) = \mathbb{E}[W_i \mid X_i = x] \]  

(3)

where \( W_i = 1 \), for adopters, and \( W_i = 0 \), for non-adopters; \( x \) = soil organic resource management practice; and \( X_i \) is the vector of covariates. This study estimated the propensity scores using a binary (0,1) probit regression. Several estimations were made while checking the balancing properties to test whether adopters and non-adopters observations had the same distribution of propensity scores. The most complete and robust specification that satisfied the balancing tests was the one that was used for impact estimations.

With the propensity scores in place, matching was implemented using nearest neighbour and kernel matching algorithms. With nearest neighbour matching, the adopting and non-adopting farmers are matched based on the closeness of the propensity scores. With Kernel matching (KM) the weighted averages of all farmers' propensity scores in the non-adopting category is used to construct the counterfactual outcome (Kuntashula and Mungatana, 2015). Stata version 13 was used to run the regression models and matching algorithms.

### RESULTS AND DISCUSSION

#### Description of soil fertility management practices

Seven types of soil organic resource management practices were identified in the study area. The management practices were the use of; green manure, cover crops, improved fallows, mulching, animal manure, composting and residue retention. For the sake of making comparisons on a number of covariates, a farmer who used at least one of the aforementioned management practices in 2014/2015 production season was treated as an adopter of soil organic resource management practice. However, the empirical evaluation of the practices tested this broad variable as well as the effects of each of the management practice on maize yields and household income. About 51% of the farmers used at least one of the aforementioned practices. The order of popularity of the individual practices among the surveyed farmers was: residue retention > animal manure > cover crops > green manures > improved fallows > composting > mulching (Table 1).

Maize was used as a test crop outcome variable because it is the staple food crop that is widely grown in the study area and the whole country. Estimates from the household survey, showed that almost every farmer grew maize. Overall, 98.7% of the whole sample grew maize in 2014/2015 season. All adopters of at least one soil organic resource management practice and 97.3% of those who had not used any of the practice grew maize. Other crops grown in the study area included groundnuts, cotton, soybean and tobacco.

#### Descriptive characteristics of the farmers

The various demographic and socioeconomic characteristics of the farmers involved in the household survey are shown in Table 2. On average, adopters of at least one soil organic resource management practice had cultivated more land, allocated more land to maize and had more household income, than the non-adopters. The average age of the household head from the whole sample was 40.3 years while those who had adopted at least one organic resource management practice and non-adopters had similar average ages. The two groups had similar household member size, with the estimate from the whole sample being 6.6. In terms of sex of the farmers, 69.6% of those surveyed were male. About 69.3% of the farmers surveyed were married, 24.1% single, 6.3% widowed and 0.3% were divorced. Fifty eight percent of the surveyed farmers had completed primary school level of education while 33% had completed secondary school. Only 1.7% completed some form of tertiary education. The remainder (7.3%) did not receive any formal education at all. Again there were no statistical differences observed between the adopters and non-adopters of the soil organic resource management practices. In terms of indicators of wealth, more adopters,

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**Table 1.** Proportions of farmers using soil organic resource management practice in Chipata district in 2014/2015 season.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Organic Resource Practice adopter* (N = 155)</th>
<th>Over all sample (N = 303)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green manures</td>
<td>21.94</td>
<td>11.22</td>
</tr>
<tr>
<td>Cover crops</td>
<td>26.45</td>
<td>13.53</td>
</tr>
<tr>
<td>Improved fallows</td>
<td>19.35</td>
<td>9.9</td>
</tr>
<tr>
<td>Mulching</td>
<td>17.42</td>
<td>8.91</td>
</tr>
<tr>
<td>Animal manure</td>
<td>50.32</td>
<td>25.74</td>
</tr>
<tr>
<td>Composting</td>
<td>18.06</td>
<td>9.24</td>
</tr>
<tr>
<td>Residue retention</td>
<td>92.9</td>
<td>52.28</td>
</tr>
</tbody>
</table>

*Farmers who were using at least one of the organic resource management practices.

Source: Authors own computation, Chipata household Survey, 2016
Table 2. Demographic and socioeconomic characteristics of the surveyed households in Chipata district.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Adopters (N = 155)</th>
<th>Non-adopters (N = 148)</th>
<th>Over all (N = 303)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize (t ha⁻¹)</td>
<td>2.073 (0.094)</td>
<td>1.76 (0.077)***</td>
<td>1.92 (0.062)</td>
</tr>
<tr>
<td>Income (ZMW '000)</td>
<td>5.04 (0.47)</td>
<td>3.83 (0.37)**</td>
<td>4.45 (0.301)</td>
</tr>
<tr>
<td>Cultivated area (ha)</td>
<td>2.19 (0.10)</td>
<td>1.94 (0.11)*</td>
<td>2.07 (0.07)</td>
</tr>
<tr>
<td>Cultivated maize area (ha)</td>
<td>1.37 (0.81)</td>
<td>1.20 (1.04)*</td>
<td>1.29 (0.93)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>40.7 (9.20)</td>
<td>39.8 (8.60)</td>
<td>40.3 (8.90)</td>
</tr>
<tr>
<td>Household size (Number)</td>
<td>6.7 (3.46)</td>
<td>6.4 (3.09)</td>
<td>6.6 (3.30)</td>
</tr>
</tbody>
</table>

Gender (% households heads)

- Male: 69.7, 69.6, 69.6
- Female: 30.3, 30.4, 30.4

Education (% households heads)

- Never been to school: 7.7, 6.8, 7.3
- Completed primary: 60.7, 55.4, 58.1
- Completed secondary: 29.7, 36.5, 33
- Completed tertiary: 1.9, 1.4, 1.7

Marital status (% households)

- Married: 69.7, 68.9, 69.3
- Single: 24.5, 23.7, 24.1
- Widow/er: 5.2, 7.4, 6.3
- Divorced: 0.65, 0, 0.33

Asset ownership

- Cattle owned: 30.9, 10.14***, 20.8
- Goats owned: 20.0, 14.2, 17.2
- Pigs owned: 28.4, 23.0, 25.7
- Sheep owned: 7.7, 1.35**, 4.6
- Poultry owned: 80.0, 65.5**, 72.9
- Owned an ox-plough: 19.4, 9.5**, 14.5
- Owned a ripper: 5.8, 2.7, 4.3
- Owned an ox-cart: 12.3, 6.1*, 9.2
- Owned a radio: 59.4, 56.8, 58.1
- Owned a cell-phone: 53.6, 52.0, 52.8
- Owned a bicycle: 67.7, 50**, 59.1

*, **, ***Significant at 90, 95 and 99% confidence levels.
Source: Authors own computation, Chipata household Survey, 2016.

than the non-adopters, owned cattle, sheep, poultry, ox-drawn ploughs, ox-cart and bicycles (Table 2). This shows that those using soil organic resource management practices were relatively well resource endowed compared to their counter parts.

Impact estimates of soil organic resource management (ORM) practices

The most robust propensity score estimation model that satisfied the balancing property was achieved using the explanatory variables shown in Table 3. The distribution of the estimated propensity is shown in Figure 1. There was significant similarity or matching in the distribution of the propensity scores between the adopters of at least one of the soil organic resource management practice and the non-adopters. The overlap condition was met with reasonably a high number of non-adopting households.

Similarly, the matching tests showed that the mean differences of the explanatory variables used in the matching algorithms, between the adopters and the non-adopters group were statistically insignificant after
Table 3. Probit propensity score estimation on the adoption of at least one soil organic resource management practice.

| Variable               | Coefficient | Std. Err. | Z    | P>|z| |
|------------------------|-------------|-----------|------|-----|
| Gender                 | -0.208      | 0.270     | -0.77| 0.441|
| Marital status         | -0.079      | 0.199     | -0.39| 0.693|
| Education level        | -0.019      | 0.090     | -0.22| 0.828|
| Household size         | 0.013       | 0.023     | 0.55 | 0.585|
| Group membership       | 0.278       | 0.215     | 1.3  | 0.194|
| Access to credit       | 0.291       | 0.185     | 1.58 | 0.115|
| Owning a ripper        | 0.081       | 0.403     | 0.2  | 0.841|
| Owning radio           | 0.038       | 0.161     | 0.24 | 0.808|
| Owning oxcart          | 0.143       | 0.329     | 0.43 | 0.665|
| Owning ox-plough       | 0.369       | 0.275     | 1.34 | 0.179|
| Owning cellphone       | -0.079      | 0.159     | -0.5 | 0.617|
| Low soil fertility     | -0.292      | 0.183     | -1.59| 0.111|
| Kapita camp            | -0.005      | 0.161     | -0.03| 0.973|
| Constant               | -0.057      | 0.574     | -0.10| 0.921|

This is despite some variables showing statistically significant differences before matching (Table 4).
Table 4. Balancing tests of propensity scores and covariates (t-tests and standardized % bias).

| Variable                  | Sample       | Adopters | Non-adopters | %Bias | %Reduction in |bias| t   | t   | p>|t| |
|---------------------------|--------------|----------|--------------|-------|--------------|----|-----|-----|-----|
| Age (years)               | Unmatched    | 40.69    | 40.02        | 7.5   | 87.6         |    | 0.64| 0.520|
|                          | Matched      | 40.69    | 40.77        | -0.9  | -0.08        |    | 0.935|
| Gender (male =1, 0, otherwise) | Unmatched    | 0.69    | 0.69        | 1.6   | 0.14         |    | 0.892|
|                          | Matched      | 0.69    | 0.70        | -1.5  | -0.13        |    | 0.898|
| Marital status Single     | Unmatched    | 1.37    | 1.38        | -1.9  | -0.16        |    | 0.870|
|                          | Matched      | 1.37    | 1.34        | 5.1   | 0.46         |    | 0.648|
| Educational level         | Unmatched    | 1.56    | 1.60        | -4.6  | -0.40        |    | 0.691|
|                          | Matched      | 1.56    | 1.63        | -8    | -0.68        |    | 0.497|
| Household size (number)   | Unmatched    | 6.69    | 6.48        | 6.6   | 0.57         |    | 0.572|
|                          | Matched      | 6.69    | 6.66        | 1.1   | 0.10         |    | 0.920|
| Group members (1=yes, 0=No) | Unmatched    | 0.88    | 0.82        | 17.9  | 1.55         |    | 0.122|
|                          | Matched      | 0.88    | 0.89        | -0.6  | -0.06        |    | 0.951|
| Access to credit (1=yes, 0=No) | Unmatched    | 0.29    | 0.17        | 30.1  | 2.59         |    | 0.010|
|                          | Matched      | 0.29    | 0.30        | -2.3  | -0.19        |    | 0.853|
| Owning a ripper (1=yes, 0=No) | Unmatched    | 0.06    | 0.01        | 24    | 2.05         |    | 0.042|
|                          | Matched      | 0.06    | 0.05        | 4.4   | 0.32         |    | 0.753|
| Owning a radio (1=yes, 0=No) | Unmatched    | 0.59    | 0.56        | 5.7   | 0.49         |    | 0.621|
|                          | Matched      | 0.59    | 0.60        | -2    | -0.18        |    | 0.861|
| Owning ox cart (1=yes, 0=No) | Unmatched    | 0.12    | 0.05        | 26.8  | 2.30         |    | 0.022|
|                          | Matched      | 0.12    | 0.14        | -5.5  | -0.40        |    | 0.693|
| Owning ox plough (1=yes, 0=No) | Unmatched    | 0.19    | 0.08        | 32.5  | 2.79         |    | 0.006|
|                          | Matched      | 0.19    | 0.19        | 0.9   | 0.07         |    | 0.948|
| Owning cell phone (1=yes, 0=No) | Unmatched    | 0.53    | 0.53        | 0.9   | 0.08         |    | 0.936|
|                          | Matched      | 0.53    | 0.54        | -0.9  | -0.08        |    | 0.935|
| Low soil fertility (1=yes, 0=No) | Unmatched    | 0.18    | 0.25        | -16.6 | -1.43        |    | 0.153|
|                          | Matched      | 0.18    | 0.21        | -7.1  | -0.64        |    | 0.521|
| Kapita (1=yes, 0=No)      | Unmatched    | 1.51    | 1.51        | 1.2   | 0.10         |    | 0.917|
|                          | Matched      | 1.51    | 1.49        | 4.6   | -282.9       |    | 0.686|

Marital status: 1 = Married, 2 = Single, 3 = widowed. Education level: 1 = Primary, 2 = Secondary, 3 = Tertiary, 4 = None.

**Effects of soil organic resource management practices on maize productivity**

The effects of the soil organic resource management practices on maize productivity are shown in Table 5. Estimates show that all the soil organic resource management practices except compost and animal manure, positively increased maize productivity. The increases in maize per hectare were however significant in only two cases out of the seven: the use of cover crops and improved fallows. Controlling for other variables, the kernel matching and the nearest neighbor matching
Table 5. Average treatment on the treated estimation of each practice on log of maize productivity (ha⁻¹).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Method</th>
<th>No. treated</th>
<th>No. control</th>
<th>ATT</th>
<th>Std. Err.</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORM adoption¹</td>
<td>Nearest neighbor</td>
<td>79</td>
<td>154</td>
<td>0.089</td>
<td>0.095</td>
<td>0.939</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>154</td>
<td>142</td>
<td>0.103</td>
<td>0.077</td>
<td>1.340</td>
</tr>
<tr>
<td>Green manures</td>
<td>Nearest neighbor</td>
<td>34</td>
<td>33</td>
<td>0.074</td>
<td>0.130</td>
<td>0.570</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>32</td>
<td>262</td>
<td>0.113</td>
<td>0.117</td>
<td>0.970</td>
</tr>
<tr>
<td>Cover crops</td>
<td>Nearest neighbor</td>
<td>41</td>
<td>40</td>
<td>0.211</td>
<td>0.119</td>
<td>1.772</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>41</td>
<td>255</td>
<td>0.162</td>
<td>0.085</td>
<td>1.90</td>
</tr>
<tr>
<td>Improved fallows</td>
<td>Nearest neighbor</td>
<td>30</td>
<td>28</td>
<td>0.223</td>
<td>0.112</td>
<td>1.999</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>28</td>
<td>266</td>
<td>0.311</td>
<td>0.132</td>
<td>2.35</td>
</tr>
<tr>
<td>Mulching</td>
<td>Nearest neighbor</td>
<td>27</td>
<td>28</td>
<td>0.127</td>
<td>0.185</td>
<td>0.687</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>26</td>
<td>269</td>
<td>0.104</td>
<td>0.119</td>
<td>0.88</td>
</tr>
<tr>
<td>Animal Manures</td>
<td>Nearest neighbor</td>
<td>78</td>
<td>64</td>
<td>-0.049</td>
<td>0.086</td>
<td>-0.576</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>78</td>
<td>218</td>
<td>0.063</td>
<td>0.080</td>
<td>0.79</td>
</tr>
<tr>
<td>Composting</td>
<td>Nearest neighbor</td>
<td>28</td>
<td>27</td>
<td>-0.052</td>
<td>0.178</td>
<td>-0.294</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>28</td>
<td>268</td>
<td>0.033</td>
<td>0.132</td>
<td>0.25</td>
</tr>
<tr>
<td>Residue retention</td>
<td>Nearest neighbor</td>
<td>144</td>
<td>82</td>
<td>0.061</td>
<td>0.095</td>
<td>0.641</td>
</tr>
<tr>
<td></td>
<td>Kernel matching</td>
<td>144</td>
<td>152</td>
<td>0.077</td>
<td>0.081</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Source: Authors own computation, Chipata Household Survey, 2016.

showed that cover crops increased maize yields per hectare by 16 and 21%, respectively. The two algorithms showed that the use of improved fallows increased maize yield per hectare by about 31 and 22%, respectively.

The common cover crops used in the study area are velvet bean, lablab, cowpea, and sun hemp. These provide a lot of biomass and since they are leguminous in nature, they can leave large quantities of organic matter and nitrogen in the soil which subsequent crops, mainly maize, benefits from. Bargali et al. (2019) observed that unlike in open crop lands, good soil health, higher amount of microbial biomass and better soil qualities occur in tree planted soils mainly due to the greater availability of organic matter, litter diversity and fine roots. All these parameters positively affect yields for crops grown in such farm plots. Therefore, the use of cover crops could have led to the promotion of good soil health and microbial activities that positively impacted on maize yields.

Similarly, in addition to providing organic matter, the efficacy of improved fallow agroforestry technologies in improving maize yields through addition of large quantities of nitrogen, has been reported elsewhere (Kuntashula and Mungatana, 2015). Kuyah et al. (2020) recently conducted a meta-analyses study where it was observed that average yields of staple crops were almost twice as high in agroforestry compared to yields in treeless systems. However, it should be noted that these crop yield increases are subject to certain conditions with regards to tree management. Bayala et al. (2015) observed that trees improve growth and yield of crops when the appropriate species are planted in optimum densities and appropriate pruning regimes are applied. Bargali et al. (2009) observed reduction in rice crop yields grown under *Acacia nilotica* traditionally based agroforestry systems in the sub-humid regions of the Chhattisgarh plains. The negative effect was mainly due to the dense tree canopy provided by the older trees. It was reported by Bargali et al (2009) that the removal of 10% of basal tree branches increased the rice grain yield without having any adverse effect on the tree component. Further, contrary to findings in this present study, Bargali et al. (2004) observed reduction in gram crop yields (in addition to other crop growth parameters) due to light limitation as the age of *A. nilotica* traditionally based agroforestry systems increased. This therefore means that the ecological and private benefits of agroforestry tree based technologies such as improved fallows can only be achieved simultaneously if proper tree and crop management practices are followed.

**Effects of soil organic resource management practices on household income**

Estimates on the effects of soil organic resource
management practices on household income are shown in Table 6. Like in the case of maize productivity, most of the soil organic resource practices showed positive contribution to household income. However, only improved fallows and green manure estimates showed significant positive estimates at the 95% confidence level. Tree based agroforestry technologies have been found to contribute to income levels of households either directly through the sale of by-products such as fuel wood and/or merchantable timber (Bargali et al., 2009; Kuntashula and Mungatana, 2015; Padalia et al., 2017) and indirectly through sale of increased crop yields. Very recently Kuyah et al. (2020) observed that agroforestry contributes to sustainable livelihoods through four pathways namely; food production, health and nutrition, provision of wood-based energy and income generation. The authors indicated that crop and livestock products from agroforestry can be directly used for home consumption or sold on the market to generate income. Moreover, Kuyah et al. (2020) argues that the improved fallows provide services such as improvement of soil fertility which serves as a substitute for fertilizer which farmers would otherwise have to buy. This indirectly increases the availability of income for other household consumables.

The importance of trees in providing household income in most developing countries cannot be overemphasized. According to Miller et al. (2017), trees account for an average of 17% of the total annual gross income for tree-growing households and 6% for all rural households in Ethiopia, Malawi, Nigeria, Tanzania and Uganda. It is further argued that in Burkina Faso, Mali and Senegal, close to 50% of households obtained income from agroforestry (Binam et al., 2015).

Since green manure did not show any positive significant influence on the production of maize, the positive impact results could imply that the practice is expressing its significant effect on household income through cash crops such as cotton, soybean, tobacco, and vegetables, which are common in the study area. Farmers in the study area are known to use biomass transfer technology which is essentially a “cut and carry system” in that green leaves and twigs of improved fallows are moved from one location to another to be used as green manure (Kuntashula et al., 2004). Since most crops nutrient requirements are quite substantial, this type of green manure technology works well when used on small portions of land and is thus highly profitable in the production of high-value crops, especially vegetables, such as cabbage, rape, onion, garlic and tomato (Kuntashula et al., 2004).

CONCLUSIONS AND RECOMMENDATIONS

The study had an overall objective of determining the
impact of soil organic resource management practices on smallholder maize productivity and household income in Chipata district of Zambia. The practices under study included green manures, cover crops, improved fallows, mulching, animal manures, compost and residue retention. Cover crops and improved fallows significantly increased productivity of maize whilst most of the other practices showed positive but insignificant effect on the production of the crop. Again, only two practices, green manure and improved fallows were significant in influencing household income.

These findings may imply that while most soil organic resource management practices produce a lot of biomass, the practices might not be providing enough nitrogen to significantly increase crop productivity. Further, this showed that the effect of most of the practices on the maize crop and other crops is not significant enough to influence the income levels of the households. It appears like the practices are fit for promotion at subsistence level, since in some cases, they will only be able to increase crop yield for consumption and not for sale. The non-significance in the contribution of some of the practices to private benefits in terms of income could be affecting the rates at which the practices are adopted. Whereas the environmental stewardship of the practices could positively influence lobbying for the massive uptake of the practices, the private benefits accruing to the farmers could affect the potential gains from the promotional activities. Since the significant contribution of the practices towards environmental sustainability is not debatable, there is need for payment of some mark-up to the adopters of the practices which could go towards compensation for production of environmental services through the practice. For instance, this could be in the form of input subsidies that the government provides to some small scale farmers in Zambia. This will increase the private benefits accrued from adopting the practices, with the spill-over effects of increasing adoptability of the practices.

ACKNOWLEDGEMENT

We would like to thank the Swiss Program for Research on Global Issues through a project titled Organic Resource Management to Build Soil fertility (ORM4SOIL) for funding this study. The authors also thank the farmers involved in the interviews, and the unknown reviewers for their helpful comments.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES


Modernizing extension services to improve rice productivity: Lessons from Ghana’s planting for food and jobs program

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Received 27 May, 2020; Accepted 18 September, 2020

The Government of Ghana introduced Planting for Food and Jobs (PFJ) program in 2017 to help raise farm productivity, improve food security, create jobs and modernize agriculture. Among the core pillars of PFJ program include the provision of modernized extension service to farmers. This study analyzed the productivity difference between beneficiaries and non-beneficiaries of the modernized extension service among rice farmers in the Talensi District of Ghana using Independent Samples t-test. Productivity is measured as output per acre (kg/acre). A multi-stage sampling technique was used to draw representative samples during the 2019 production season for the study. The results showed that farmers who benefitted from the modernized extension service were more productive than the non-beneficiary farmers. Specifically, average yield of modernized extension service beneficiaries was about 140kg/acre higher than that of non-beneficiary farmers.

Key words: Planting for food and jobs, modernized extension service system, independent samples t-test.

INTRODUCTION

Modernizing agriculture is a major policy concern in Ghana. A modernized agriculture and food systems is expected to raise farm productivity, build efficient food marketing and distribution channels and, ultimately translate into significant reduction in food wage bills (MoFA, 2007). In 2017, the Government of Ghana introduced the Planting for Food and Jobs (PFJ) program in accordance with this objective to modernize agriculture and food systems in the country. The PFJ is a four-year intervention that offers subsidized inputs and modernized extension services to producers of selected crops to enhance their productivity.

Rice is one of the selected crops for modernization under the PFJ program. This is because rice is one of the most important cereals in the country’s food basket whose consumption is increasing rapidly relative to domestic production. Ghana’s rice consumption increased by more than 70 percent, from 800 thousand metric tonnes in 2010 to over 1.4 million metric tonnes in 2019 (Fig 1). Nevertheless, the volume of domestic production increased from some estimated 300- to 550- thousand metric tonnes over the same period. Consequently, there has been a significant surge in imports to supplement domestic consumption, raising imports from 580

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thousand metric tonnes in 2010 to 900 thousand metric tonnes in 2019.

Furthermore, the low domestic production relative to consumption implies that Ghana is highly depended on international markets to meet its domestic consumption. More than 60% of the rice consumed in Ghana is sourced from international markets (FAO, 2020). This poses a risk to national food security because countries cannot fully rely on international supplies to meet their domestic consumption in times of global food crises (Nakuja and Kerr, 2019). Thus, there is the need to improve domestic rice production and processing to limit reliance on foreign markets. In line with this objective, the PFJ program will provide quality seeds and agrochemicals at subsidized prices to farmers. In addition, the PFJ also offers modernized extension services to enhance the productivity of these farmers.

The usefulness of extension services in the rice sector has been widely researched (Abdulai et al., 2018; Anang et al., 2020; Danso-Abbeam et al., 2018; Emmanuel et al., 2016). Agricultural extension service agents generally transfer information between farmers and concerned institutions; demonstrate new farming practices; and link farmers to markets and credit opportunities. Under the modernized extension system, however, the capacity of Agricultural Extension Agents (AEAs) has also been built to be able to assist farmers analyze their farm businesses, use Mobile Applications (Mobile Apps) and internet sources to enhance farm decision making and productivity (MoFA, 2017). Nevertheless, studies investigating the effects of the modernized extension service on the productivity of rice farmers under the PFJ program are limited. Mabe et al. (2018) evaluated the potentials of PFJ program across maize, rice and soybeans value chains in the Northern, Volta, and Brong-Ahafo regions of Ghana. Their findings suggest that farmers were less aware of the modernized extension service and market linkage components of the program. Consequently, they recommend an intensive awareness campaign to inform stakeholders about the various components of the PFJ program.

Ansah et al. (2018) argued that farmers’ capabilities should be enhanced to effectively participate in the PFJ program. According to their study, capabilities of rural farmers in particular can be improved by providing roads and markets in remote production areas. Nonetheless, their study does not underscore the role of the modernized extension service in building farmers’ capabilities. Furthermore, Tanko et al. (2019) examined the impact of PFJ program on the productivity of rice farmers in Northern Ghana. Their results suggest that PFJ has had a positive impact on rice productivity. However, since the PFJ program was relatively new and not fully understood by farmers at the time of their study, the estimated impacts could be misleading. This is because the long-term impacts of the program, which can be negative or positive, havr the tendency of changing the conclusions reached in their study.

Moreover, Pauw et al. (2018) suggested that job creation along the agri-food system emanating from PFJ program could be hampered when investments in extension services, rural infrastructure and research and development is neglected. Consequently, this study focuses on the modernized extension service aspect of the PFJ program. The paper primarily analyzes the productivity between beneficiaries and non-beneficiaries of the modernized extension services among rice farmers in Talensi District of the Upper East Region, Ghana. The lessons drawn from this study can be used to improve the PFJ program and/or other policy related interventions.
MATERIALS AND METHODS

The study area

This research was conducted in the Talensi District of the Upper East Region, Ghana. Talensi is one of the districts in the Upper East Region where rice is largely produced. Of the total 14,291 farmer population in the district, approximately 96.7% grow rice and vegetables in addition to other crops (MoFA, 2018). Furthermore, there are about 6250 acres of land under rice cultivation in the district, yielding approximately 7500 tonnes of rice annually. Rice produced in the district is targeted for domestic market and export to neighboring Burkina Faso due to the proximity of Burkina market. The district lies between latitude 10° 15’ and 10° 60’ North of the equator and longitude 0° 31’ and 1° 05’ West of the Greenwich meridian.

The district has four agricultural extension service agents working with over 14,000 farmers. The PFJ program, in this district, is largely focused on the provision of improved rice varieties and agrochemicals to farmers at subsidized prices. In addition to field demonstrations, extension agents also provide assistance to farmers on the use of mobile apps, internet sources and geographic information system to support their farming activities and improve productivity.

Data and sampling technique

The contact of farmers registered under the PFJ program in the Talensi District was obtained from the district MoFA office. The study employed multi-stage sampling technique to draw representative samples from the list of registered farmers. Talensi District has about twenty (20) communities involved in rice farming. At the first stage of the sampling, a simple random sampling technique was used to draw ten (10) communities for the study. At the second stage, snowballing sampling technique was used to reach all the targeted respondents in the selected communities. In all, the sample size includes 110 beneficiaries of the modernized extension services and 180 non-beneficiaries.

Method of analysis

The research objective was analyzed using Independent Samples t-test. Independent Samples t-test is used to compare mean difference between two samples (Sokal and Rohlf, 1995; Wilks, 2006; Matsoukis et al., 2018). The application of Independent Samples t-test in agriculture and agribusiness research is extensive. Methot and Bennett (2018) used Independent Samples t-test to compare food security statuses of smallholder farmers in Guatemala. Tsinigo and Behrman (2017) used Independent Samples t-test to analyze productivity difference between adopters and non-adopters of improved rice varieties in Ghana. Khan et al. (2016) analyzed the mean difference between men and women’s marginal willingness to pay for direct-seeded rice seeder in India using Independent Samples t-test. In this research, one group of farmers benefited from the modernized extension services provided under the PFJs while the other did not. Hence, applying Independent Samples t-test to analyze the mean difference in their productivity levels is suitable. The null and alternate hypotheses are:

Ho: There is no significant difference in average productivity between beneficiary and non-beneficiary of the modernized extension service.

Ha: There is significant difference in average productivity between beneficiary and non-beneficiary farmers of the modernized extension service.

The Independent Samples t-test is stated as:

\[ t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S^2_{x1}}{n_1 - 1} + \frac{S^2_{x2}}{n_2 - 1}}} \]

Degrees of freedom = \( (n_1 - 1) + (n_2 - 1) \)

Where, \( \bar{X}_1 \) = Average productivity of beneficiary farmers

\( \bar{X}_2 \) = Average productivity of non-beneficiary farmers

\( S^2_{x1} \) = Variance of beneficiary farmers

\( S^2_{x2} \) = Variance of non-beneficiary farmers

\( n_1 \) = Sample size of beneficiary farmers

\( n_2 \) = Sample size of non-beneficiary farmers

The null hypothesis is rejected if \( t \)-calculated is greater than \( t \)-critical\(^1\).

RESULTS AND DISCUSSION

Socio-economic characteristics

The socio-economic characteristics of the respondents are presented in Table 1. Of the 110 respondents who benefited from the modernized extension service, 77% were males while 23% are females. Similarly, approximately 78 and 22% of the non-beneficiary farmers were males and females, respectively. This suggests that rice farming in the district is largely dominated by males. This could be attributed to the argument that women have limited access to farmlands in Northern Ghana (Kuusaana et al., 2013; Azumah et al., 2018). Moreover, the results also reveal that rice farming is largely dominated by smallholder farmers. For instance, more than 70% of the respondents grow rice on less than five acre farms. Further, while most of the respondents (over 70%) have over 10 years of rice farming experience, their levels of education is relatively low. More than 50% of the respondents have not had any form of formal education. Hence, their ability to independently access information under the modernized extension service, especially using Internet and Mobile Apps, may be challenging.

Respondents’ sources of information

Respondents depend on a variety of information sources to support their farming activities. These include the use of Mobile Apps, internet sources, talking to AEAs and

\(^1\) t-critical refers to tabulated values of t statistics on the t-table. The hypothesis is tested at 1%, 5% or 10% significance level.
Table 1. Socio-economic characteristics of respondents.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beneficiaries</th>
<th>Non-beneficiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of farmers</td>
<td>Percent</td>
</tr>
<tr>
<td>Sex of respondents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>85</td>
<td>77</td>
</tr>
<tr>
<td>Female</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>100</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 30</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>30 to 40 years</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>More than 40 years</td>
<td>63</td>
<td>57</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>100</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Formal Education</td>
<td>65</td>
<td>59</td>
</tr>
<tr>
<td>Basic Education</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>Secondary</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Post-Secondary</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>100</td>
</tr>
<tr>
<td>Years of experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>5 to 10 years</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>More than 10 years</td>
<td>80</td>
<td>73</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>100</td>
</tr>
<tr>
<td>Farm size (acres)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 5 acres</td>
<td>70</td>
<td>64</td>
</tr>
<tr>
<td>5 to 10 acres</td>
<td>35</td>
<td>32</td>
</tr>
<tr>
<td>More than 10</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Author’s computation from field survey (2019).

other farmers (Table 2). However, while 100% of the beneficiary farmers expectedly seek information from AEAs, non-beneficiaries do not. A potential explanation for the low patronage of AEAs services among non-beneficiary farmers could be due to awareness. Some farmers may not even be aware of the existence of AEAs in their communities. Hence, there may be reasons to create awareness and enlighten farmers about the roles of AEAs in the communities.

Furthermore, a considerable proportion of the beneficiary farmers depend on Mobile Apps and internet sources as part of the modernized extension service system. The results, however, suggests that farmers’ use of Mobile Apps and Internet sources to seek information is relatively low. For instance, only 9 and 22% of the beneficiary farmers used Mobile Apps and Internet sources respectively. Non-beneficiary farmers do not use Mobile Apps and Internet Sources. The relatively low patronage of Mobile Apps and Internet sources could be attributed to high levels of illiteracy, incompatibility of mobile equipment and/or inadequate access to internet facilities. For instance, the demographic information reveals that more than 60 percent of the respondents do not have formal education (Table 1). This likely makes it challenging for them to read/write and hence, affects their ability to access information using internet and mobile apps. Furthermore, most Mobile Apps are usually more compatible with smartphones technology. Hence, farmers without these smartphones may find it challenging to use the apps.

Productivity difference between beneficiary and non-beneficiary farmers

The results of productivity difference are presented in
Table 2. Respondents sources of information.

<table>
<thead>
<tr>
<th>Source</th>
<th>Beneficiary</th>
<th>Non-beneficiary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Apps</td>
<td>Yes: 10 (9%)*</td>
<td>No: 100 (91%)</td>
</tr>
<tr>
<td></td>
<td>Yes: 180 (100%)</td>
<td>Non: 180 (100%)</td>
</tr>
<tr>
<td>Internet sources</td>
<td>Yes: 24 (22%)</td>
<td>No: 86 (78%)</td>
</tr>
<tr>
<td></td>
<td>Yes: 172 (96%)</td>
<td>Non: 172 (96%)</td>
</tr>
<tr>
<td>Extension Agents</td>
<td>Yes: 110 (100%)</td>
<td>Non: 0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Yes: 180 (100%)</td>
<td>Non: 180 (100%)</td>
</tr>
<tr>
<td>Other farmers</td>
<td>Yes: 77 (70%)</td>
<td>No: 33 (30%)</td>
</tr>
<tr>
<td></td>
<td>Yes: 155 (68%)</td>
<td>Non: 25 (14%)</td>
</tr>
</tbody>
</table>

Source: Author’s computation from field survey. 2019.
*Figures in parentheses represent percent.

Table 3. Productivity of beneficiary and non-beneficiary farmers.

<table>
<thead>
<tr>
<th>Sample statistic</th>
<th>Beneficiary</th>
<th>Non-beneficiary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity (kg/acre)</td>
<td>870</td>
<td>730</td>
</tr>
<tr>
<td>Productivity variance</td>
<td>8292</td>
<td>7531</td>
</tr>
<tr>
<td>Sample size</td>
<td>110</td>
<td>180</td>
</tr>
</tbody>
</table>

Source: Author’s computation from field survey (2019).

Table 4. T-statistics.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Estimated value</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-calculated</td>
<td>14</td>
</tr>
<tr>
<td>t-critical at α=1%</td>
<td>1.645</td>
</tr>
<tr>
<td>t-critical at α=5%</td>
<td>1.960</td>
</tr>
<tr>
<td>t-critical at α=10%</td>
<td>2.576</td>
</tr>
</tbody>
</table>

Table 3. The average productivities for beneficiary and non-beneficiary farmers are approximately 870 and 730 kg/acre respectively. Thus, the output of beneficiary farmers is about 140 kg/acre more than their non-beneficiary counterparts. The estimated t-statistic for the data is 14. Comparing t-calculated with t-critical values at 1, 5 and 10% (Table 4) show that t-calculated is greater than t-critical values. This implies that farmers who benefitted from the modernized extension service were more productive than the non-beneficiary farmers. The results agree with Danso-Abbeam et al. (2018) who showed that access to extension services is associated with productivity gains among rice farmers in the northern Ghana. Nevertheless, this result must be interpreted with caution since this finding does not attribute the productivity difference to the extension service. The findings primarily reveal that respondents who had access to modernized extension services were more productive. An analysis of attribution/causality can be established once the implementation of the PFJ program is complete.

CONCLUSION AND RECOMMENDATIONS

The study concludes that farmers depend on a variety of information sources to support their farming activities. In all, farmers who benefitted from the modernized extension service were more productive than their non-beneficiary counterparts. This is important to ascertain whether or not the observed productivity differences are due to some other factors other than access to extension service.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Survey on indigenous knowledge of farmers in identifying enset varieties at Labu Koromo Kebele in Dore Woreda, Sidama Zone

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Received 16 August, 2019; Accepted 29 April, 2020

Enset is a multipurpose plant, of which every part is thoroughly utilized, cultivated, as a food and crop only in Ethiopia, particularly in the southern and southwestern parts of the country. The main objective of this research is to assess the indigenous knowledge of farmers for identifying the different enset varieties grown in Labu Koromo kebele, Dore woreda. The data were collected using open and close ended questionnaires, key informative, oral interview and field observation. There are different characteristics that farmers use to differentiate enset variety such as leaf color, midrib and pseudo stem. According to the responses of farmers, enset variety at Sidama Zone is estimated to be 51 to 60. Among this amount of enset diversity, 11 to 20 were recorded in Dore woreda. Upgrading the indigenous knowledge of farmers is required in the future for better recognition and standard. Moreover, further study regarding the varieties growing at Dore woreda is required for scientific documentation.

Key words: Dore woreda, Enset, farmers, Sidama zone, variety.

INTRODUCTION

Enset (Ensete ventricosum (Welw) Chessman) is known to exist in Asia and Africa (Gebremariam et al., 1997; Baker and Simmonds, 1953). It is a perennial, herbaceous and long broad leaves endemic root crop plant in Ethiopia, which belongs to musicale family. This crop is widely grown in home gardens in central, south and southwest part of Ethiopia for its food, forage, fiber, and medicinal uses. It contributes to food security (a traditional staple food crop) for more than 20% of Ethiopian's population, notably Southern and southwest parts of Ethiopia (Shigeta, 1996; Ayele and Omprakash, 2014).

Enset is grown and distributed at altitudes between 1600 and 3000 m above sea with an average annual rainfall of 1100 to 1500 mm and it is chiefly propagated (Tshehay and Kebebewu, 2006). It is one of major economic and socio-cultural important crops for a wide range of smallholder households in the country's population as staple and co staple food, and also used as a traditional medicine (Tsegaye and Stiruk, 2001; Magule et al., 2014). Enset has been known to play the role of a barrier food deficit for humans and feed for animals during the dry spell and recurrent drought, due to its resistance to fluctuating rainfall patterns after establishment (Belachew...
et al., 2017).

Each plant takes 4 to 5 years to mature, at which time a single root will give about 40 kg of food. Due to the long period of time from planting to harvest, plantings need to be staggered over time, to ensure that there is enset available for harvest in every season. Enset tolerates drought better than most cereal crops (Hunduma et al., 2015). Wild enset plants are produced from seeds, while most domesticated plant are propagated from suckers. Up to 400 suckers can be produced from just one mother plant. Enset can be intercropped with maize and coffee (Addis et al., 2008). The crop can withstand relatively long period of drought (about 5 months). It is noted for its tolerance to environmental fluctuations, storability, and for its multiple uses that play a pivotal role in preventing famine. Such uses coupled with cultural values make enset attractive to the people in the enset agro ecology of the county, particularly south and southwest parts (Ayele and Omprakash, 2014). Sizes of enset plant vary depending on management, the enset type/cultivar, soil type and fertility, amount and distribution of rainfall, and altitude of the area. It reaches up to 10.3m in height and the girth at the fattest point can be up to 4m. The corn and leaf sheathes are the main sources of human and animal feed. The major foods obtained from enset are kocho and bulla which are obtained from pseudo stem and leaf petioles and the other types is amicho obtained from the underground corm that is eaten boiled (Alem, in press; Hunduma et al., 2015).

General description of the plant

Given the restricted geographical distribution of domesticated enset and the degree of complexity and variability in contemporary enset agricultural system, agronomists and biogeography’s have long considered the Ethiopia highlands to be the primary center of origin for enset agriculture (Uloro and Mengel, 1994; Brandt, 1996). Anthropologist, Archaeologist, Historians, and other scholars have also developed theories that argue for the domestication of enset in Ethiopia as early as 10,000 years ago and today the vast majority of enset farmers live in southern Ethiopia currently; thus, enset distribution is restricted to south, south west, and central part of Ethiopia and it is not known as food crop in Northern part of Ethiopia. However, historical evidence suggests that enset may have once played a much more important role in the agricultural practice of central and Northern Ethiopia before mid-19th century. The possible reason for total disappearance of enset culture in the North could be disease, drought and instability in the sociopolitical events between 1700 and mid 1800 (Kefale and Stanford, 1991; Brandt et al., 1997).

Uses of enset

Enset is a staple food crop for 15 million people; it provides year round food, fiber, animal food, medicine. It gives higher yield per unit area (25 t ha⁻¹ year⁻¹) than wheat (Adimasu and Struik, 2001). In Ethiopia, enset is cultivated for food. The edible part of the plant is formed by the pseudo stem and the underground corm (Zerihun et al., 2014).

Food use of enset

The major food obtained from enset is kocho, bulla and amicho. Kocho is bulk of fermented starch obtained from the mixture of the decorticated (scraped) leaf sheath grated corm (underground steam base). Kocho can be stored for long periods of time without being spoiled. The quality of kocho depends on the age of the harvest enset plant the type of clone (variety), and the harvesting season. Moreover, within one plant, the quality is influenced by the part of leaf sheath and corm processed. The preferred type is white in color and it is obtained from the inner most leaf sheath and inner part of corm, while the lowest grade is blackish and is obtained from the outer leaf sheath and corm. Although many different dishes are prepared, kocho, pancake-like bread is the most common one. Currently Kocho has become extremely popular at restaurants particularly those who serve kitfo row ground beef mixed with butter and spices, (Adimasu and Struik, 2001). Bulla is obtained by: 1) scrapping the leaf sheath, peduncle, grated corm into a pulp; 2) squeezing liquid containing starch from the pulp; 3) allowing the resultant starch to concentrate in to a white powder by removing the water by evaporation and 4) rehydrating with water it is considered the best quality enset food and is obtained mainly from fully matured enset plants. Bulla can be consumed in the form of pancake, porridge or dumpling. Amicho is prepared from boiled enset corm, usually of a younger plant. Enset plant may be uprooted for preparing meals quickly if the amount of enset harvested is insufficient, or for special occasions. The corm is boiled and consumed in a manner similar to preparation methods for other root and tuber crops. Certain clones are selected for their amicho production (Brandt et al., 1997; Taye, 1984).

Medicinal uses of enset

Particular clones (landraces) and parts of enset plants are used medicinally for both humans and livestock to cure bone fractures, broken bones, childbirth problems (that is assisting to discharge the placenta), diarrhea, and birth control (Brandt et al., 1997).

Socio economic value

On the top of the food value, enset products are used for making ropes, mats, building houses and making pads.
The pseudo stem yields very strong fibers, even up processed leaf sheaths is used for tying livestock, harvests from fields, and building fences. According to Brandt et al. (1997), the fibers have excellent structure and its strengths is equivalent to the abaca, a world class fibers crop. The enset plant can also be sold in some cases and the processed products like kocho and bulla are sold any time in the rural areas.

Enset variety

Land race is a variable population, which has a local name, lacks formal improvement and is associated with the traditional uses, knowledge, habits, and celebration of the people who continues to grow it (Merser and Perales, 2010). There were various enset varieties grown in Sidama zone having various purposes depending upon the type of variety used by the society. Thus, the aim of this study is to assess the indigenous knowledge of farmers for identifying different enset varieties at Labu Koromo Keble in Dore woreda.

MATERIALS AND METHODS

Description of study area

Sidama has geographic coordinates of latitude, north: 5° 45’ and 6° 45’ and longitude, East, 38° and 39°. It has a total area of 10,000 km², of which 97.71% island and 2.29% is covered by water. Hawassa city is the capital of the zone and the region. Hawassa Lake and Logita falls are water bodies that attract tourists. Of the land, 48.70% is cultivated, 2.23% is forest, 5.04% is shrub and bush land, 17.47% is grazing land, 18.02% is uncultivated, 5.38% is unproductive and 2.10% has other uses. Some of the cultivated lands are in undulating escarpment and create difficulties for the farmers in the area. Sidama has a variety of climatic conditions. Warm conditions cover 54% of the area. Locally known as Gamojoj or Woinadega, this is a temperate zone ranging from an elevation of 1500 m to 2500 m above sea level. The mean annual rainfall of the area varies between 1200 mm and 1599 mm, with 15 to 19.9°C average annual temperature. A hot climatic zone, Kolla, covers 30% of the total area. Its elevation ranges from 500 to 1500 m above sea level. It has a mean annual rainfall of 400 to 799 mm, and the mean annual temperature ranges from 20 to 24.9°C. Cool climatic conditions known as Aliicho or Dega exist in the mountainous highlands. This covers 16% of the total area with an elevation between 2500 and 3500 m above sea level. This part gets the highest amount of rainfall, ranging from 1600 to 1999 mm. It has a mean annual temperature of 15 to 19.9°C (Sidama Development Corporation planning and statistic, 2000). The present study was carried out at Dore woreda (Hawassa Zuria) of Sidama zone south nation Nationalities, and peoples’ Region. Dore (Hawassa Zuria) is located 22 km from the city of Hawassa at the direction of East has a Population size of is 124,472, of whom 62,774 are men and 61,698 women based on the 2007 census data.

Method of data collection

The data was collected using both open and close ended questioners. In addition oral interviews and discussions were also carried out to gather additional information on the targeted issues. The major contents included in the questionnaire were: the common methods of identifying enset varieties, the regularly grown species in the area, and the socioeconomic values of those varieties. All the data was collected using systematic random sampling from January 2018 to May 2018 in the selected kebele. All knowledgeable people in each locality were listed first and 30 from each locality were selected based on lottery method for the survey.

Data management and analysis

The collected data were organized and entered into the excel spread sheet and verified prior to analysis, by means of percentage calculation using excel. The calculated percentages are presented using table, with respective categories and responses.

RESULTS AND DISCUSSION

Table 1 show category and number of respondents of data analysis. Farmer’s rich knowledge accumulated on the crop over many years has played a significant role in naming, characterizing and maintaining of the existing genetic diversity. The classification of enset land races has been accommodated by phenotypic differences, unique traits and specific uses of land races, as pointed out by Olanjo (2008). As the results have shown in the table, there are 50 to 60 varieties, estimated in Sidama zone by the farmers. In contradist of this 87 varieties has been reported by (Tesfaye, 2008). This variation is due to climatic variation and adaptation. 10 to 20 varieties were estimated in Dore woreda, this is due to climatic variation. Contradicting there are 55 varieties in Aleta chuko district as pointed by Amare and Daniel (2016). Geenna, ado and madicha are dominantly found in Dore woreda. This could be probably due to environmental adaptation and climatic variation. The varieties that are preferred for food are Geenna, madicha and ado. This could be that those varieties are more productive and familiar to the people. The farmers used enset variety for animal food, building houses, twist ropes and for making pads. Similar result has been reported (Hunduma et al., 2015). The time of maturation estimated by farmers is four years, five years and six years. This could be due to adapting to environmental condition, temperature and rainfall. Similar with this result is that reported by Mulalem and Walle (2014). The varieties requiring longer period to mature are Geenna, Ado and Madicha. The consequence of the climatic condition is that those varieties grow slowly. There are different charactersistics that farmers use to differentiate enset varieties. Leaf color, midrib and pseudo stem color have been used by the farmers to identify one variety from the other. This could be because they are observable morphological parts of the plant. A similar result has been reported by Tesfaye (2008). Farmers use enset as source of income, as farmers reported in the study cite that all enset varieties are used for income. This could be as a result that people depends on maize; this means they do not know more enset varieties gives
Table 1. Category and number of respondents of data analysis.

<table>
<thead>
<tr>
<th>Number</th>
<th>Category</th>
<th>Responses</th>
<th>Number of respondents</th>
<th>Frequencies (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Estimated no of enset variety existing at Sidama zone</td>
<td>10-20</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21-30</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31-40</td>
<td>7</td>
<td>23.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>41-50</td>
<td>5</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>51-60</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td>2</td>
<td>Those that exist at Dore woreda</td>
<td>10-20</td>
<td>22</td>
<td>73.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21-30</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td>3</td>
<td>Which methods are frequently used to identify one variety from the</td>
<td>Leaf color</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steam color</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Length</td>
<td>13</td>
<td>43.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size</td>
<td>19</td>
<td>66.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Petiole</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>The most commonly found varieties at Dore woreda</td>
<td>Geenna</td>
<td>27</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Madicha</td>
<td>18</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ado</td>
<td>18</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kambaticha</td>
<td>5</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Haassa</td>
<td>10</td>
<td>33.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wankoore</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agana</td>
<td>2</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kitiicha</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Varieties that are preferred for food</td>
<td>Geenna</td>
<td>21</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Madicha</td>
<td>19</td>
<td>66.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ado</td>
<td>11</td>
<td>36.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Haassa</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wankoore</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agana</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kitiicha</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For animal food</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For building house</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Other uses than food</td>
<td>For twist rope</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For making pad (making mat)</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>Estimated time of maturation</td>
<td>Four year</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Five year</td>
<td>23</td>
<td>76.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Six year</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>8</td>
<td>A variety requiring longer period to mature</td>
<td>Madicha</td>
<td>20</td>
<td>66.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ado</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Geenna</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kitiicho</td>
<td>2</td>
<td>6.6</td>
</tr>
<tr>
<td>9</td>
<td>Which of them are used as source of income?</td>
<td>All variety</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>Basis for naming the varieties</td>
<td>Not known by the farmers</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cabbage</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>11</td>
<td>Plants co-cultured with enset</td>
<td>Coffee</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maize</td>
<td>12</td>
<td>40</td>
</tr>
</tbody>
</table>
income. The plants co cultured with enset are cabbage, coffee and maize, since none of those plants damage the enset varieties when cultured with them. This idea has been reported by Addis et al. (2008). The bases for naming the varieties are not known by the people, this is because it is named by the traditional people. A similar result has been reported by Magule et al. (2014).

Conclusion

From the present study, it has been confirmed that farmers use their own indigenous knowledge to identify one enset variety from the others. Leaf color, midrib and pseudo stem color were confirmed as the most frequently used morphological characteristics to distinguish one variety of enset from the other. In addition, Geenna, madicha, ado are dominantly found in Dore woreda and two of these (Geenna and Medicha) are preferred for food. There are some plants that can be co cultured with enset varieties, such as cabbage, coffee and maize.

Recommendations

Based on the finding of the study the following recommendation was made:

(i) The local naming of enset varieties needs to be recognized and standardized with a better scientific procedure/knowledge.

(ii) Non-food uses of enset were not well documented and number of enset varieties that exist in Dore woreda are not well documented so further study is also required.

(iii) Valuable and productive varieties are not really known by the farmers; thus, it needs scientific approval in the future.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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- International Journal of Livestock Production
- Journal of Agricultural Biotechnology and Sustainable Development
- Journal of Agricultural Extension and Rural Development
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