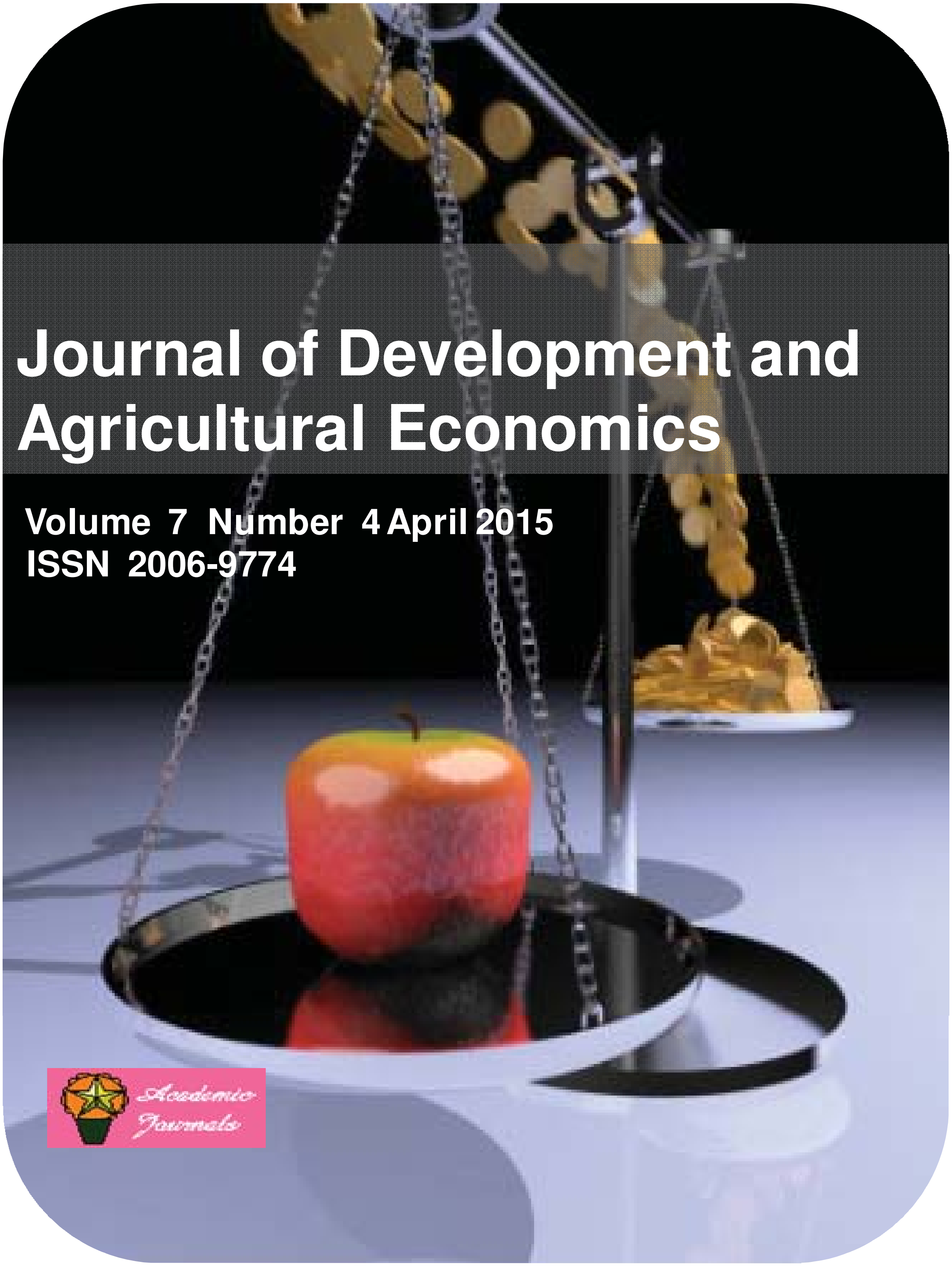

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Table of Contents: Volume 7 Number 4 April 2015

ARTICLES

Research Articles

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Journal of Development and Agricultural Economics

Full length Research Paper

Bread wheat production in small scale irrigation users agro-pastoral households in Ethiopia: Case of Afar and Oromia regional state

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Conceptually, benefits of irrigation are realized through improvements in agricultural productivity. At household level, agricultural production increases could be followed by improvements in food consumption patterns. The goal of this research is to examine relationship between irrigation, production and consumption patterns for rural smallholders with pre-scaling up of bread wheat (Ga'ambo variety). A survey was undertaken and data collected on demographics, landholdings, irrigation, returns, consumption behaviors, farmer perceptions, experiences, and other related variables. The results show that using irrigation to the production of bread wheat has positive impact in yield. Though overall production increases the agricultural income of households but amounts spend on food for each household did not increase as consequence because the produced wheat was changed as food source in the form of bread, Injera, Qolo and other forms. However better dietary diversity was found on the consumption pattern of the households with higher income since part of the generated yield was supplied as a seed to the surrounding agro-pastoral wheat producers. Integrated approaches are needed to secure a healthy diet when the food supply of the family is increasing from the cereal part. The average total land holding was found 2.9 ha while the average land cultivated in the bread wheat production at the season was 1.4 ha. Average years of experience of agro-pastoral households in using different improved verities were 2.5 years which had good contribution in production management. The seed amount used on average for the production was found 84.5 kg/ha which lies between the national recommendation which is 80 to 90 kg/ha for irrigated areas while the average seed cost was 13.1 birr (Ethiopian currency) per kg. The average yields collected from the small scale irrigation users were found 31.8 quintal (which is about 3,180 kg) yet at individual levels it was varied from 15 to 37.3 quintals the variation was because of management practice with keeping other heterogeneous factors constant.

Key words: Bread wheat, yield, irrigation, land, extension, labor, food consumption, dependency ratio, adult equivalent.

INTRODUCTION

Wheat *(Triticum aestivum L.)* is one of the important grain crops produced worldwide. Ethiopia is the second largest wheat producer in sub Saharan Africa, next to South Africa, area under wheat cultivation expanded from 1.4 million hectare 2004/05 to 1.6 million hectare by 2010/11 and from these the production yield was 2.9 million tones.

Table 1. Wheat import trade in Ethiopia /2005-13/.

Wheat	2005	2006	2007	2008	2009	2010	2011	2012	2013
Import Q_T	862,145	328,306	384,127	1,100,050	1,111,522	1,048,704	953,237	851,037	792.941

Source: Authors elaboration based on UNCOMTRADE data.

Table 2. Per capita calories.

Crop	Urban	Rural	National	% of National
Wheat	200.59	309.79	294.30	12.63

Source: Guush Berhane et al. (2011).

Wheat accounts for the fourth largest share of total cereal production (Table 1).

Wheat is not only for making bread, biscuit and pastry products, but also for the production of starch and gluten. The raised bread loaf is possible because the wheat kernel contains gluten, an elastic form of protein that traps minute bubbles of carbon dioxide when fermentation occurs in leavened dough, causing the dough to rise (Hanson et al., 1982).

Sources of growth in smallholder agriculture

Central to the role of agricultural growth in Ethiopia is an understanding of the mechanism by which the agricultural sector itself can grow. Partial equilibrium, taking such factors as prices and demand in other sectors as exogenously given, in order to understand the relationship between the general economy context and the progress of the agricultural sector. Taking agricultural growth to endogenous and understanding how incentives in other sectors drive the direction of agricultural growth is fundamental: these incentives provide the multipliers tat sustain impact of well-designed policies over time.

Within smallholder agriculture, we focus on wheat productivity: First intervention to adopt Ga'ambo variety (bread wheat) which is a new technology to Amibara and Fentale districts.

Consumption

In Ethiopia, wheat grain is used in the preparation of a range of products such as: The traditional staple pancake ("injera"), bread ("dabo"), local beer ("tella"), and several others local food items (that is, "dabokolo","ganfo", "kinche"). Besides, wheat straw is commonly used as a roof thatching material and as a feed for animals. Wheat contributes; approximately 200 calories per day in urban areas compared to about 310 calories in rural areas (Table 2). It accounts for about 12% of the national calorie intake.

The role of extension

The conventional method of transferring knowledge and experience amongst farmers and so facilitating the scaling of innovations has been the extension service, typically a government institution under the Ministry of Agriculture and Research Institutes.

In addition, extension services have seen significant modifications in the way in which they are provided. Early approaches favored a top-down model where agro-pastoral were passive recipients of the 'knowledge' transferred by extension agents.

Over time, extension training has broadened in scope and is more relevant to the needs of sustainable intensification, covering issues such as nutrition as well as more typical topics such as integrated pest management. It has also been built on participatory models, which treat agro-pastoral as more dynamic participants and sources of knowledge, or even as the trainers' themselves as model agro-pastoral.

Reaching agro-pastoral

The challenge of reaching agro-pastoral over often large and remote areas has also generated interest in the potential of new technologies to help foster linkages. Pre-scaling up were important for getting innovation to scale and helping deliver knowledge to rural smallholder agro-pastoral over a wide area.

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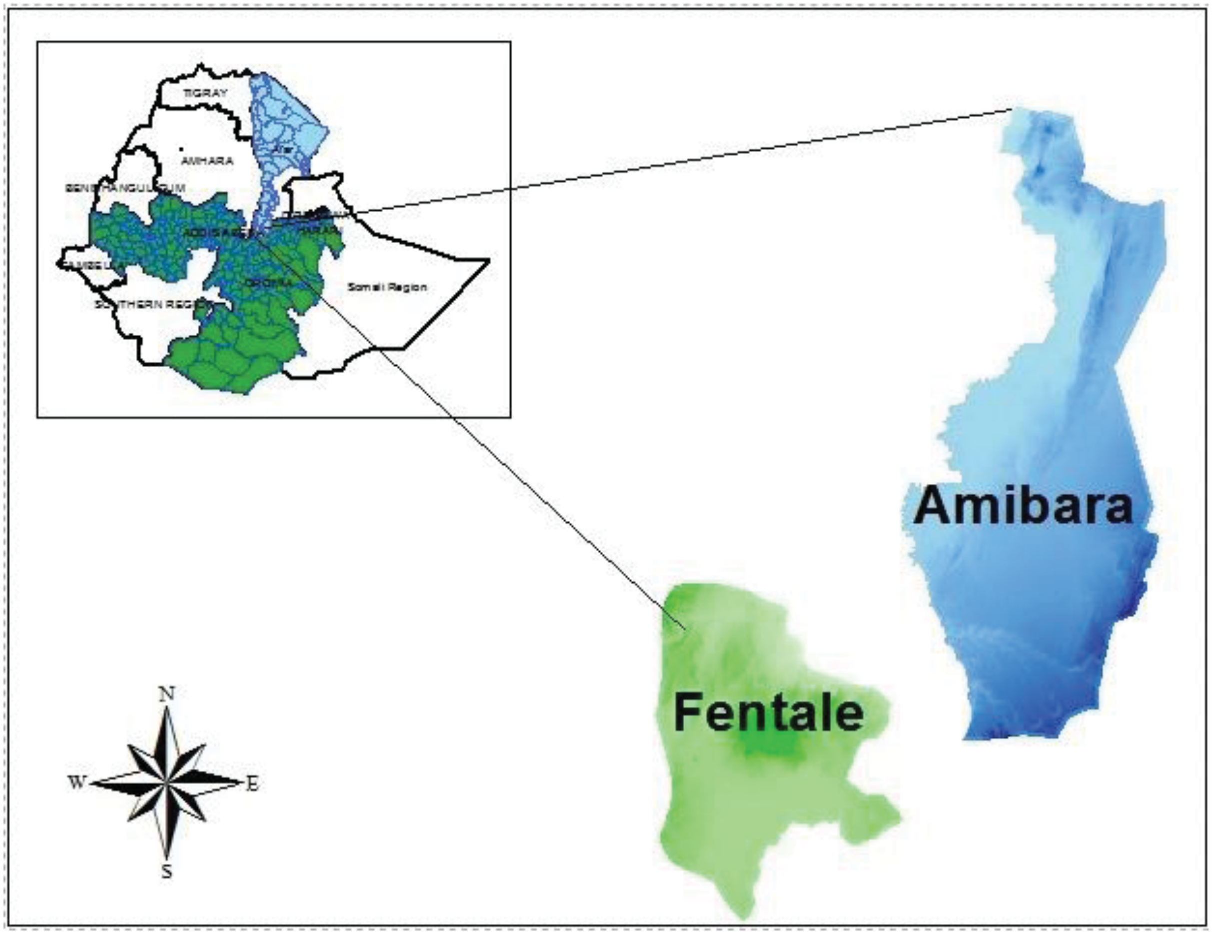

Figure 1. Pre-scaling up of bread wheat sample districts.

METHODOLOGY

Description of the study area

This research consisted of two sets of experiments namely assessment of bread wheat production in pre-scaling up methods and local marketing systems for the supply. The bread wheat production and marketing systems survey was conducted only in Amibara district of Afar regional state and Fentale district of Oromia regional state of Ethiopia (Figure 1).

Amibara woreda is one of the 30 woredas in the Afar Region and part of the Administrative Zone 3, it is bordered on the south by Awash Fentale, on the west by the Awash River which separates it from Dulecha to the southwest then on the northwest by the Administrative Zone 5, on the north by Gewane, and on the east by the Oromia Region. Towns in Amibara include Awash Arba, Awash Sheleko, Melka Sedi and Melka Were. Based on figures published by the Central Statistical Agency (CSA) in 2008, this woreda has an estimated total population of 63,280, of whom 35,301 were males and while 27,979 females. From the population 16.37% are agro-pastoral both raise crops and livestock, while 1.7% only grow crops and 81.93% only raise livestock.

Fentale is one of the 180 woredas in the Oromia Region of Ethiopia. Part of the Misraq Shewa Zone located in the Great Rift Valley, Fentale is bordered on the southeast by the Arsi Zone, on the southwest by Boset, on the northwest by the Amhara Region, and on the northeast by the Afar Region. The administrative center of Fentale is Metehara; other towns include Addis Ketema. The Fentale woreda has an estimated total population of 82,225 of which 43,510 are male and 38,715 are female (CSA, 2008).

Bread wheat production and marketing system survey

Amibra district has semi-arid agro-ecologies and bread wheat is grown in irrigated user parts of the district. Therefore, bread wheat production and systems assessment study was carried out in the irrigation user parts of the district. Sample agro-pastoral associations (APs) for this study were selected following random sampling technique. As a result, four peasant associations namely, D-3, Bonta and Bedul-alea and in Fentale district Eilala, Gidara and Derea-sedi Aps were selected as sample Aps from the two pre-scale up districts.

Innovative markets

As with other approaches, agro-pastoral-research institutes (center) partnerships can be instrumental in generating appropriate market innovations. Interventions to supply agro-pastorals with the resources they need to be productive, innovative and to sustainably intensify are critical. But there are innumerable potential points for innovation along the value chain from field to end users- better methods of harvesting and storage, processing and quality control,

Table 1. Household characteristics of the study area.

Character	Amibara	Fentale	Total	χ^2
Gender				
Men	97.3	98.1	97.7	
Women	2.7	1.9	2.3	
	100	100	100	5.1
Marital status				
Single	3.3	4.2	3.6	
Married	86.7	75.0	82.6	
Polygamous	8.9	20.8	13.4	
Widow	1.1	-	0.7	
	100	100	100	4.5
Education				
Illiterate	40.0	60.4	47.1	
Informal	24.4	6.3	18.1	
Primary	16.7	10.4	14.5	
Secondary	18.9	16.7	18.1	
Diploma	-	4.2	1.5	
Degree	-	2.1	0.7	
	100	100	100	15.0***

***, ** and * indicate significance at 1, 5 and 10% respectively, χ^2 the chi- square significance.
Source: Survey data (2013).

improved links to markets, and selling strategies.

National markets

The biggest challenge in going to scale is to bring not only market information to smallholders but to help them connect to national markets, since this will significantly increase their returns. Local markets are now springing up in many parts of rural Ethiopia. The challenge is to link them to national markets so that agro-pastoral even in remote places can get good prices.

To characterize the wheat production and marketing systems of Amibara district, preliminary visits were made to develop questionnaire. The questionnaire had many open ended questions that allowed respondents to express their opinions on Ga'ambo bread wheat production and marketing issues. Both secondary and primary data sources were used for this study. Primary data was collected using formal survey. Information was gathered using semi-structured questionnaire. The questionnaire pre-tested prior to the actual survey to assess its clarity and check the possibility of collecting all necessary information using this questioner. The main themes of the survey would be bread wheat production, marketing systems and major constraints and opportunities of bread wheat production and marketing systems that the suppliers encountered. The following are some of the questions included in the questioner.

In bread wheat production system land holding/hh, area of crop land, varieties preference, major diseases and control measures and cost of wheat production were included. In bread wheat marketing bread wheat marketing season, major buyers, price per quintal, factor affecting market price, place of sale and major marketing problems were included.

Data analysis

The statistical analysis was conducted using appropriate statistical software; Statistical Package for Social Science (SPSS) Version 16 was used to analyze the bread wheat production and marketing systems data collected through the survey.

According to Wudnesh (1991) the labor input of household members in each activity will calculated as follows:

The labor-hours spent to perform bread wheat production were calculated by using the following formula:

$$MHY=T*N*F$$

Where, MHY = labor-hour/household/production season; T = time taken to do the job/day, week or month; N = number of people engaged in the job, and F = frequency per production season.

RESULTS AND DISCUSSION

Irrigation and bread wheat production

Awash River has created opportunities for irrigation development, which is believed to be a means for livelihood improvement in the basin area. Nighty percent of the respondents is practicing irrigated agriculture only while 10% are rain-fed and irrigation.

Socio-economic characteristics of households
Household characteristics

Almost all the total sampled bread wheat households (95.4%) were men headed while 4.6% of the respondents were women headed households. The marital status of

Table 4. Access to extension service.

Characters	Amibara	Fentale	Total	χ^2
Accessed extension service	74.4	72.9	73.9	
No extension service	25.6	27.1	26.1	
Total	100	100	100	3.8
Contact extension service				
Weekly	15.9	18.8	16.9	
Biweekly	19.3	14.6	17.7	
Monthly	28.4	27.1	27.8	
Whenever I want	20.5	24.9	22.1	
At production season	15.9	14.6	15.5	
	100	100	100	5.1*
Training wheat production				
Land preparation	30.6	30.3	30.5	
Disease and pest control	22.8	23.9	23.2	
Post-harvest	23.8	23.9	23.9	
Inputs use	22.8	21.9	22.4	
			100	5.4**

***, ** and * indicate significance at 1, 5 and 10% respectively, χ^2 the chi- square significance. Source: survey data computed, 2013.

the sample respondents were married (94.2%) while 5.8% were single (Table 3). The average age of the respondents was 46 years with a minimum and maximum age of 22 and 67 years, respectively.

Social, economic and institutional interventions are crucial to innovation for sustainable intensification because they ensure that higher yields and production result in real benefits to agro-pastorals and they provide much of the enabling environment in which bread wheat production with innovation can flourish and be resilient and sustainable. It has been increasingly recognized in recent years that flourishing, efficient and fair markets, both for inputs and produce, are crucial to intensification of pre-scaling up technologies. ‘We have seen firsthand the power that providing skills and market access can have in empowering smallholder farmers to boost their production, improve their nutrition and increase their incomes – when managed effectively and coupled with appropriate technologies. In the sample district smallholders irrigation users of a very high proportion have very weak links to markets and other institutions.

Agro-pastorals extension services

As part of the Structural Adjustment Program (PAS), the government of Ethiopia has been increasing the size of the extension service and improving the service provided by development agents but yet focusing on the quality of service and contact frequency matters a lot in technological pre-scaling out to the small holder producers.

The small holder survey reveals that extension agent contact with in the production season yet is low according to the producers key informant discussions in the base line data. From preliminary survey 74.4 and 72.9% of the interviewed had had contact with an extension agent prior to the survey in Amibara and Fentale districts while 25.6 and 27.1% of the agro-pastoral reported that have no access to extension services. In addition, the farmers extension contacts have contribution to the productivity of the yield and quality in the wheat production; yet the survey in the sample producers found (28.4%) were found they have monthly contacts while (15.9%) were found to have contacts of the extension agent at the weekly base on the production season in Amibara Woreda, while in Fentale district (27.1%) establish con-tacts in monthly based yet (18.8%) and (14.6%) where have access to the extension agent in a weekly based and at production season of wheat respectively the chi-square analysis is significant at (5.1) with level of (10%) which states there a significant difference in the contact of extension period (Table 7).

The survey result indicate that training that are given to producers with the production of wheat in the district are land preparation, disease and pest control, post-harvest handling, marketing and input use. From these trainings land preparation was taken by (30.6%) of the producers in Amibara while (30.0%) from the Fentale. The types of assistance provided by extension agents did not have significance variation across samples (Table 4).

Land allocated

Based on the analysis, the average total land holding 2.9

Table 5. Average total land holding and average seed price.

Character	Amibara	Fentale	Total	t-test
Average total land holding	3.45	2.43	2.9	9.2***
Average land for wheat	1.92	0.89	1.4	9.6***
Years of experience in technologies application	3.1	1.92	2.5	4.6*
Seed used (kg/ha)	82	87	84.5	5.0**
Seed cost(birr/kg)	12.75	13.50	13.1	9.9***
Average yield per ha	35.3	28.2	31.8	

***, ** and * indicate significance at 1, 5 and 10% respectively; Seed coast is estimated by the market price of bread wheat seed
Source: survey data computed, 2013.

Table 6. Household labor contribution.

Characteristic	Amibara	Fentale	Total	χ^2
Family size	7.1	5.5	6.3	15.7**
Adult equivalent	6.3	5.2	5.0	98.0***
Dependency ratio	1.5	1.3	1.2	20.1**

***, ** and * indicate significance at 1, 5 and 10% respectively; Source: Survey data, 2013.

ha from the total sample yet the distribution in the sample area varies with 0.25 and 3.12 ha, while the average land allocated for wheat production was found 1.92 and 0.89 ha in Amibara and Fentale districts respectively. The seed amount used per hectare was ranged from 80 to 90 kg/ha and average price per kg 12.65 birr (Table 5).

The owned cultivated bread wheat land size of sample respondents varied from 0.25 to 3 ha with an average holding of 1.4 ha and a standard deviation of 0.54.

Household labor contribution

According to CSA (2012), the average family size of Ethiopia is (5.4). However, in the study district the average family size in bread wheat producer households is 6.3. As a result, the adult equivalent varies from (7.1) to (5.5) in Amibara and Fentale households respectively (Table 6). The adult equivalent shows that Amibar households have better labor input than of Fentale.

Household dependency ratio shows the economically inactive labor compared with the economically active one. It is measured by dividing the number of non-working members; children under the age of 15 and elders above the age of 64 who cannot work by the economically active family members. Dependency ratio is widely used to measure the economic labor of the household and the burden on the members of the labor force within the household in the farming system in our case bread wheat production of Ga'ambo variety.

Dependency ratio is negatively related with income and economic labor of the household. Accordingly, the dependency ratio in district shows that each 100 economically active person had 150 and 130 extra person to feed in the Amibara and Fentale household respectively (Table 6). This shows that there is more dependency in the Amibara than Fentale in the bread wheat pre-scaling up technology users.

This contain an imperative connotation for the load on members of the labor force within the household which is positively correlated with high level of workload in the rural household context due to their high participation both in productive and reproductive activities that can affect productivity of wheat production system and the households have to produce more to feed the inactive labor.

Participation of family labor in bread wheat production

Farm activities: Farm activities include land preparation, plowing, sowing, weeding, harvesting, threshing, transporting and storage. As shown in Table 7, about 73 and 56% of land clearing tasks were performed by both gender of the family members in Amibara and Fentale areas, respectively, yet ranking it 84.4% in Amibara are tasks shoulder by men while 81.3% in Fentale. In the case of gaping 72.2 and 65.5% were done by both parts of the families considering gender issues but ranking it 63.3 and 72.8% were activities that are done by women part of the families in Amibara and Fentale districts respectively.

There is a strong justification that more labor hours spent in Fentale with production of bread wheat. The t-value for differences shown in Table 8 suggests a significant difference in the production levels of wheat at the 0.05 level of significance. In Ambra households spent

Table 7. Families labor participation in bread wheat production activities.

Activities	Participation		Rank	
	Amibar	Fentale	Amibar	Fentale
Land clearing				
Men	14.44	31.25	84.44	81.25
Women	1.11	2.08	4.44	6.25
Both	73.33	56.25	0.00	0.00
No participation	11.11	12.50	11.11	12.50
Plowing				
Men	24.44	37.50	56.67	50.00
Women	1.11	0.00	3.33	0.00
Both	34.44	12.50	0.00	0.00
No participation	40.00	50.00	40.00	50.00
Planting				
Men	6.67	12.50	27.78	22.92
Women	5.56	8.33	62.22	54.17
Both	77.78	56.25	0.00	0.00
No participation	10.00	22.92	10.00	22.92
Gapping				
Men	4.44	5.80	26.67	16.30
Women	13.33	18.12	63.33	72.83
Both	72.22	65.22	0.00	0.00
No participation	10.00	10.87	10.00	10.87
Weeding				
Men	1.11	8.33	66.67	27.08
women	2.22	2.08	22.22	60.42
Both	85.56	77.08	0.00	
No participation	11.11	12.50	11.11	12.50

Source: Survey data, 2013.

341.71' hours per four months in the production process bread wheat while 520.88' hours are spent in Fentale districts. This can be indicate that the more labor hours spent in the production activities can help the agro-pastorals to manage the efficiency of increasing yield yet efficiency are not only the matter of more time spent so further data are required for efficiencies analyses. On the other direction more time spent by household in Fentale area can for go in the expense other activities like livestock management or other activities yet out weight of comparative advantage must be considered which need further investigation.

In alkaline soils mono-ammonium phosphate (MAP) and ammonium polyphosphate (APP) can have an advantage over Di-ammonium phosphate (DAP). From this information the pH value of this soil is greater than 7 which were 8.2 in Amibara and 8.1 in Fentale sample district.so we can conclude that these soil is alkaline soils. Due to these value you can recombined that MAP and APP fertilizer can have an advantage over DAP. From the above result of the soil we can conclude that the EC value of the soils are less than 4 ds/m or 4 mmhos/cm and the PH value are less than 8.5.so, the soil type is non-saline soil. The organic matter (OM) in soil may account for anywhere from 3 to 75% of the total P in a soil (not necessarily the same as "available P").due to these literature these soil value of OM and TN are moderate. So, to form good condition for plant growth need more nitrogen source (urea) rather than DAP. Since; urea is a source of nitrogen and correlation with organic matter (Table 9).

CONCLUSION AND RECOMMENDATION

We believe that innovation for sustainable intensification is going to be essential if food and nutrition security is to be achieved in Ethiopia. It is a significant challenge. Inevitably in a briefing paper of this nature we raise more questions than we answer. Most important it is clear that we will need partnerships and research organizations to embrace the goal of sustainable intensification; we will

Table 8. Mean difference of average labor-hour spent on production process.

Statistical analysis	Amibara	Fentale
Average labor-hour per house hold in bread wheat production season 4 months	341.71	520.88
t-value	7.21***	

***, ** and * indicate significance at 1, 5 and 10% respectively.
Source: Survey Data (2013).

Table 9. Farm soil analysis.

Woreda	pH	E.C(ds/m)	%Total OC	% OM	% TN	Ca+Mg	%Clay	%Silt	%Sand	Texture class
Amibara	8.2	0.38	1.22	2.11	0.11	20.2	25.2	26	48.8	Sandy clay loam
Fentale	8.1	0.47	1.31	2.26	0.11	21.2	23.2	22	54.8	Sandy clay loam

Source: Survey Data (2013).

need fair and efficient markets; we will need systems of education that produce the Ethiopian innovators of tomorrow; for agro-pastoral innovation to be embedded in formal processes, and most importantly we need new technologies to address a wide range of food and nutria-tion security and environmental challenges in a variety of contexts. But for this to happen we have to develop appropriate cultures and institutions for innovation. In turn we will need supportive government policies and leadership creating enabling environments fit for the purpose of innovation for sustainable intensification of agricultural technologies at small scale irrigation users. We believe the questions raised in this paper provide the basis of an agenda for research, dialogue and policy making as we go forward for intervention with different agricultural technologies for food security with environ-mental development in addressing nutrition values for healthy society. For this to improve this paper argues that agro-pastorals need few key interventions, each requiring innovation in social, economic and institutional arenas.

Practical and policy interventions to improve farmer links to markets are as follows:

1. Facilitate access to high-quality seed, fertilizer and other inputs, storage materials that are practical and low-cost and professional advice.
2. Build the institutional capacity of agro-pastorals to allow them to self-organize at sufficient scale and complexity and thus benefit from collectively accessing credit, input and output markets.
3. Deliver market information on quality standards, prices and risks as well as support and advice to assist fledgling agro-pastoral enterprises to increase in size, impact and competitiveness.
4. Increase public sector investment in rural infrastructure, research and extension to improve physical access to inputs, services and markets and media access to information, for example on agro climatic risks.

Conflict of Interest

The authors have not declared any conflict of interests.

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Full length Research Paper

Climate change and household food insecurity among fishing communities in the eastern coast of Zanzibar

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This paper examines the local vulnerability of households in two study communities in the east coast of Zanzibar focusing on food security, which is negatively impacted by climate variability and change. Findings have indicated that overall the local people in eastern coast of Zanzibar are insecure with respect to most major sources of food. Households solely dependent on natural resources through farming, fishing, livestock and poultry farming, have been found to be more vulnerable to food insecurity as these activities are facing considerable uncertainties associated with climate change and variability as well as other stress factors. Agricultural failure resulting from various factors, including local climate variability, coupled with uncertainty of fishing has pushed many households towards increasing dependence on market for their staple food supplies. Therefore, this enhances the household's vulnerability to food insecurity especially among households with low purchasing power. With increasing demand of fisheries resources in urban areas associated with the expanding tourism industry in the study area the price for fisheries resources has increased, causing the poor, including the fishers, to consume less fish and other seafood, and thereby limiting their dietary protein intakes.

Key words: Agriculture, climate change and variability, coastal communities, fisheries based livelihoods, food insecurity, food accessibility, vulnerability, Zanzibar.

INTRODUCTION

The Fourth Assessment Report of the IPCC confidently contends that the observed climate variability and predicted changes in climate will potentially impact food and water security in Africa (Boko et al., 2007). Evidence in support of this argument include the considerable incidents of famine, food insecurity and water stress across Africa, which are partly associated with the variability of climate and the domination of El Niño Southern Oscillation (ENSO) events on the regional climatic patterns (Dai, 2011; Droogers, 2004). Similarly, more than 40% of people in Africa go to bed without enough nourishing food (Cordell et al., 2009). The east coasts of both islands of Zanzibar are frequently affected by localised food shortages and, are sensitive to even moderate abnormalities of rainfall. For instance, in 2010-2011 more than 7,000 people in Micheweni district, in north-east Pemba, where Kiuyu Mbuyuni (one of the study site) is located, did not have enough food (Said, 2011). This was caused by high fluctuations in rainfall which started around 2006 and which affected crop production. Indeed, even without climate variability, access to food for the majority of the households along

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the drier east coasts of both islands is problematic and is one of the major food security problems of Zanzibar (Boetekees and Immink, 2008). Rose (1994), cited in Walsh (2009) argues that even during the best years, malnutrition along the east coasts is widespread. This study therefore provides the data needed to inform future interventions to reduce poverty and vulnerability and to help to accomplish future sustainable development goals set to take off after 2015 when the current millennium development goals (MDGs) expire.

The definition of food security provided by FAO during the World Food Summit in 1996, and applauded by many, recognises food security as “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (Ericksen, 2008). Unlike previous definitions, this one highlights the role of food availability in connection to the accessibility of food for understanding food security at all levels (Ericksen, 2008). Since the 1970s, food security as a concept has evolved and has been defined extensively across disciplines because of its multi-disciplinary nature and complexity. However, it is now widely recognised that food security comprises four components: food availability, accessibility, stability and utilisation (Ziervogel and Ericksen, 2010; Balaghi et al., 2010; Ericksen, 2008).

Food availability is determined by the ability of households to produce, distribute and exchange food, while access to food is determined by affordability (purchasing power), allocation and preferences (social and cultural determinants influencing consumers). Utilisation is influenced by the nutritional value of the food, its social value and by food safety (Ziervogel and Ericksen, 2010; Ericksen, 2008). Indeed, all components of food security are tightly connected to various global and local determinants and thus they are sensitive to a number of stressors that may include environment, politics, ethics, employment, choices, land alienation and/or land grabbing, land degradation and climate variability and change (Chakrabortya and Newton, 2011; Ziervogel and Ericksen, 2010; Merino et al., 2012; Barnett, 2011; Wang, 2010; Charles et al., 2010). This highlights the fact that food insecurity is unevenly distributed both between and within social systems, as interactions between these determinants vary both between and within social systems or decision units, such as the household. For example at the household level, food insecurity may also be triggered by household choices and preferences influenced by livelihood security. A household may choose to go hungry to preserve assets and future livelihoods (Ericksen, 2008; Maxwell, 1996).

Climate variability and change is an additional pressure on food security and affects all four components of food security in many ways. Erratic rainfall, floods, increasingly warm conditions, increasing intensity and frequency of drought and storms and sea level rise (estimated at 1-2 mm/year) are likely to increase the problem of coastal and ocean problems in Zanzibar (Zanzibar Revolutionary Government, 2009) and affect livelihoods, purchasing power, distribution systems, health, freshwater availability for farming and domestic use, important agricultural areas and marine resources, and ultimately affect the stability of food resources (Hanjra and Qureshi, 2010; Ziervogel and Ericksen, 2010; Ericksen, 2008; Charles et al., 2010). Therefore, the poor, who have low coping strategies and those who are dependent on climate sensitive ecosystems, are highly vulnerable to food insecurity.

METHODOLOGY

Study areas

This study was conducted in Kiuyu Mbuyuni, in the north-eastern parts of Pemba Island, and Matemwe, in the north-eastern parts of Unguja Island (Figure 1). Pemba and Unguja islands together form the island nation of Zanzibar which is part of the United Republic of Tanzania and located offshore Tanzania mainland coast. Zanzibar experiences two rainy seasons, the long rainy season locally known as *masika* is usually received in March, April and May and short rainy season locally known as *Vuli* in October, November and December. In between these two seasons the islands experience summer season (dry period) locally known as *kiangazi* in January, February and March and winter seasons locally known as *pupwe* in Unguja and *mchoo* in Pemba in June, July and August. The annual average rainfall along the east of both islands where the study sites are located is around 1400 mm, while the central and western parts receive up to 2000 mm per annum. The rainfall of 1400 mm cannot be considered low, however, recent studies (Walsh, 2009; Mustelin et al., 2010) revealed that east coasts are experiencing variations in the distribution of rainfall, onset of the rainy seasons and general decline of rainfall received particularly during short rainy seasons. Figure 2 for example shows that a total of 11 out of 19 years experienced rainfall below average during short rainy seasons between 1992 and 2010. The average annual rainfall is 1678 and 1623 mm/year in Unguja and Pemba islands respectively. Both study sites fall in the coral rag agroecological zone, which is less fertile than other agroecological zones and get exhausted easily in terms of soil fertility under minimum pressure and erratic water supply (Walsh, 2009). Shifting cultivation has been the main methods of farming in these areas (Walsh, 2009). The combination of poor soils and variability in rainfall along the east coasts have long been considered as major factors for the frequent localised food shortage in these areas including the study sites (Walsh, 2009).

Zanzibar is endowed with coastal and marine resources such as beaches, coral reefs, crop and grazing land, mangroves and other forests, sea grass, seaweed farms, fishery resources, salt marshes and collectable seafood that form the foundation of livelihood activities and which are important for the coastal well-being and the nation at large (Zanzibar Revolutionary Government, 2009). Fishing and agriculture are traditional livelihood activities in these areas, but people’s livelihood portfolios have changed over the last two decades. Livelihood activities such as seaweed farming and those related to tourism (for example, handcrafts) have started to play a considerable role in the rural economy (Lange and Jiddawi, 2009).

Data collection and sampling procedure

To understand the current situation of food security in the

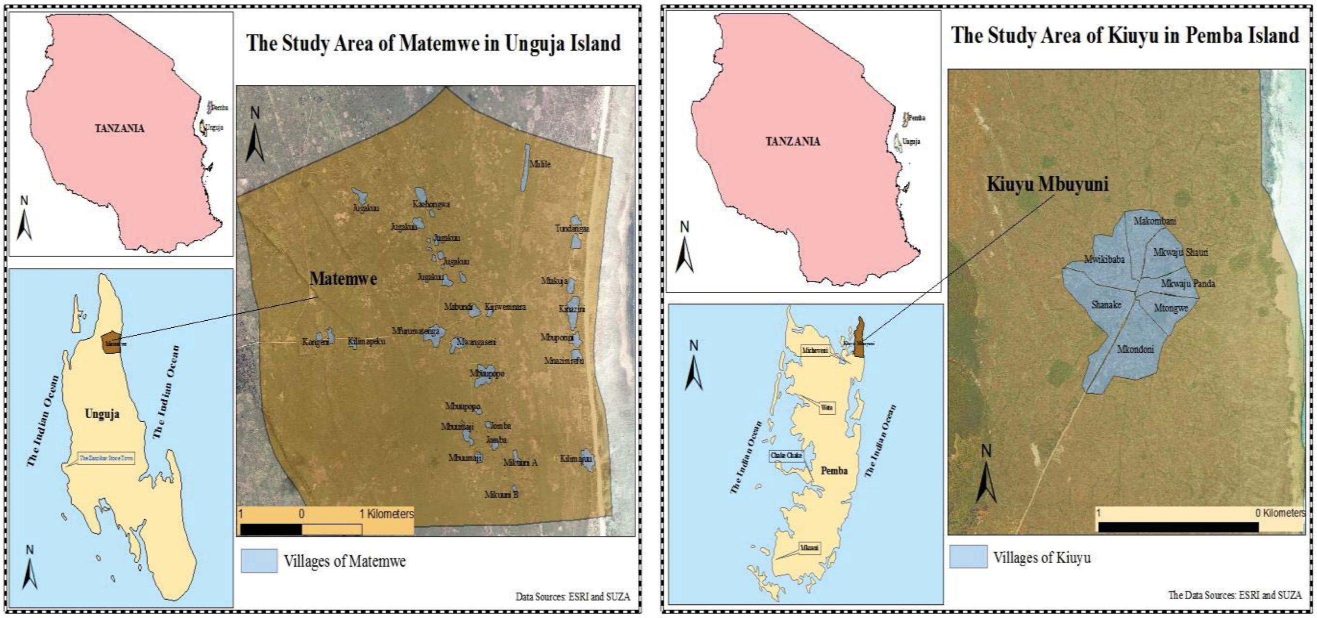

Figure 1. Map showing the locations of the study sites.

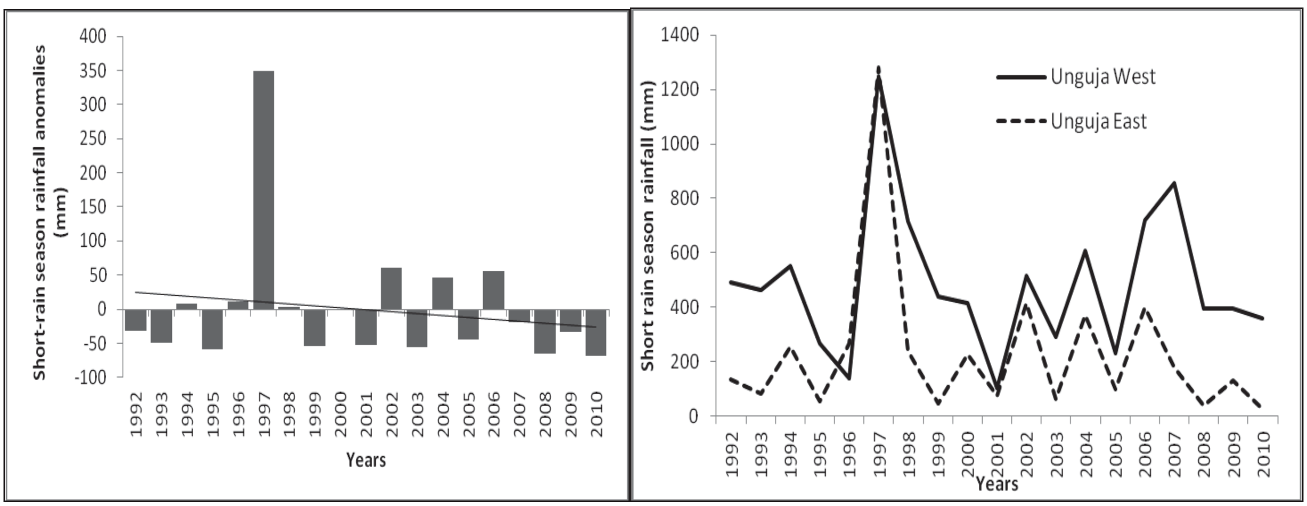

Figure 2. Left: Inter-annual variability of rainfall in the short-rain season/*Vuli* (October-December) on the east coast of Unguja from 1992-2010. Right: inter-annual variability of rainfall in short- rain season between Unguja West and East from 1992-2010 (Source: Makame 2013: pg 126-128). Note: The study did not compare rainfall received in Pemba West and East coasts as weather stations along the Pemba east coast were not operating reliably.

households, this study employed a household survey, where 200 households were randomly selected, 100 from each site. With regard to availability and accessibility of main sources of food, the survey was designed to gather data on variables such as sources of major types of food, access to staple food, fish, and vegetables; the costs incurred by a household for staple food and fish per month; and accessibility of other types of food such as seafood, meat and chicken. The information collected provides insights into the current status of food security situation amongst households in the study sites. With regards to stability of staple foods, the survey was designed to capture data on consistency of food supply in the households and seasonality. Lastly the survey aimed at understanding the various coping strategies employed by the households during the time of localised food shortages.

Data from the survey were analysed using the Statistical Package of the Social Science (SPSS) where descriptive statistics, including frequencies and percentages of respondents were determined across the four major themes of the study, namely availability, accessibility, stability and coping strategies during the time of crisis. The analytical results were disaggregated by study

Table 1. Percentage responses on availability of staple foods, fish and vegetables.

Adequate availability of food	Staple food		Fish		Vegetables	
	Kiuyu Mbuyuni (n=92)	Matemwe (n=97)	Kiuyu Mbuyuni (n=93)	Matemwe (n=92)	Kiuyu Mbuyuni (n=85)	Matemwe (N=96)
Yes	7 (8%)	17(18%)	26 (28%)	22 (24%)	9 (11%)	15 (16%)
No	85 (92%)	80 (82%)	67 (72%)	70 (76%)	76 (89%)	81 (81%)

Table 2. Pearson correlation results between inadequate availability of food and fish and livelihood diversification and family size.

Kiuyu Mbuyuni, Pemba			Matemwe, Unguja		
Types of food	Pearson Correlation	Livelihood diversification	Types of food	Pearson Correlation	Livelihood diversification
Food (N=94)	Correlation	-0.002	**Food (N=97)**	Correlation	-0.022
	P value	0.982*		P value	0.834*
Fish (N=93)	Correlation	0.015	**Fish (N=92)**	Correlation	0.121
	P value	0.886*		P value	0.249*

* Pearson correlation was not significant (p >0.05 level, 2 tailed).

sites to facilitate comparisons between the two sites.

RESULTS AND DISCUSSION

Availability and accessibility of food in the households

The major staple foods in the study area are cassava, sweet potatoes, rice, sorghum and maize meal. Respondents across the study sites were asked if they had enough staple foods, fish and vegetables throughout the year and the results showed that 85 out of 92 (92%) households in Kiuyu Mbuyuni and 80 out of 97 households (82%) in Matemwe experienced periods of inadequate availability (Table 1). With regards to fishery products the results also showed that majority of the respondents 72% (67 households) in Kiuyu Mbuyuni and 76% (70 households) in Matemwe experienced inadequate availability of fisheries products throughout the year. The proportion of households that experienced inadequate availability of fish is slightly higher in Matemwe than in Kiuyu Mbuyuni. This is probably influenced by the high demand triggered by tourism and the urban market in Zanzibar town. This is an issue for concern as both sites are considered as fishing villages and fisheries products are the major sources of cheap animal protein preferred and accessible by most people.

A large percentage of the households who perceived inconsistency in the accessibility and availability of staple food and vegetables (Table 1) may be influenced by the fact that the surveys were undertaken in the aftermath of the 2007-2010 periods which was characterised by prolonged dry conditions and declining rainfall (Figure 2) which impacted local farming and production. Vegetables, both wild and locally grown are sensitive to erratic rainfall, especially where the soil is poor. This is captured in the following quote from a respondent in Matemwe: “If rainfall becomes erratic we get a small amount of wild spinach in the bush, but these days even if we receive good rainfall and thus more wild spinach, we may not enjoy it because after a short while the plants are affected by pests. I remember in those early days we used to have massive coverage of wild spinach in the bush, to the extent of inviting people from the neighbouring villages to come and harvest”. It is clear from this quotation that conditions have changed to the extent that local production of foodstuffs is being increasingly challenged by the changing climate.

A Pearson correlation was performed to understand whether there was a relationship between inadequate availability of food and fish, as observed and livelihood diversification and family size. The results revealed no relationship between these variables across the sites (p >0.05) (Table 2), suggesting that livelihood diversification and family size within the household do not necessarily reduce the risk of food insecurity.

The observed food insecurity mirrors the findings in the study by Walsh (2009) which showed that localised food shortages along the east coast of both major islands including the study sites, is attributed to poverty, unreliable rainfall, and poor soils. Unlike the 1971/72 famine, which

Table 3. Percentage responses on sources of major food types.

Source	Staple Food		Fisheries products		Vegetables	
	Kiuyu Mbuyuni (n=99)	Matemwe (n=96)	Kiuyu Mbuyuni (n= 100)	Matemwe (n= 91)	Kiuyu Mbuyuni (n=99)	Matemwe (n=99)
Buying	17	40	36	34	29	29
Own farm/fish	-	-	42	39	19	11
Buying+ own/ fish/ gardens	83	60	22	22	52	50
Relatives/neighbours	-	-	-	5	-	-
Wild	-	-	-	-	-	10

was influenced by both drought and the banning of food imports, recent food shortages may be linked to the low capacity of people to purchase or produce own food as even during good years, food insecurity and malnutrition are prevalent (Walsh, 2009). Furthermore, while local climate variability, affects locally grown crops, global climate change affects rice production in Asia, the major supplier of rice to Zanzibar (Peng et al., 2004). In terms of fish, households that were solely dependent on buying fish are more vulnerable compared to those who practice fishing as they cannot afford to consume fish on a daily basis because of competing prices offered by urban markets, particularly during the fishing off-seasons.

With regards to the relationship between households food insecurity and diversity of livelihood portfolio, the results from the present study differ from a study conducted in northern Ghana which highlighted the positive and statistically significant impact of livelihood diversity particularly off-farm activities on household food security (Owusu et al., 2011). Although livelihood diversification in known as a coping strategy to food security (Barrett et al., 2001a,b), the observed low availability of food throughout the year is probably indicative of the failure of livelihood diversification to ensure food security in the study areas. This is mainly due to the fact that diversification of livelihoods was based on activities that are sensitive to normal seasonal variations in climate and to global market such as seaweed farming. Stress factors other than climate could have a role to play in influencing food insecurity in the area, especially since food shortage has traditionally been experienced even in years with good weather conditions. However, this was outside the scope of this study. Insights on other stress factors influencing food security in other parts of Tanzania are provided by Kangalawe et al. (2011) and Kangalawe (2012) from studies in the southern highlands, and Lyimo and Kangalawe (2010) in the semiarid zone of Tanzania.

Understanding sources of major food types in connection with availability and accessibility of food in the households

Respondents were asked ‘where the household gets most of its food, fish and vegetables’. The results in Table 3 show that none of the households interviewed depended solely on the farm to meet their staple food demands throughout the year. The majority of the households (85%) in Kiuyu Mbuyuni, and more than half of the households in Matemwe were both buying and producing their staple food stuffs. The results indicated that more people still do some farming in Kiuyu Mbuyuni, probably due to the fact that the village is experiencing less competition on the land use compared with Matemwe. In Matemwe 40% of the respondents reported to solely depend on buying food stuffs from shops. This is probably associated with land scarcity due to increasing land value in the area caused by the expansion of the tourism industry. The reasons cited for the high dependence on food from shops included poor soils, seasonality of rainfall, land scarcity, lack of water for irrigation, pests and diseases, and the absence of suitable land for rice cultivation (Valipour, 2014a,b,c,d; Valipour et al., 2014). This dependence on purchased food is highlighted below in a comment from a respondent in Matemwe. “For five years now, a large part of my food comes from shops. Farming is like our religion - one must do it but truly speaking, we are getting nothing out of it. The soil is very poor and the short rainy seasons have disappeared lately” (Figure 2). While it is acknowledged in the above quote that there are other stress factors influencing agricultural production, such as soil fertility, the variations in the seasonality of rainfall has a considerable influence in altering the cropping calendar that farmer used to follow, hence affecting food availability and/or security during some seasons. Figure 3 shows that in both Unguja and Pemba islands the monthly rainfall is relatively low during some months of the year (particularly June, July and August), which may influence seasonal production of crops like vegetables, especially where no irrigation facility is available.

With regard to fish, a large proportion of the respondents across the study sites reported to catch their own fish for domestic consumption (Table 3). About 36 and 34% respondents in Kiuyu Mbuyuni and Matemwe, respectively, were buying most of their fish, whereas 22% in both sites were both buying and fishing for themselves. Reasons such as engagement in other works, old age

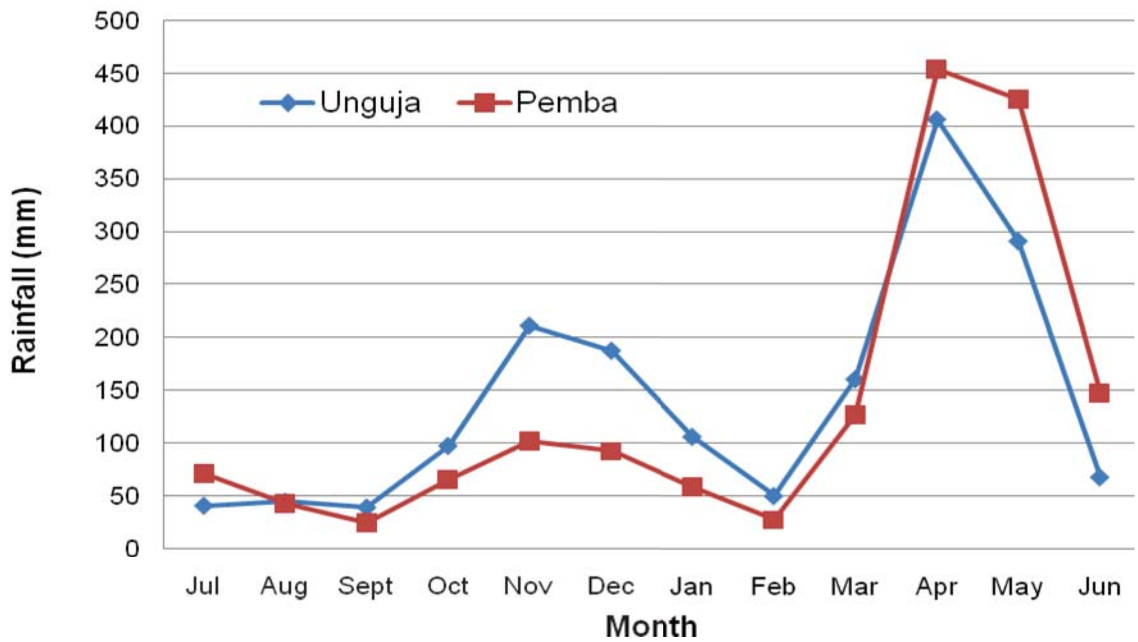

Figure 3. Monthly rainfall in Unguja and Pemba Islands.

and health, and seasonality of wind seasons were cited as barriers that prevented them from self-reliance in fishing. The above observations further confirm the exis-tence of multiple stress factors influencing food insecurity in the area. Interestingly however, 5% of the households in Matemwe were mostly dependent on remittances of fish and/or fish products from relatives and neighbours who practice fishing.

Perhaps the most striking results relate to the sources of vegetables. Unexpectedly, only 19 and 11% of the households in Kiuyu Mbuyuni and Matemwe, respectively, were largely dependent on their gardens for vegetables. About 29% in both sites bought most of their vegetables, while 53% in Kiuyu Mbuyuni and 50% in Matemwe bought and produced their vegetables (Table 3). The fact that a considerable proportion of respondents from both study sites were engaged in producing their own vegetables indicates that it has become important to diversify the sources of livelihoods in these predominantly fishing villages, especially given the various factors above that cause some of them not to engage in fishing. Nevertheless, most of these farmers/fishers have not been self-sufficient in vegetables because of the locally perceived poor soils, variations of rainfall, scarcity of land, diseases and pests and insufficient water for irrigation. Interestingly, however, 10% of the households in Matemwe draw many of their vegetables from the wild (Table 3), which indicates the need for continued protections and conservation of the source areas.

The results demonstrate that the majority of the households across the sites were using a combination of buying and producing their staple food, vegetables and fish. These results are inconsistent with other parts of Africa, particularly with regard to staple food; for instance, in the rural district of Moma and Mabote in Mozambique more than 80% of households draw their food solely from their own farm plots (Hahn et al., 2009). Given the high levels of poverty within the households across the sites (Wash, 2009), concentrating on buying most food requirements, including vegetables, could be a major source of vulnerability to climate variability, food in-security and social insecurity. Although over-dependence on small-scale farming for household food is always considered a source of vulnerability (Hahn et al., 2009; McDowell and Hess, 2012), the observed trend toward solely buying, diminishes the purchasing power, savings and access to assets for future adaptation to climate variability and change in the long run. For example, the reported localised food shortages in 2006-2007 (Walsh, 2009) and 2009-2011 (Said, 2011), especially in Kiuyu Mbuyuni were probably influenced by low purchasing power in the households as imported food was readily available in the food stores unlike during 1972 famine. This calls for a critical analysis of possible coping strategies and long-term adaptation options that these communities are using.

The findings from this study also suggest that a household’s self-sufficiency with regard to the main types of food is challenged by a number of factors both climatic and non-climatic. Some of the explanations cited, such as scarcity of land for farming, poor soils and infrastructure for irrigation, are more powerful than the observed variability of rainfall for the last decade (Figure 2).

However, climate change has the potential to interact

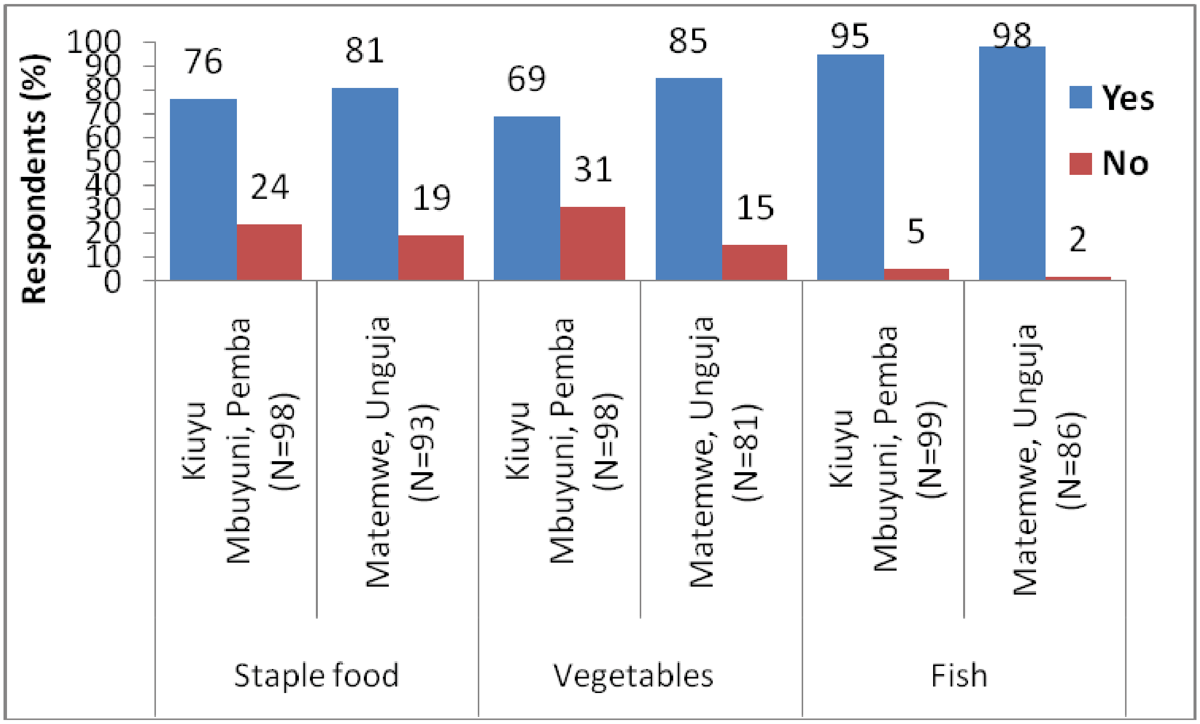

Figure 4. Responses on whether households ever experienced food/ fish/ vegetable instability over last five years.

adversely with these natural and developmental challenges, increasing vulnerability to food insecurity. Even in countries with massive land resources, these challenges threaten rural livelihoods and food security all over the developing world (Droogers, 2004; McDowell and Hess, 2012; Aggarwal et al., 2010; Ellis and Mdoe, 2003). Thus, reducing the severity of localised food shortages in small islands like Zanzibar requires a strict land use plan and increased access to irrigation facilities, better soil management through provision of farming inputs and enhanced access to assets related to fisheries.

Stability of food in the households

In order to understand the nature of food stability in the study areas, all respondents, including those producing fish for themselves, those buying, and those who combine buying and self-producing, were asked whether they had ever experienced an inconsistent supply of food/ fish/ vegetables in their household over the last five years. The results in Figure 4 show that the majority of the respondents across the study sites had experienced such inconsistencies and instability in the supply of fish, staple food and vegetables, which negatively influence their food security.

An inquiry to identify years or seasons when households were severely affected by supply inconsistency over the last five years showed similar responses to those on staple food and vegetables (Table 4). Most of the respondents mentioned the 2009-2010 period in which they faced both food and vegetable instability. During this particular period, both islands particularly along the eastern coast, experienced low rainfall (Figure 2), this resulted in localised food shortages in the study sites. Other periods identified in which households experienced difficulties in obtaining food and vegetables included the period in between 2007-2008 which experienced extended dry seasons, particularly along the east coast, that affected both staple crops and vegetables. Similar difficulties were reported to be experienced during the dry seasons of each year (Figure 3), during the south-easterly winds season locally known as *kusi*.

Since the majority of the households depend on fishing for their income to buy food, a considerable number of the households face food and vegetables instability during the fishing off-season (season of south-easterly winds). Therefore, the reported difficulties in obtaining food during this period can be translated as a lack of savings obtained during the fishing seasons. This again highlights the danger of over-dependence on purchased food stuff, as commented by one of the respondents in Kiuyu Mbuyuni: “Although we now obtain more money for selling just a small amount of fish catch, whatever we earn ends up in buying food, so we are facing difficulties of obtaining money for food during the off-season”.

The majority of the households across the study sites believe that the insufficient availability of fish is most

Table 4. Years or seasons of difficulty in obtaining enough food.

Variable	Year/season	Kiuyu Mbuyuni	Matemwe	Total
	Staple food	**n=72**	**n=67**	**N=139**
Year or season shortage of food experienced	Dry season of each year	4	10	7.0
	South-easterly wind season each year	10	13	11.5
	2009-2010	83	75	79.0
	2007-2008	3	2	2.5
	Vegetables	**n=66**	**n=67**	**N=133**
Year or season shortage of vegetables experienced	Dry season of each year	17	36	26.5
	South-easterly wind season each year	-	2	2.0
	2009-2010	80	60	70.0
	2007-2008	3	3	3.0
	Fisheries products	**n= 93**	**n=86**	**N=179**
Season shortage of fish products experienced	South-easterly wind season of each year	97	94	95.5
	Rainy season of each year	3	4	3.5
	North-easterly wind season of each year	-	2	2

pronounced during the south-easterly wind season which normally lasts approximately four months in June, July, August and September. This windy season, is a period in which the winds blows from south-easterly direction to the north away from the Zanzibar coast and believed to drive fish away from the coast. More importantly, the wind hampers small vessels, the most common fishing vessels, from making fishing trips, mainly because these vessels cannot sail against the south-easterly wind on their way back from fishing trips. Thus many fishers remain at home during this season to minimise risk. During this period therefore very few boats operate (mostly motorised boats), and thus as a result of diminished supply, the demand increases and the price of fish products becomes too high for most people to afford. Even those households who were solely buying fish from the market face instability of fish consumption as they cannot compete with the prices paid in urban and tourism markets during this time of the year. Incidentally, this south-easterly wind season is also a period when the monthly rainfall is at the lowest (Figure 3), thus not being able to support significant crop production, especially of seasonal crops like vegetables. Consequently, the above two conditions together aggravate the food insecurity situation of the study sites during the respective months of June, July, August and September.

Even during normal fishing seasons (calm periods in April-May and October-November and some days of the north-easterly wind seasons in December-March), most of the fishers only operate during spring tides (approximately 17 or 20 days in each month); A similar example is given by Hill (2005) from his study in Vamizi island. Local experience indicated that a spring tide occur when the moon is either new or full and the difference between high and low tide is the greatest. During the spring tides in the dry season the water is usually saline with influx of brackish water. During this season the coastal areas are highly prone to cyclone-induced storm surges that may bring about the catastrophic damage (Chowdhury, 2010). In Zanzibar, the knowledge about the tidal cycles is crucial for fish vendors coming to buy fish. Tide may also affect inter tidal activities carried out during low water at spring tides such as collection of octopus, seashells, and sea cucumber (Zanzibar Revolutionary Government, 2009). Given the perceived decline in fish catch per fisher and the high demand for cash amongst fishers to buy food, many households experience food instability on monthly basis as far as the availability and accessibility of fish is concerned. This is demonstrated in the following remarks by one of the respondents in Matemwe: “the amount of fish supplied at home depends on the amount of fish caught; if we land more fish we will consume more fish, but if we land less we will consume less”.

The foregoing analysis demonstrates that seasonality, coupled with variability of rainfall, lack of savings and of course, lack of off-farming and off-fishing activities affects the constant availability and accessibility of food. For example, although food instability and widespread malnutrition are common along the east coast, even in good years (Walsh, 2009) seasonal variation in rainfall intensifies the severity of food insecurity and nutritional status of the coastal communities (Makame, 2013). In Dinajpur, Bangladesh, food instability is far higher during the monsoon season than other seasons in the year (Hillbruner and Egan, 2008). Similarly, poor rural families in India are forced to cope with food insecurity mainly attributed to seasonal agricultural production caused by

Table 5. Percentage responses on the consumption of other sources of protein.

Variable	Seafood		Meat		Chickens	
	Kiuyu (n=100)	Matemwe (n=88)	Kiuyu (n=98)	Matemwe (n=88)	Kiuyu (n=99)	Matemwe (n=94)
Often	5	4	-	1	1	1
Sometime	42	38	14	32	86	65
Rarely	53	58	86	67	13	34

erratic rainfall (Agarwal, 1990). In assessing the risk of climate variability and change in two Mozambican communities, Hahn et al. (2009) also found that apart from other stress factors, climate variability and change, disasters such as floods and droughts have caused food instability for between three and eight months per year.

Availability and accessibility of other food types

In a situation where the consumption of fish in coastal villages is perceived to be declining because of seasonality, lack of technology, increasing demand and low access to storage facilities such as electricity and refrigeration, make the communities more vulnerable as they are not able to preserve the food stuffs for long. Respondents in this study were asked on how often their households consumed other foods, such as seafood, meat and chicken. Here, seafood comprised of crustaceans (crabs, prawns, shrimps, and lobsters), molluscs (various types of shellfish), cuttlefish and octopus. Meat comprised both beef and meat from goats and other small animals. Strikingly, the results in Table 5 show that more than half of the households in both the study sites rarely consumed seafood, while 42 and 38% of the households in Kiuyu Mbuyuni and Matemwe, respectively only consumed seafood sometimes. Seafood consumption, which was once regarded as an important source of additional protein in coastal villages has diminished considerably and become rare for the majority, because of its value to both tourists and urban dwellers. Consequently once caught these crustaceans and molluscs are sold to earn cash incomes. While the sales contribute to household ability to buy food staples, these seafood become inaccessible in regular diets of the household.

Although Pemba site has no tourism hotels, seafood is traded as far as Zanzibar town and Mombasa, Kenya. For instance, it was observed that in Pemba, octopuses are informally traded in Mombasa, Kenya. Despite the local belief that eating octopus increases male potency, fishers themselves cannot afford to eat them; they prefer to sell them in order to provide for household needs, including food and iron roofing materials for their homes. Local testimonies highlighted that “Currently one octopus can fetch up to USD 10, thus no one would dare to consume an octopus; after all, octopus is not a staple food. Everyone would rather sell it in order to obtain money to meet other demands. Truly speaking, octopus has become a food for tourists and not for the poor”. As similar testimony was given regarding other types of fish. It was narrated in Matemwe for instance, that “fish are available in Matemwe but people who are eating good fish are not natives. Most of them are tourists. People of this village cannot afford to buy fish. Villagers eat vegetable mostly. The only type of fish we afford to buy is dry anchovy (dagaa kavu). Octopus and squids are very expensive and none of the villagers can afford to buy them”.

Table 5 shows also that most households in the study sites rarely consumed meat. Interestingly, the consumption of chicken has also inclined towards the rare category. As such meat or chicken have become part of the diet only during celebrations such as Eid celebrations (two Eid celebrations per year in the Islamic calendar) and during wedding ceremonies. Although livestock and poultry keeping are common, especially in Kiuyu Mbuyuni, both cattle and chicken are used as a source of manure to improve the soil and as assets to sell when needed.

In this instance, it can be argued that Zanzibar coastal communities experience low accessibility, not only of primary sources of food (staple food, fish and vegetables) but also of other types of foods such as seafood, meat and chickens and are thus vulnerable to food insecurity. However, the observed low consumption of meat and chicken may be associated with household choices in order to increase assets (Erickson, 2008; Maxwell, 1996). For instance, a household may opt not to sell their cattle in order to solve an immediate but small problem (for example, a food shortage in the household) so that they can increase stock for future adaptations. With regard to other seafood, the observed low consumption is clearly linked to increasing demand both within and outside the country, especially in the tourism industry (Garcia and Rosenberg, 2010), and these food stuffs are no longer an important part of the diet for the majority of coastal communities. Globally, these commodities represent the most valuable fisheries exports (Bondad-Reantaso et al., 2012). In examining the role of crustaceans and aquaculture in global food security, Bondad-Reantaso et al. (2012) postulated that the high income obtained from selling crustaceans would enable producers to buy lower

Table 6. Percentage responses on coping strategies for food insecurity at the household level.

Coping Strategy	Kiuyu Mbuyuni (n=67)	Matemwe (n=60)	Total (N=127)
Coping with staple food insecurity			
Food loan	51	52	51.5
Food aid	3	-	3.0
Eating wild food	5	-	5.0
Sleeping without eating	20	8	14.0
Reducing volume per meal	19	38	28.5
Reducing number of meals	3	2	2.5
Coping with vegetables insecurity			
	Kiuyu Mbuyuni (n=73)	**Matemwe (n=71)**	**Total (N=144)**
Consuming fish	27	25	26.0
Buying from market or other village	22	17	19.5
Eating staple food without vegetables	48	42	45.0
Eating food with beans bought from shops	3	6	4.5
Eating dried wild spinach obtained during rain seasons	0	10	5.0
Coping with fisheries product insecurity			
	Kiuyu Mbuyuni (n=82)	**Matemwe (n=84)**	**Total (N=166)**
Eating fish stored in fridge	1	2	1.5
Eating beans, pigeon peas and vegetables	37	31	34.0
Buying from outside	1	-	1.0
Eating fresh sardine and mackerels	-	10	10.0
Eating dried small anchovies	30	38	34.0
Eating staple food only	32	19	25.5

value products and thus contribute to food security. However, changes in food patterns as observed in the study areas may have a negative impact on the nutritional status and health of coastal communities (Receveur et al., 1997; Kuhnlein et al., 2004). For example, Kuhnlein et al. (2004) found a significant correlation between obesity and changes in dietary patterns all over the world. One may argue that sacrificing consumption of various seafood, including octopus, to generate income, without replacing it with foods of equal nutritional value, may have negative consequences for the dietary patterns of the coastal communities.

Coping strategies for food instability at the household level

Periodic food shortages and famine are not new phenomena in the study areas. For example, in the 1971-1972 famine, local people used various strategies to cope (Walsh, 2009). The most frequently cited strategies for coping with staple food instability were loans from shops or neighbours, reducing the volume of the meal, sleeping without eating and reducing the number of meals (Table 6). Other coping strategies, only cited in Pemba, were eating wild food and accruing food aid. With regards to vegetables, which in most cases are considered as optional, respondents also cited a wide range of coping strategies. These included consuming staple foods without vegetables, eating more beans bought from the market and consuming dried wild spinach. Eating dried wild spinach locally known as *mchunga* is more common in Unguja than in Pemba.

The findings mirror those in urban Uganda (Maxwell, 1996), in urban Accra, Ghana (Maxwell et al., 1999) and in an informal settlement in the Vaal Triangle, South Africa (Oldewage-Therona et al., 2006). In urban Uganda, for instance, people are reported to eat foods that were previously less preferred, limited portion size, borrowed food or money and skipped meals (Maxwell, 1996). Similar experiences are reported in some parts of North-western Tanzania where many people decline to eat other foods (such as maize and rice), except in periods of absolute food (banana) shortage (Mwisongo and Borg, 2002).

Unlike the 1971-1972 famine, during recent localised food shortages, the consumption of cultivated plants and wild food such as poisonous wild yam (*Dioscore sansibarensis Pax*), locally known as *chochoni* as a response to famine (Walsh, 2009) was marginal, probably due to the availability of imported foods in the shops, and because it was not difficult to a obtain a food loan from local shops because of the high social bonding capital. Although food insecurity is widespread along the eastern parts of Pemba and Unguja (Boetekees and Immink, 2008), strong social capital, and willingness to help each other and strong neighbourhoods, coupled with the availability of imported food in the shops, has probably helped reduce the severity of food insecurity, especially during droughts (Makame, 2013).

With regard to fisheries products, respondents also identified a range of strategies that helped them cope with insufficient fish products in their meals. The most cited coping mechanism was consuming dry anchovy and vegetables. About 10% of households in Matemwe replaced high-value fish species with low-value (based on the local perception of the consumers), cheaper species such as sardines and Indian mackerel. The prices for these species are generally affordable and thus they are a common food for the poor and needy all over the developing world (Albert and Marc-Metian, 2009). Interestingly, some households in both study sites were doing nothing to cope with insufficient fisheries products; they simply ate plain meals without either vegetables or dried anchovies. Given the observed low intake of other sources of protein, these households could become more sensitive to dietary problems. The "do nothing" segment of the population demonstrates the variance in vulnerability across social groupings.

For many, eating dried anchovies *(dagaa kavu),* particularly amongst the fishermen, is less preferred by the affluent population. However, the increasing price of fresh fish due to high demand in both urban and tourism markets, and the need for hard cash on the part of the fishers have forced households to rely heavily on dried anchovies as a replacement for fresh fish, even during fishing seasons. Kent (1998) concluded for example that “when fish decline and the price go up, poor people are forced to shift into inferior food, putting them at risk of missing important micronutrients”. A dry anchovy probably contains as many important micronutrients for human health as fresh fish but competition between non-food uses and direct human consumption and global climate change (Albert and Marc-Metian, 2009) is threatening this small pelagic fish all over the globe. Indeed, increasing demand for dried anchovies in urban areas and in mainland Tanzania and neighbouring countries will, sooner rather than later, put dry anchovies out of the reach for the majority of the poor in Zanzibar. This will further intensify vulnerability to food insecurity for the majority because vegetables, peas and beans, both cultivated and wild, are sensitive to periodic drought.

Conclusions

Food security requires that all members in the household, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The overall picture emerging across the study sites is that local people are insecure with respect to major sources of food. Agricultural failure resulting from various factors, including local climate variability, coupled with uncertainty of fishing has pushed households towards buying most of their staple foods. This trend has affected food security tremendously due to low purchasing power, attributed to poverty. Increased demand in urban areas and the expansion of tourism industries within the study area and in neighbouring countries have increased the price for the limited fisheries resources, causing the poor, including the fishers, to consume less fish and seafood, thereby limiting their dietary protein intakes. Furthermore, the relationship between climate and coastal activities for both food and income is likely to affect all four components of food security, making the coastal communities even more vulnerable.

Food availability, accessibility and stability are threatened not only by climate variability but also by a number of development challenges, such as limited land and a small economy, and lack of irrigation facilities. Thus while addressing the community vulnerabilities associated with climate change and variability it is paramount to also manage other non-climatic factors that compound vulnerability to climate change-related food insecurity.

Conflict of Interest

The authors have not declared any conflict of interest.

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Technical and allocative efficiency gains from integrated soil fertility management in the maize farming system of Kenya

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Declining land productivity and *per capita* food availability poses challenges to overcoming land degradation and poverty in sub-Saharan Africa. There is a need to identify ways of improving land productivity particularly among smallholders. This study investigated the contribution of integrated soil fertility management (ISFM) practices to both technical and allocative efficiencies in the maize farming system of Kenya. To determine efficiency gains from ISFM, we compared efficiencies of two groups of smallholders: those within the contact areas and their counterfactuals. We estimated Cobb-Douglas stochastic functions based on maize production data collected from a stratified sample of 373 farmers. The results indicate that farmers who applied ISFM were more efficient both technically and allocatively than those who did not. Application of ISFM practices increased technical and allocative efficiencies by 26 and 30%, respectively. However, other favourable factors are required for farmers to realize maximum efficiency gains from maize farming activity. They included farming experience, extension contacts, off-farm income and market access. Therefore, policies and practices aimed at enhancing farming efficiency in smallholder agriculture should address these factors. We recommend increased dissemination of ISFM technologies to the wider farming community through effective and participatory approaches to increase efficiency and enhance farm returns.

Key words: Maize, land husbandry, productivity, small-scale, stochastic frontier.

INTRODUCTION

Sub-Saharan Africa (SSA) is the only region in the world where land productivity and *per capita* food availability continues to fall over time (Clover, 2003; Lambin et al., 2003). Declining soil fertility and high cost of purchasable inputs are the main contributory factors to low agricultural productivity among farming communities in SSA (CGIAR, 2002). Soil fertility loss is viewed as a key source of land degradation and environmental damage in the long-term

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(Henao and Baanante, 2006). This is because continuous farming without adequate replenishment of nutrients drains the productive potential of the soil. The soil becomes less fertile when the nutrients and trace elements are constantly used without taking proper care of the mass balance of the soil (Bojö, 1996). This problem is more profound among resource-poor, smallholder farming households because they lack knowledge on better soil management options. They also have low capacity to invest in soil nutrient replenishment—especially using chemical fertilizers—and have less ability to bear risk and wait for future payoffs from such investments (Jayne et al., 2010). According to Todaro and Smith (2008), widespread abject poverty can precipitate over-use and destruction of the natural resources where short-term survival goals and practices are pursued with little regard to long-term sustainability concerns.

Kenya, like many SSA countries, grapples with the twin problems of increasing poverty incidence and land degradation, especially in rural areas. Declining soil fertility in high agricultural potential areas of the country has raised concerns regarding the sustainability of the smallholder maize production system (Mureithi et al., 2002). For example, the resource-poor smallholders in Western Kenya hardly invest in farming activities due to liquidity constraints, experience more than twice the erosion rates and achieve less than one-third of potential maize yields (Mureithi et al., 2002). This raises food security concerns as smallholder farmers are the major producers of maize in the country; hence, there is a need for them to increase their farm productivity in order to satisfy the increasing food needs in Kenya. The low maize productivity attributable to both insufficient farm resources and inefficient allocation of available farm inputs, hinders progress in this direction (Seyoum et al., 1998). To bridge the resource insufficiency gap, low-cost, integrated soil fertility management (ISFM) technologies have been availed through participatory approaches such as farmer participatory research and farmer field schools, to tackle soil fertility loss and boost productivity in smallholder farming system of North-western Kenya (Nyambati et al., 2003). The promoted ISFM technologies included the application of organic residues and animal manure; inorganic fertilizers; integration of leguminous crops e.g. soya beans, groundnuts, pigeon peas, *Mucuna pruriens* and *Crotalaria spp;* and agro-forestry practices such as incorporation of *Tithonia diversifolia* residues. Others included integrated pest management using extracts from neem, hot pepper and tephrosia plants and low-cost soil conservation methods such as grass strips. However, knowledge about the efficiency contribution of the ISFM technologies within the maize farming system of Kenya remains unknown.

There is an increasing interest in determination of productive efficiency in various fields since the pioneering work by Farrell (1957), and analytical advancements that followed (Aigner et al., 1977; Battese and Broca, 1997; Coelli, 1996; Meeusen and van Den Broeck, 1977). Determination of actual efficiency levels is essential in effective policy-making and practical implementation of various economic activities. Therefore, many researchers have empirically investigated whether economic units such as farms, firms, and organizations, were utilizing the scarce resources to produce maximum quantities of goods and services.

Efficiency studies in SSA have reported varied technical efficiencies ranging from 46% in Nigeria (Olowa and Olowa, 2010), 56% in Ethiopia (Seyoum et al., 1998) to between 64 and 76% among two groups of farmers in Lesotho (Mochebelele and Winter-Nelson, 2000). Two studies conducted in Kenya reported technical efficiency of 49% (Kibaara 2005) and 71% (Liu, 2006) in maize production, while in Malawi Tchale and Sauer (2007), found on average 87% technical efficiency among smallholder maize farmers. These empirical findings clearly show that SSA farming system generally is not efficient and produces less output than the possible potential. This suggests therefore that inefficiency is one of the principal causes of low productivity of agriculture in SSA. Consequently, there is a need to establish whether the application of ISFM practices contribute to efficiency in maize farming system and which factors are key to maximizing the efficiency benefits from ISFM practices. This is important because the greatest challenge to adoption of sustainable production practices is not only liquidity constraints but also a lack of knowledge on efficient production plans (Place et al., 2002). In fact, it is not only the lack of credit and poor farm revenue but also the absence of information that often prevent the poor from making the best resource-augmenting investments important for improving farm productivity (Todaro and Smith, 2008). As observed by Bationo et al. (2004), tackling poor soil fertility and low farm productivity requires both a long-term perspective and an all-inclusive approach to which this study aims to contribute.

The specific objective of this study was to estimate the prevailing technical and allocative efficiencies and examine their determinants in two maize producing systems of North-western Kenya. Unlike many efficiency studies conducted in SSA, which focus on technical efficiency alone (Mochebelele and Winter-Nelson, 2000; Olowa and Olowa, 2010; Seyoum et al., 1998; Sherlund et al., 2002; Tchale and Sauer, 2007), we concurrently estimate both technical and allocative efficiencies and evaluate farming efficiency gains from the ISFM technologies availed to smallholder farmers. Providing information on ways to enhance efficiency in maize production is essential in improving *per capita* output and farmers' incomes to reinvest in soil fertility improvement, including the use of available ISFM technologies in Kenya. This is in line with the Kenya government's vision that sustainable and efficient production practices within the smallholder agriculture is key to ameliorating the negative environmental

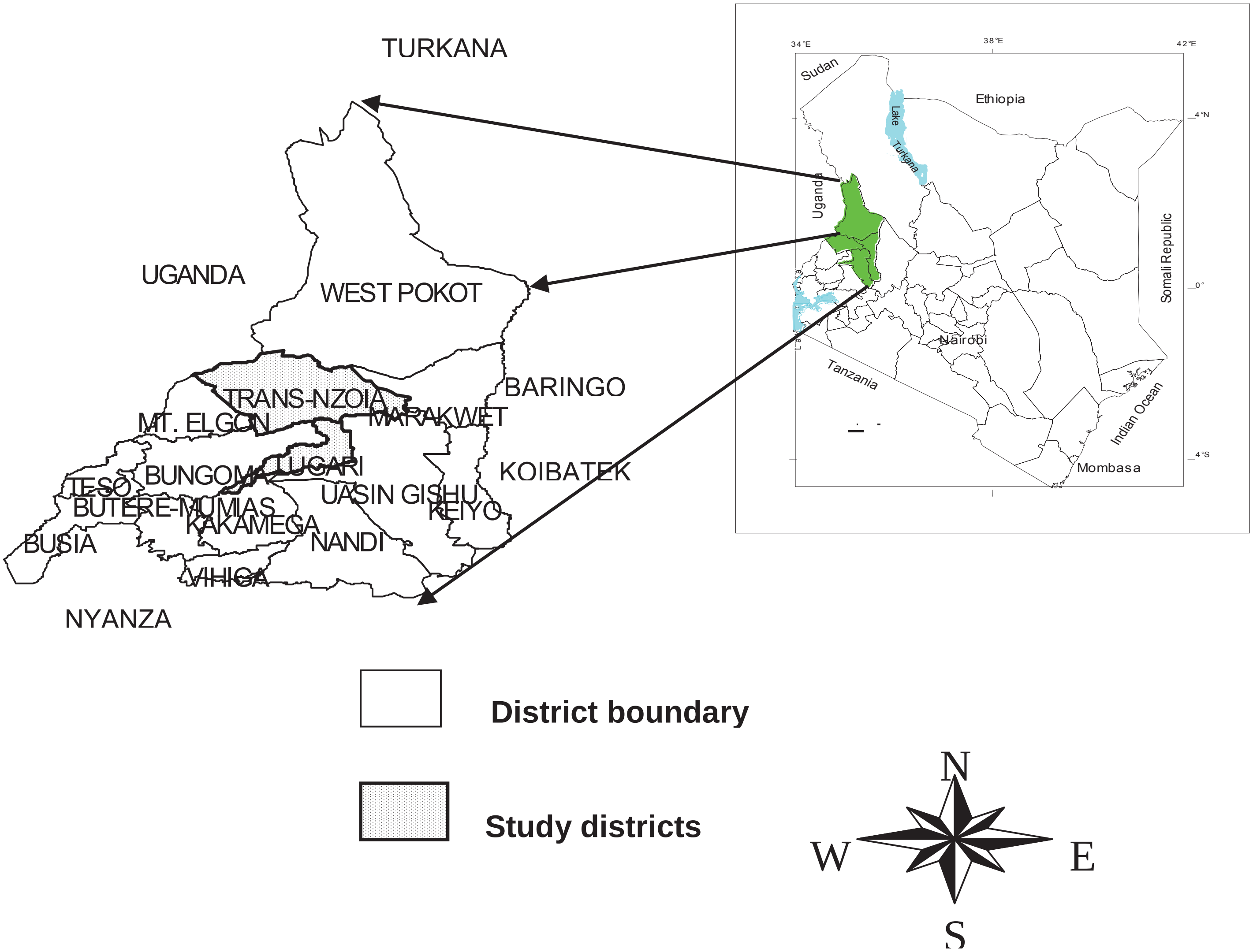

Figure 1. Map showing study districts (dotted) in North-western Kenya.

effects of poverty and improving better livelihoods in rural areas (Government of Kenya, 2004). As noted in the policy document, the greatest emphasis should be given to improving efficiency among smallholders so as to simultaneously mitigate poverty-related land degradation and raise agricultural productivity (Government of Kenya, 2005). This study therefore provides useful information on policy options and best practices to improve maize yields to enhance food security and sustainable land management not only in Kenya but also in other similar SSA countries.

METHODOLOGY

Study area

The North-western Kenya is a high agricultural potential region and accounts for about 90% of total maize output in the country. Trans Nzoia and Lugari Districts are located in this region (Figure 1). Trans Nzoia District dubbed, 'Kenya's granary' remains the major maize producer in the country (Wangia et al., 2002). Trans Nzoia District was selected for the study because yields have been declining in recent years. As a result, the district was targeted with ISFM options aimed to address low yields. On the other hand, we chose Lugari District because it has comparative maize farming system like that in Trans Nzoia, but was not covered by the soil management project.

The two districts receive between 1000 to 2100 mm of bimodal rainfall pattern. Rainfall received is considered reliable for agricultural activities. The elevation ranges from 1300 to 1900 m above sea level, with Upper Midlands (UM_4) being the predominant agro-ecological zone accounting for 94 and 47% of all land area in Lugari and Trans Nzoia Districts, respectively. This zone is the area of intensive maize cultivation in the study districts (Government of Kenya, 2006; Jaetzold et al., 2007). The major soil type is humic Acrisols, which is deep and well-drained. Soil fertility is moderate given that poor soil fertility is one of the most limiting factors to agricultural productivity in the study area (Government of Kenya, 2006; Nyambati et al., 2003). Farm sizes are on average 2.5 ha in

Lugari and 3.6 ha in Trans Nzoia. The common farming system is mixed crop-livestock production. Maize-bean production takes about 90% of total cropped land (Government of Kenya, 2006). Maize yields have been declining in both districts to as low as just 2 tha^{-1}. The declining trend has been blamed on among other factors, the soil fertility loss due to continuous monoculture cropping.

Population density is 328 people/km^2 for Trans Nzoia District and 437 people/km^2 in Lugari District (KNBS 2010). Poverty incidence is 50.2% for Trans Nzoia and 47% for Lugari District (Government of Kenya, 2011). In both districts, smallholders form the bulk of maize producers amid the waning importance of large-scale maize production due to continuous land sub-division (Mose et al., 2006).

Sampling techniques

Stratified sampling, based on agro-ecological zonation and concentration of smallholders, was applied to select two localities in each district for the study. These were: Kaplamai (UM_4) and Kiminini (LH_{3-4}) in Trans Nzoia District, as the contact areas where ISFM technologies was promoted for about a decade (Nyambati et al., 2003), and Mautuma (UM_4) and Matete (LM_3) in Lugari District, as the matching counterfactual areas.

The optimum sample size was chosen in a two-step process (Rangaswamy, 1995). First, a total sample size of 373 farmers was derived based on the number of strata, total farming households and variance of maize yields (calculated from data reported in Mose (2007), in each district. The total sample was made up of 154 farmers for Trans Nzoia District and 219 farmers for Lugari District. Second, we used the Neyman allocation method to distribute the total sample across the four study strata. For each stratum, we developed updated sampling frames with the assistance of frontline agricultural extension staff and local leaders. We used randomly generated numbers in MS Excel computer program to select individual farming households for interviews.

Data collection

We conducted face-to-face interviews at each of the selected households using a detailed and pre-tested, semi-structured questionnaire. The questionnaire was administered to the household head or member knowledgeable about farm and off-farm activities. We obtained data on physical quantities and monetary value of farm inputs (that is, fertilizers, manures, labour, seeds, and land) and maize output. We also collected farm level data on the ISFM practices that they applied in maize production. In addition, we collected socio-economic data on farmer's age, number of years in farming, family members and their level of education. Farmers also provided information on the cost of market access, distance and condition of the main roads as well as access to credit and the number of contacts they had with agricultural extension agents during the year. Finally, we collected data on planting date, maize varieties grown, weeding frequency and pest control. These data were analysed applying the analytical procedures specified next.

Analytical framework

The economic theory of production provided the analytical framework for this efficiency study (Debertin, 1986). The fundamental idea underlying the measurement of technical efficiency is that of attaining maximum possible output from a set of physical inputs. A farmer is considered technically inefficient if little output is produced from a given bundle of inputs (Ogundari et al., 2006). Allocative efficiency on the other hand, reflects the ability of the farmer to use inputs they have in optimal combinations given their relative prices (Coelli, 1996). A farmer is deemed allocatively inefficient if excessive cost is incurred to achieve the same level of output.

Following Ogundari et al. (2006), two self-dual stochastic functions were estimated from production data to generate technical and allocative efficiency values. Stochastic functions used in this study attribute part of the inefficiencies to external factors and are suitable when analysing the role of measurable socio-economic factors in observed efficiency differences (Coelli, 1996). This made it possible to establish the effects of farmers' responsiveness to the incentive structure and technologies that defines their production environment. This was important in this study because efficiency gains from ISFM interventions had to be estimated taking into consideration all possible relationships (Tchale and Sauer, 2007).

We estimated a self-dual, stochastic Cobb-Douglas production (Equation 1) and cost function (Equation 2) to generate technical and allocative efficiency values, respectively.

$$\ln(y_i) = \ln\beta_0 + \sum_{i=1}^{4}\beta_i \ln(x_i) + \beta_5 dist + (v_i - u_i) \qquad [1]$$

Where y_i is maize output (tha^{-1}), and x_i are physical inputs (fertilizer, seeds, total labour and manure per ha). A binary variable *dist* (1=Trans Nzoia; 0=Lugari) accounted for the difference in physical attributes important for farm production such as natural soil fertility and rainfall. β_0 is a parameter common to all farms while β_i and β_5 are unknown coefficients estimated in the model. v_i is the ordinary two-sided error term assumed to be normally, identically and independently distributed and u_i is the one-sided error term assumed half-normal that captured technical inefficiency.

$$\ln(c_i) = \ln\alpha_0 + \sum_{i=1}^{4}\alpha_i \ln(r_i / w_i) + \alpha_5 \ln(y_i) + (v_i + u_i) \qquad [2]$$

Where c_i is the total variable cost of maize production (KES/ha), r_i are the unit prices for fertilizer, seed, ploughing, w_i is the labour wage and y_i is maize yield (tha^{-1}). α_0 is the intercept taking care of the fixed costs in maize production, while α_i is a vector of coefficients estimated for the prices of fertilizer, seed, ploughing, labour and yield. μ_i is the half-normal error term that measured allocative inefficiency.

We applied a one-step maximum likelihood estimation procedure (Wang and Schmidt, 2002) to estimate each of the above equations simultaneously with those determinants of technical and allocative efficiency in maize production, specified in Equation 3.

$$\mu_i = \delta_0 + \delta_1 EXP_i + \delta_2 EDU_i + \delta_3 CRAC_i + \delta_4 HSIZ_i + \delta_5 OFIN_i + \delta_6 SFM_i + \delta_7 EXT_i + \delta_8 MAC_i + \delta_9 AEZ_i + \varepsilon \qquad [3]$$

Where μ_i is the inefficiency (technical or allocative) score; *EXP* is farming experience of the farmer (years); *EDU* is formal education level of the decision-maker (years of schooling); *HSIZ* is the number of household members (those living and eating in the same household); *OFIN* is a binary variable for off-farm income earning (1 = for household with positive earnings; 0 = otherwise). *CRAC* is a binary variable for credit access (1 = for households that obtained credit; 0 = otherwise); *SFM* is binary variable for soil fertility management practice (1 = for ISFM practices; 0 = fertilizer alone). *EXT* is the number of extension contacts during the year; *MAC* is market access (transport cost/bag of maize in KES). *AEZ* is a binary variable for agro-ecological zone (1 = Upper Midland; 0 = otherwise) controlling for the influence of natural soil fertility, rainfall and temperature and ε is the error term. The selection of these variables was based on past studies that found their significant influence on various efficiency measures (Mochebelele and Winter-Nelson, 2000; Mutoko et al., 2014; Ogundari et al., 2006; Olowa and Olowa, 2010; Seyoum et al., 1998; Sherlund et al., 2002; Tchale and Sauer, 2007). We used FRONTIER 4.1(c) for efficiency estimations (Coelli, 1996).

Before estimations, we tested for the violations of classical assumptions of OLS commonly expected in cross-sectional data used in this study, such as heteroscedasticity, multi-collinearity and endogeneity (Gujarati, 2005). The Breusch-Pagan-Godfrey test did not show evidence of heteroscedasticity in the data; hence, the parameter estimates were unbiased, consistent and efficient. The endogeneity test ensured that the error term μ_i and the explanatory variables do not co-vary. Since the estimation of the stochastic production and cost frontiers is based on the distribution of this error term, this independence is critical for two reasons. First, the variables describing the inputs in the stochastic frontier functions need to be independent from the socio-economic variables explaining inefficiency effects. Second, the stochastic frontier functions and the equation explaining inefficiency have to be estimated simultaneously. If the independence condition were not satisfied, the parameter estimates from both functions would be biased and inconsistent (Verbeek, 2008). The procedure to establish independence between the error term and the explanatory variables involved a regression of each variable against the others in the set and assessing the strength of the R^2 (Verbeek, 2008). Those R^2 values greater than 0.5 indicate high dependence and therefore such a variable is endogenous (Gujarati, 2005). Soil fertility management choice had the highest value (R^2=0.4) whereas all the other variables in Equation 3 had lower values (R^2≤0.2). Given that all R^2 values were less than 0.5, we concluded that none of the explanatory variables was endogenous. Following Maddala (2001), we confirmed the presence of multi-collinearity based on the high degree of variance inflation factors for seed and fertilizer. Gujarati (2005), recommends expressing variables as deviations from the mean as one practical ways of reducing the effect of multi-collinearity in estimations. We followed this suggestion with the implication of the transformation being that the results had to be interpreted at the mean values. Independent samples t-tests were used to determine statistical difference on key variables between the two main study districts.

RESULTS AND DISCUSSION

Description of the maize production system

Survey results indicate that maize farmers were on average 48 years old, decision-makers were mostly male (70%) with eight years of formal schooling. The average family had six members out of which two had attained secondary education level. This result implies that each household had appreciable levels of both physical and technical aspects of human capital. However, the low active participation of the youth and women may influence the degree of interest in and implementation of new technologies including ISFM practices.

Off-farm earnings averaged only KES 2,400 per month per household, mainly from casual employment and remittances. Only 6% of the farmers obtained agricultural credit, mainly from informal sources including 'merry-go-rounds', input stores, family members and neighbours. Most farmers blamed low access to credit on the lack of information about credit providers and lack of land title deeds (by 62%) that would serve as collateral for the loan. Some farmers cited the main deterrent as stringent requirements imposed by formal credit institutions and the perceived risks in case they defaulted re-payment. This finding indicates poor injection of liquidity into the farming system from external financial sources thereby limiting farmers' affordability of essential inputs. Most of the maize production costs (61%) were financed from farm income demonstrating the need to improve farm returns to guarantee considerable investments in maize production.

Agricultural extension contacts with the farmers were low (only 27%), on average just one visit per year. This is because farmers were yet to embrace the new demand-driven extension delivery system. In the earlier system, the extension agents were entirely responsible for making visits to individual farmers or organizing group trainings in order to provide them with better agricultural knowledge and skills.

The average cost structure of maize production included expenditure on chemical fertilizers (34%), land preparation (20%) and seed (12%). These were the major costs taking about two-thirds of all variable costs incurred in maize production. To enhance smallholders' access to these inputs, there is need for appropriate policy intervention to minimize transaction costs thereby making their acquisition more affordable. All other expenditures on labour input accounted for 34% of total production costs, indicating that labour was not a limiting resource in the study area.

Forty per cent of the sampled farmers used some components of low-cost ISFM options, which included incorporation of maize crop residues (30%), use of farmyard (24%) and compost manures (22%) as well as integration of crotalaria (10%) and groundnuts (6%). The preference of these ISFM practices was due to the availability of the manures or the bonus benefits to the household from the legumes. Within such farming environment therefore, we hypothesized that the average maize yield of 2.6 tha^{-1} was below the technically feasible and allocatively efficient levels.

Status of efficiency in maize production

Results in Table 1 indicate that overall farmers on the average achieved 64% technical efficiency. Therefore, it is possible to improve yields by an additional 36% through adoption of better farm practices such as improved soil fertility management, early land preparation, timely planting; proper spacing, use of hybrid maize varieties and effective weed control. The significant gamma (γ) estimate indicates that 65% of the technical inefficiencies can be explained jointly by the socio-economic variables in the technical inefficiency equation. The coefficients for chemical fertilizer and seed are statistically significant. This means that inorganic fertilizer

Table 1. Stochastic production function estimated using maximum likelihood method to determine technical efficiency in maize production.

Variable	Parameter	Coefficient	SE[a]
Production frontier function			
Intercept	β_0	0.50*	0.30
Fertilizer	β_1	0.19**	0.05
Seed	β_2	0.20*	0.13
Labour	β_3	-4.26***	1.68
Manure	β_4	0.03	0.07
District	β_5	0.06***	0.01
Efficiency measures			
Sigma-squared, $\sigma_\mu^2+\sigma_v^2$	σ^2	0.31**	0.08
Gamma, $\sigma_\mu^2/(\sigma_\mu^2+\sigma_v^2)$	γ	0.65**	0.18
Mean technical efficiency[b]	TE	64%	

[a]SE is standard error of the estimate, [b]Technical efficiency estimates a farmer's actual yield in relation to the optimal yield, given a production technology. The maximum possible technical efficiency level is 100%. Significant at the following levels: *10%; **5%; ***1%.

and seed are the main limiting inputs in maize production because as shown by positive coefficients, their use beyond the current levels will increase yields. The practised seed rate of 24 $kgha^{-1}$ was closer to the recommended rate of 25 $kgha^{-1}$; hence, yield increases can only be realized by planting improved varieties. Therefore, the results demonstrate that the current stage of production is inefficient (Debertin, 1986). The expectation in this study was that when efficiency is improved in the use of available inputs, farmers are more likely to expand their scale of production, since most of them are constrained by lack of finances to invest in farming consistent with Jayne et al. (2010).

The coefficient for labour is negative indicating that at the mean, increased labour use has a decreasing effect on maize yields because the current level is beyond the optimal amount required for efficient production. Since most of the labour (67%) was from own family, it was likely under-valued and over-used. The result is consistent with past findings (Seyoum et al., 1998; Tchale and Sauer, 2007) that associated negative marginal product for labour with production systems that relied on cheap family labour and usually employed it beyond the economically optimal level.

The significant coefficient for district showed that on average farmers in Trans Nzoia realized higher maize yields than those in Lugari. This is due to the relatively large farm sizes of better quality and favourable climatic conditions over there, confirming the considerable role of conducive environmental conditions in farm productivity (Sherlund et al., 2002).

The estimates of the cost frontier showed that maize farmers on average exceeded the minimum cost of production by 34% (Table 2). We calculated allocative efficiency score as the inverse of allocative inefficiency value. This translated to allocative efficiency level of 75% and meant that there was opportunity to enhance efficiency by up to 25% through better allocation of scarce financial resources in maize production.

The significant estimate of the intercept indicates that there were considerable fixed costs in maize production. When farmers do not engage in any maize farming activity (and total variable costs are zero), they still incur significant opportunity cost of land. Cost of ploughing, price of seed and labour wage have positive and significant coefficients indicating that a marginal increase in their unit prices has sizeable effect on the production cost of maize. This implies that pricing of these inputs was beyond reach of many resource-poor smallholders. Therefore, efforts targeted at reducing cost of purchasable inputs will go a long way in enhancing affordability and access by majority of the resource-poor farmers. Similarly, an increase in yields would raise total cost of production, an indication that farmers were operating in the inefficient stage I of production (Debertin, 1986). This implies that there existed scope for increasing the scale of production without necessarily raising production costs so much by improving technical efficiency to benefit from economies of scale.

Assessment of differences in farming efficiencies

Farmers in the project area where they were exposed to ISFM practices achieved higher technical efficiency and lower allocative inefficiency compared to those in the counterfactual area (Table 3). The difference in estimated efficiency levels between farmers within the project area and those outside the project area represents ISFM contribution to technical and allocative efficiencies in

Table 2. Stochastic cost function estimated using maximum likelihood method to determine allocative efficiency in maize production.

Variable	Parameter	Coefficient	SE
Cost frontier function			
Intercept	α_0	6.771***	0.476
Fertilizer price	α_1	-0.026	0.077
Seed price	α_2	0.116**	0.058
Labour wage	α_3	0.109**	0.026
Ploughing cost	α_4	0.282***	0.037
Yield	α_5	0.118**	0.030
Efficiency measures			
Sigma-squared, $\sigma_\mu^2+\sigma_v^2$	σ^2	0.074**	0.013
Gamma, $\sigma_\mu^2/(\sigma_\mu^2+\sigma_v^2)$	γ	0.351***	0.029
Mean allocative inefficiency[c]	AE	34%	

[c]Allocative efficiency measures by how much the farmer exceeded the minimum feasible cost of production for a given level of output. We subtract 100 from the allocative inefficiency percentage to estimate the excess costs incurred by the farmer or group of farmers above the minimum efficient cost. This computation is implicit in all interpretations of differences in allocative inefficiency. Significant at the following levels: *10%; **5%; ***1%.

Table 3. Differences in technical and allocative efficiencies between farmers within and outside the project area.

Efficiency by site	Technical efficiency (%)		Allocative efficiency (%)	
	Mean	SD	Mean	SD
Within project area	84***	11	110***	16
Outside project area	58***	19	140***	17
Efficiency gain	26		30	

SD is standard deviation; *** Significantly different at 1% level.

maize production.

As presented in Table 3, significant differences (p=0.001) between the two sites (i.e. within and outside the project areas) demonstrate that adoption of ISFM practices has potential to narrow the yield gap by 26%, (84% less 58%), which is comparable to 30% reported in Tchale and Sauer (2007) and reduce cost incurred in maize production by 30% (140% less 110%). This clearly indicates that there is room to increase yields through more use of ISFM options to improve returns for smallholder farmers who cannot afford recommended rates of chemical fertilizers.

Factors influencing technical and allocative efficiencies

Table 4 shows the influence of the factors identified to contribute to farming efficiencies in maize production. They include farming experience, education level of the household head, household size (proxy for family labour), extension contacts and soil fertility management option. Others were credit access, off-farm income, market access and agro-ecological zone. We reversed the signs for all coefficients to enable direct inferences in relation to efficiency gains as opposed to inefficiency effects.

The coefficient for farming experience is significant and negative indicating that technical efficiency decreased with every year spent in farming (Table 4), in contradiction with previous findings (Külekçi, 2010; Seyoum et al., 1998). Although we expected higher efficiency among farmers with longer experience, the knowledge and skills gained over time may become less relevant with new technologies and constraints. However, farming experience enhanced allocative efficiency, supporting the view that the ability to acquire and process useful financial information increases with time, in line with Ogundari et al. (2006). The finding indicates that most experienced farmers gain various cost-saving strategies over time, which they apply in maize production. For instance, experience must have taught the seasoned maize producers to purchase key inputs such as fertilizers and seeds, and plough maize fields before the peak planting period when costs rise rapidly.

Formal education was found to increase technical efficiency, consistent with Külekçi (2010). The result points to

Table 4. Maximum likelihood estimates of factors affecting technical and allocative efficiency in smallholder maize production.

Factor	Coefficient	SE	Coefficient	SE
	Technical efficiency		Allocative efficiency	
Constant	0.54	1.55	0.34	0.56
Farming experience	-0.03**	0.01	0.01*	0.001
Education level	0.03*	0.02	-0.01*	0.007
Household size	-0.04*	0.03	0.01	0.01
Extension contacts	0.05*	0.04	0.03***	0.003
Soil fertility management	0.01***	0.001	0.02**	0.005
Credit access	-0.22	0.20	-0.05	0.09
Off-farm income earning	-0.61	0.55	-0.09*	0.08
Market access	-0.004**	0.001	-0.01**	0.001
Agro-ecological zone	0.23*	0.13	-0.08	0.15

Significant at the following levels: *10%; **5%; ***1%.

the importance of human capital in making and implementing informed and timely farming decisions. This means that most educated farmers have the capacity to source for, interpret and apply technical information well than the less educated ones. Moreover, better adoption of complex production technologies may call for technical knowledge and skills. Therefore, it is possible that these decisions and skills certainly benefit from some level of formal education. However, we found that higher education reduced allocative efficiency, consistent with Ogundari et al. (2006). This was surprising because it contradicts the view that the higher the number of years of schooling, the better the ability of farmers to match input use to their relative costs. Nevertheless, higher education level is likely to give farmers other off-farm income generating alternatives, which compete with maize production for management attention.

Agricultural extension contacts were associated with relatively higher technical and allocative efficiencies. The result demonstrated the value of providing farmers with skills and modern production techniques to improve yields and minimize production constraints. This finding is in agreement with other studies (Seyoum et al., 1998; Tchale and Sauer, 2007), which established that the farmers that regularly received extension information recorded higher technical efficiency compared to their counterparts. In fact, this study indicates that farmers who applied ISFM practices operated closer to their efficient frontiers. Therefore, promoting these practices through an effective extension approach will lead to greater efficiency gains in the entire farming system.

The application of ISFM practices in maize production contributed to both technical and allocative efficiencies than the use of chemical fertilizers alone. This observation point to the beneficial role played by organic nutrient sources in improving the productive capacity of the soil (Nyambati et al., 2003; Zingore et al., 2008). Further analysis already presented clearly show that those farmers who implemented some ISFM practices incurred on average 30% less costs of production at the same level of maize output. This confirms findings in other studies that have advocated for combination of inorganic and organic nutrient sources in different farming systems (Ranamukhaarachchi et al., 2005; Tchale and Sauer, 2007; Wanyama et al., 2010).

Off-farm income generation had an impact on allocative efficiency but not on technical efficiency contrary to the finding by Mochebelele and Winter-Nelson (2000). This is probably due to the possibility that farmers who earn more income away from the farm engage hired labour to carry out most activities in maize farming. However, hired labourers are less thorough in implementing agronomic activities. Moreover, owing to high demand for labour during peak periods, the implementation of critical agronomic activities such as planting, weeding and top-dressing may be untimely and this may eventually lead to low yields. The significant contribution to allocative efficiency was due to better financial capacity that enabled households that had off-farm income sources to acquire farm inputs timely before prices rose rapidly.

Higher cost of accessing the input-output markets led to lower technical and allocative efficiencies in maize production. This result can be associated with low use of purchasable inputs such as chemical fertilizers and hybrid seeds because of poor roads and costly transport system. The cost of accessing markets adds an extra financial burden to farmers located in remote areas characterized by poor roads network. The finding indicates the importance of enhancing access to input and output markets in order to improve farm productivity as also found by Tchale and Sauer (2007).

CONCLUSIONS AND RECOMMENDATIONS

Determining and overcoming possible constraints to efficiency in smallholder farming system can contribute to sustainable use of farm resources in sub-Saharan Africa (SSA). Efforts aimed at enhancing overall efficiency among smallholders aims to improve maize productivity, net farm returns and soil fertility management in the maize farming system of Kenya. We investigated whether the availed integrated soil fertility management (ISFM) technologies have had impacts on both technical and allocative efficiencies in maize production.

We found that overall farmers achieved only 64% technical efficiency and 75% allocative efficiency. Farmers who applied ISFM practices were closer to their efficient frontiers compared to those who did not. We established that ISFM contributed about 26% to technical efficiency and 30% to allocative efficiency. Other factors that were found to determine efficiency gains included farming experience, provision of extension services, market access and off-farm income. These factors indicate the need for farming knowledge and profitability, and that farmers were responsive to policy-induced incentives. Therefore, we recommend the promotion of ISFM technologies through farmer groups and participatory extension system, in order to achieve greater efficiency gains in maize production in the country. We suggest the integration of efficiency considerations in agricultural research and policy formulation processes to ensure continued use of improved technologies and for enhanced food availability and incomes among the rural poor in similar SSA countries.

Conflict of Interest

The authors have not declared any conflict of interests.

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Determinants of the responsiveness of cooperative farmers to the cocoa renaissance programme in Osun State, Nigeria

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A key policy instrument in the cocoa transformation agenda is to provide subsidized inputs for farmers to replace old grooves to increase cocoa production in Nigeria. The study examined the role of cocoa marketing cooperatives in enhancing the incomes of its member patrons in Osun State under the cocoa renaissance policy. Multi stage sampling method was used to select 100 respondents from four cocoa produce marketing unions in the State. Data obtained were analysed with descriptive statistics, budgetary analysis and the multiple regression technique. The study revealed that the average age of the respondents was 64.4 years and only 16% of the cocoa farms were developed after the commencement of the renaissance policy. The farmers operated an average of 5.4 ha farm sizes while inputs supplied respondents through cooperative societies were much cheaper compared to what obtained in the open market. The gross margin to enterprise was ₦387, 639 while the net income was ₦345, 282. The regression analyses revealed that while family size, age, level of education, farm size and cooperative experience were significant determinants of output, family size, farm size, cooperative experience and amount of cocoa marketed through cooperative societies were significant determinants of income realized in the cocoa enterprises. The study concluded that greater efforts should be put in place to attract younger and educated farmers to achieve policy objectives.

Key words: Renaissance, transformation agenda, marketing cooperatives, subsidize, agrochemicals, fertilizer, seedlings.

INTRODUCTION

The importance of cocoa to Nigeria's socioeconomic development cannot be overemphasized and has been documented in several empirical studies (Olayide, 1969; Olayemi, 1973; Folayan et al., 2006). Although its prime place has since been taking by petroleum production, cocoa remains the most important agricultural product as no other export commodity has earned more foreign exchange than it (Abang, 1984; Akinbola, 2001). It is a major employer of labour (Folayan et al., 2006) and also supplies raw materials to local industries. Unfortunately,

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the production of the commodity has continued to dwindle while the standing of the nation among producers of the product has continued to diminish. From a peak of 308,000 tonnes in early 1970s, output declined to 110,000 tonnes in 1981 and in spite of spirited efforts to increase output as engendered by the Structural Adjustment Programme (SAP), output only increased to 205, 000 tonnes in 2000 (Koekoek, 2003).

Major problems implicated in the dwindling fortunes of Nigeria in the production of cocoa included the old age of cocoa farmers (Amos, 2007) and the cocoa trees (Adegeye, 1977); incidence of pests and diseases; poor management of the economic deregulation system which affected product quality control (Ajayi and Okoruwa, 1996); depleted soil fertility, use of poor planting materials, poor maintenance of cocoa farms, defective method of harvesting, poor handling of post harvest process and inefficient agricultural extension service (Adenikinju et al., 1989). The adoption of SAP which liberalized the marketing of cocoa produce and the abolition of the Nigerian Cocoa Marketing Board led to the shipment of poor quality cocoa beans from Nigeria (Ajayi and Okoruwa, 1996) with serious implications for the demand and pricing of cocoa from Nigeria at the international commodity market. To worsen this, dwindling world market price of cocoa from US$3,000 per tonne in 2002 to US$1,860 in 2004 to US$1,580 in 2005 have according to Ogunleye and Oladeji (2007) crushed farmers' willingness to invest in measures to boost output.

In the attempt by the Nigerian government to diversify the nation's economic base, attention has shifted to the agricultural sector with cocoa production as key in the structural transformation of the economy. A key strategy is the efforts of government to rejuvenate cocoa production in the country through its Cocoa Renaissance Policy in 2000. The strategy adopted to achieve the policy objective were the provision of cocoa producing States with marketing grants to raise hybrids, disease resistant, high yielding and early maturing seedlings for distribution to the farmers at subsidized prices. The strategy adopted by government in supplying improved inputs and technology to the poor farmers follows the high input pay-off model. The model which posits that farmers are economically rational, productive and take wise economic decisions but have exhausted potentials available. Accessing new farm technologies and improved inputs to them will enhance their efficiency and hence output (Akinyosoye, 2005; Schultz, 1964). The success in achieving very high output from the development of new, high-yielding varieties of wheat in Mexico in the 1950's and rice in the Philippines in the 1960's lends credence to the relevance of the model in tackling the challenges confronting cocoa farm enterprises in Nigeria.

While farmers have responded to the new initiative of government, a major disincentive has been the dwindling prices of cocoa at the international commodity market and the size of this income that actually accrue to farmers as a large proportion of this are claimed by intermediaries (exporters, middlemen and assemblers) (Ogunleye and Oladeji, 2007). This affects their capacity to compete in the market place. However, the severity of the impact of the market price of the commodity as well as market imperfections will depend on national policies, production and marketing conditions as well as the existence and participation in socio-economic networks like the co-operative societies and farm organizations. Fortunately, the cocoa renaissance programme is taking place within the free market policy of government. While government is providing the necessary conducive policy environment and incentives, private commercial concerns like the cooperative societies should be able to tap into these initiatives to curb the unhealthy activities of market intermediaries and complement the government's goal of increasing output and incomes to cocoa producers.

Cooperatives are a voluntary association of persons or business enterprises owned by member patrons pursuing common goals and who contribute capital and business and is controlled by member patrons who run the affairs of the association along democratic lines (Gupta, 2012; Dogarawa, 2005; Adegeye and Dittoh, 1985). Key values of cooperatives include self-help, equality, equity, solidarity democratic control. Cooperatives harnesses the individual strengths and/or resources of members which on their own are too weak to be competitive in a free market system to meet their common economic, social and cultural needs. These are used to provide services or products at cost to members who share the net surplus as benefits. The close relations of members ensures trust and compliance with the rules and principles of the association (Aremu et al., 2013; Nkonya et al., 2010). These inherent advantages coupled with reduced costs in providing services to a large group of farmers in cohesive society is a veritable tool for government to explore to implement policy measures aimed at reaching a large group of atomized farmers in a free market system.

Cooperative societies according to Akinbola (2001) are out to promote fair trade as well as seek to give a higher share of the final consumer price directly to farmers through effective marketing system. Cooperative societies are able to buy farm inputs in bulk and sell to members (by cash or on credit) at cheaper prices at the beginning of the production year and pay higher prices to member- farmers through the maintenance of inventory and storage facilities. This enables the cooperative society to hold cocoa products when there is a glut and sell when market prices are more favourable. The incentives provided by the income raise is expected to provide an additional impetus for cocoa farmer members to take advantage of the policy initiatives to increase farm size, outputs and hence incomes. Since the introduction of the policy strategy in Osun state, little efforts have been made at examining its effect on the cocoa production sub-sector in general and the impact of cocoa marketing cooperatives in exploiting the opportunities offered under the programme for the benefit of its member patrons in particular. Hence, this study aims at identifying the role of cocoa marketing cooperatives in enhancing the outputs and incomes of its member patrons under the cocoa renaissance programme in Osun State, Nigeria. The specific objectives were to:

(i) Examine the extent to which the policy initiative has influenced the farming decisions of cocoa farmers,
(ii) Evaluate factors determining responsiveness of farmers to the cocoa renaissance policy initiative in Osun State, and,
(iii) Analyse factors determining output and incomes among cocoa farmers

METHODOLOGY

Sampling technique and data collection

The study was carried out in Osun State, Nigeria. The State covers an area of approximately 14,875 sq/km and lies between longitude 4° and 5°E and latitude 7° and 8°N. The State is divided into 30 Local Government Areas (LGAs) and experiences two main seasons: the rainy season that runs through April and October, and the dry season that covers the rest of the year (November to March). Mean annual rainfall averages 1,570 mm while the mean annual temperature is about 27°C. The State lies within the tropical rainforest belt of the western uplands (Agboola, 1979) where climatic and edaphic factors provide the ideal environment for cocoa cultivation.

The multi stage sampling technique was employed to obtain necessary data from the major cocoa producing areas of the State. First, five Cooperative Marketing Unions involved in cocoa marketing were purposively selected. Each of these Unions were based in five LGAs namely: Ife Central, Ife East, Ifelodun, Boluwaduro and Boripe LGAs. From each of the Marketing Unions, four cooperative societies were randomly selected. In all, 20 cooperative marketing societies were selected. Finally, from each of these marketing societies, five member participants were randomly selected for interview. In all, 100 respondents were interviewed for this study.

Data analysis

Descriptive statistics, budgetary analysis and the multiple regression analytical techniques were used to analyse information obtained from the respondents. Descriptive statistics, including frequency counts, means and percentages were used to describe the socio-economic characteristics (including age, education level, family size, farm size) of selected cooperative member participants in the study area. Budgetary analysis was employed to estimate costs and returns to cocoa production using the gross margin as stated in Equation (1):

$$\pi_i = P_i Q_i - TCi \quad (1)$$

Where, π_i = gross margin per tonne (₦/tonne), P_i = price per unit of cocoa produced (₦), Q_i = cocoa output (tonne), and, *TCi* = total costs of production (fixed cost {FC} plus variable cost {VC}) (₦) Variable costs (VC) included in the analysis were expenditures on labour, seedlings, fertilizers, agrochemicals and transportation. Items that could be used for more than a production cycle were classified as fixed costs (FC). These included cutlasses, sprayers and farm-bans.

Finally, two multiple regression models were used to estimate the socio-economic factors determining the production and marketing of cocoa through marketing cooperative channels as well as those determining the profitability of cocoa enterprises in the study area. The model on factors determining production and marketing of cocoa beans was specified as:

$$Q_1 = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \varepsilon_i) \quad (2)$$

Q_1= output of cocoa (kg), X_1 = total cost of production (N), X_2= family size, X_3= age of respondents (years), X_4= educational level of respondents (years spent in formal schools), X_5= farm size (ha), X_6= age of cocoa farm (years), X7= experience in cooperation (years), ε_i = error term.

In terms of *a priori* expectations, X_1, X_4, X_5 and X_7 are expected to be positively correlated to farm output. X_2, could be either positively or negatively correlated depending on whether the family is a production or consumption unit. X_3 is expected to be positively correlated to farm output to a certain age where it starts to show a negative relationship as increasing age affects the productivity of farmers. X_6 is also expected to be negatively correlated to farm output as cocoa trees age beyond their prime productive years. The second model on factors determining the income realised from cocoa enterprises was also specified as:

$$Y_1 = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, \varepsilon_i) \quad (3)$$

Where, Y_1 = farm income (₦), X_8= output of cocoa produced and marketed through cooperative societies (kg), X_9= distance of farm to cooperative office (km). X_1, X_2, X_3, X_4, X_5, X_6, X_7, and ε_i are as defined earlier.

In terms of *a priori* expectations, X_1, X_4, X_5, $X_7$and X_8 are expected to be positively correlated to farm income while X_2, could be either positively or negatively correlated depending on whether it is a production or consumption unit. X_3 is expected to be positively correlated to farm income to a certain age where it starts to show a negative relationship as increasing age affects the productivity of farmers. X_6 and X_9 are expected to be negatively correlated to farm incomes. X_5 is expected to be positively correlated to farm income to a certain age where it starts to show a negative relationship as increasing age affects the productivity of farmers. Three functional forms of the regression models were fitted to the data namely the linear, semi-logarithm and the double logarithm models. The models that provided the best of fit were selected and discussed.

RESULTS AND DISCUSSION

Socioeconomic distribution of respondents

The age distribution of the respondents as shown in Table 1 indicated that 90% of the farmers were over 50 years old while only 4% aged less than 40 years. The mean age of the respondents was 64.4 years. This is slightly higher than that recorded among cocoa farmers by Adesiyan and Adesiyan (2012) and Idowu et al. (2007). A critical factor in the sustainability of the new

Table 1. Socio-economic characteristics of respondent farmers.

Variable	Frequency	Percentage	Cumulative percentage	Mean
Age (Years)				
21 – 30	3	3.0		
31 - 40	1	1.0	4.0	
41 - 50	6	6.0	10.0	64.4
>50	90	90.0	100.0	
Level of education				
Did not go to school	36	36.0		
Adult/Quaranic education	10	10.0	46.0	
Primary school education	19	19.0	65.0	
Secondary school education	26	26.0	91.0	
Technical/Teachers College	9	9.0	100.0	
Marital status				
Married	78	78.0	78.0	
Widowed	17	17.0	95.0	
Divorced	5	5.0	100.0	
Family size				
6 – 10	29	29.0		
11 – 15	43	43.0	72.0	13.1
16 – 20	28	28.0	100.0	
Farm Size (ha)				
≤ 2.5	8	8.0		
2.6 – 5.0	62	62.0	70.0	
5.1 - 7.5	20	20.0	90.0	5.4
7.6 – 10.0	5	5.0	95.0	
≥ 10.1	5	5.0	100.0	
Age of cocoa farms (years)				
≤ 10	16	16.0		
11 – 20	34	34.0	50.0	
21 – 30	46	46.0	96.0	20.8
31 – 40	2	2.0	98.0	
≥ 41	2	2.0	100.0	
Cooperative experience of farmers (years)				
≤ 10	9	9.0		
11 – 20	20	20.0	29.0	
21 – 30	52	52.0	81.0	24.5
31 - 40	7	7.0	88.0	
≥41	12	12.0	100.0	
Benefits derived from membership				
Access to inputs	96	96.0		
Access to credit	98	98.0		
Access to transportation of produce	77	77.0		
Marketing of produce	100	100.0		

Table 1. Contd.

Distance of farm to cooperatives (km)				
≤ 2.0	26	26.0		
2.1 – 4.0	55	55.0	81.0	3.1
4.1 – 6.0	16	16.0	97.0	
≥ 6.1	3	3.0	100.0	

Source: Field survey (2012).

Table 2. Input costs variations between cooperative societies and the open market.

Cocoa farm inputs	Input prices (₦) per unit at	
	Cooperative market outletsb	Open market outlets
Seedlings	5	10
Fertilizer	150	200
Ridomine	200	250
Copper sulphate	200	250
Harvesting equipment	290	317
Hoe	950	1,400
Cutlass/matchet	630	650

Source: Field survey (2012).

initiative will be the set of farmers that have keyed in to the new policy initiative. Clearly, most of the farmers were old, above their prime age of production and are most probably into cocoa farming as a way of life rather than the policy initiative. The policy has therefore not succeeded in attracting new and younger farmers to drive it. This is reflected in the age of the cocoa farms where only 16% of the respondents' farms were developed after the policy became operational. The remaining 84% were cultivated long before the policy came on board and the average age of the farms was 20.8 years (Table 1).

The level of education among the farmer respondents was very low as 36% did not even attend any school while 19% attended up to primary school. Only 35% of the respondents had either Grade II Teacher's College or Technical College education. The high level of illiteracy could not only hamper the farmers from participating in the new policy drive but also in acquiring new skills and accessing technical inputs (Ogundele and Okoruwa, 2006) necessary to modernize the cocoa production subsector. However, as members of cocoa produce marketing societies, they are key to the success of the cocoa renaissance policy initiative hence, the need for increased efforts to improve the knowledge base of these set of farmers. Most of the farmers had access to family labour as 78% of them were married while the remaining were either widowed or divorced. The mean family size as shown in Table 1 was about 13 which is typical of most traditional farming communities where family labour is critical to farm production system (Oluwasola and Alimi, 2007). While this is good to meet the labour requirements in the farm, large family sizes could result in high household expenditure that could in turn become a drain on family income, savings and farm capitalization. The mean farm size was 5.4 ha which is far higher than the 2 ha average farm size in Nigeria (NINCID, 2006, Idachaba, 1989) or the 2.2 ha found among cocoa farmers by Idowu et al. (2007) in the same region. This is quite understandable as cocoa grooves with their high density tree foliage requires less efforts to weed once established compared to food crop farms. It is also a major subsector of agriculture that has enjoyed considerable commercialization since the colonial times.

The respondents have been involved in cooperative marketing for an average of 24.5 years and the main benefits derived in the long association include the marketing of cocoa produce enjoyed by all members. Ninety six percent enjoyed the supply of inputs from the societies while 98% enjoyed credit facilities from the relationship. As much as 77% also enjoyed the benefit of transporting their cocoa products to the cooperative offices with the marketing unions vehicles. In terms of distance of farms operated by the respondents to the societies' purchasing offices, most farms were located within 3.1 km.

Table 2 reveals the advantages of buying farm inputs from the cooperative marketing unions as the unit price of inputs purchased by farmers for their cocoa farms were much cheaper compared to what obtained in the open market especially if farmers needed to buy in bulk. The

Table 3. Analysis of cost and returns to cocoa marketing.

Income/cost Items	Amount (N)	Percentage in cost category
Revenue	519,000	
Seedlings	10,230	8.36
Agrochemicals	35,405	28.94
Labour (i).Weeding	32,565	26.61
(ii) Harvesting	16,675	13.63
Transportation	27,486	22.46
Total variable costs	*122,361I*	
Gross margin	387,639	
Fixed costs items	41,105	
Depreciation	10,252	
Total fixed cost	*51,357II*	
Total Cost	173,718	
Net revenue	345,282	
Expense-Structure Ratio	0.41	
Benefit-Cost Ratio	2.99	
Rate of Return	1.99	

price advantage enjoyed by the cooperative organization comes from two main sources. First as a major organization of farmers targeted by the policy on cocoa renaissance, they could receive these inputs at subsidized rates. In addition, it could also buy the inputs in bulk and distribute to farmers as they needed thereby reducing marketing and handling costs.

Analysis of costs and returns to farm enterprise

The breakdown of the cost and return components of the enterprises are presented in Table 3. The table shows that on the average, the farmers spent only ₦10, 230 (US$63.93) or 8.36% of the total variable cost on seedlings in spite of the efforts of government to access the farmers with subsidized improved seedlings. Although the cooperative marketing unions have passed the benefits of the government assistance to cocoa farmers in terms of supplying subsidized inputs to farmers at cheaper prices as indicated in Table 2, the farmers have not responded maximally to this incentive. The replacement of old cocoa grooves which has been implicated as one of the major factors in the dwindling fortunes of Nigeria in cocoa production (Amos, 2007) by new and improved seedlings is very critical if the cocoa subsector is to be revitalized hence the need for the marketing unions to embark on aggressive drive to ensure members replaced old grooves or planted new farms. The age of the farmer-members of the union which on the average was 64.4 years is however, a major disincentive to this kind of efforts, hence the need to attract younger farmers into the cocoa production subsector. The mean expenditure on agrochemicals was ₦35, 405 (US$221.28) or 28.94% of the total variable cost. Labour cost constitute the major variable cost component on the cocoa farms as the farmers spent ₦32, 565(US$203.53) (26.61%) on weeding and ₦16, 675 (US$104.22) (13.63%) on harvesting. The two labour driven activities constituted 40.27% of the total variable cost. The gross margin to enterprise was ₦387, 639 (US$2,422.74) indicating that the enterprise was far able to meet its variable costs. The total variable cost component constitutes 70.44% of the total enterprise cost while the fixed cost components constitute only 29.56%. This is possible because the fixed cost component is recouped over a long period of time and as pointed out earlier, the mean age of the cocoa farms was 20.8 years. The table shows that the net revenue accruing to cocoa farmers was ₦345, 282 (US$2,158.01). This is equivalent to ₦28, 773.50 (US$179.83)/month which is far above the national minimum wage of ₦19, 000.00 (US$118.75) of the nation. The expense-structure ratio of 0.41 indicates that for every ₦100 spent on cocoa farm business ₦41 was spent on fixed inputs while the remaining ₦59 went on variable inputs. The relatively large expenditure incurred on fixed inputs indicates that farmers could find it difficult to adjust to vagaries in market conditions hence adverse market conditions could discourage cocoa farming. This is particularly so as the farmers have very little control of the cocoa export market. The subsidy provided on farm inputs is thus very significant in encouraging farmers to replace old grooves or plant new farms. The benefit-cost ratio of 2.99 indicates that cocoa farming is profitable as every ₦100 invested returned ₦199 while the rate of return of 1.99 suggests an increasing return to scale with every ₦100 invested returning ₦199. over and above the amount invested (Table 3).

Determinants of cocoa production and marketing

Equation (3) shows the factors determining the output of cocoa in the study area. The result shows that in conformity with *a priori* expectations, family size (X_2), educational level of respondents (X_4), farm size (X_5) and experience of respondents in cooperation (X_7) were positively signed while age of respondents (X_3) and age of cocoa farms (X_6) were negatively signed. Contrary to *a priori* expectations, total cost of production (X_1) was negatively related to cocoa output. All the variables, with the exception of cost of production (X_1) and age of cocoa farms (X_6) were statistically significant determinants of cocoa production. As shown, a unit increase in family size (X_2) would increase cocoa output by 28.7%. This indicates that the family sizes are productive and an increase in the number of family sizes will provide additional family labour that can boost output of cocoa. This is particularly important as labour is the most important variable input in smallholder agriculture (Oluwasola, 2012). On the other hand, a unit increase in the age of farmers (X_3) would decrease output by 14.1%. As indicated earlier, the mean age of farmers was 64.4 years. Clearly the farmers were very old and as they age, their strength and drive will decrease with a consequent negative effect on output. Furthermore a unit increase in the educational level of respondents (X_4) would increase cocoa output by 43.8%. Increased education will help farmers understand the policy drive of government as well as access the key elements of the policy as related to the inputs. In addition, it will enable the farmers understand the instructions on the usage of these inputs. A unit increase in farm size (X_5) will also increase output by 78.2%, indicating that in smallholder farms where minimal inputs are used, farm sizes tend to be strongly correlated with output and income. Finally, the result also indicated that a unit increase in the years of experience of farmers in cooperative activities (X_7) will increase output by 18.6%. This is important in that cooperative societies provide ready market for farm produce and inputs as well as transportation of produce to cooperative stores. In addition, they also offer opportunities for agricultural extension which could enhance cocoa output. Cost of production (X_1) and age of cocoa farms (X_6) were not statistically significant. The adjusted coefficient of determination of 0.950 indicates that about 95% of the variability in cocoa output is explained by the variables specified in the model.

$$Y_1 = \underset{}{0.572} - \underset{(0.133)}{0.196\ln X_1} + \underset{(0.194)}{0.287\ln X_2^{*}} - \underset{(0.202)}{0.141\ln X_3^{*}} + \underset{(0.139)}{0.438\ln X_4^{**}} + \underset{(0.237)}{0.782\ln X_5^{**}} - \underset{(0.114)}{0.09\ln X_6} + \underset{(0.216)}{0.186\ln X_7^{**}} - \qquad (4)$$

R^2 = 0.967
$\bar{R}^2$ = 0.950
F-value= 56.3

N.B. *significant at 1% level; ** significant at 5% level

Determinants of income from cocoa enterprises

Equation (4) presents the regression analysis of factors affecting income from cocoa farms. As indicated, total cost of production (X_1) and respondents level of education (X_4) were negatively signed contrary to *a priori* expectations. Age of cocoa farms and (X_6) and distance of farm to cooperative offices (X_9) were also negatively signed but in conformity with *a priori* expectations. The remaining variables, family size (X_2), age of farmers (X_3), farm size (X_5), experience of farmers in cooperative activities (X_7) and quantity of cocoa marketed through cooperative societies (X_9) were positively signed. Four of these independent variables were statistically significant. Family size (X_2) was positively and significantly related to income and as shown, a unit increase in family size will increase cocoa income by 26.3% while a unit increase in farm size (X_5) will also increase income by 42.9%. The result further shows that a unit increase in the years of experience of farmers in cooperative activities (X_7) would increase income by18.7% while a unit increase in the quantity of cocoa products marketed through cooperative societies (X_8) will increase income by 13.4%. Although not statistically significant, there was a negative correlation between total cost of production (X_1), educational level of farmers (X_4), age of cocoa farms (X_6) and distance of farms to cooperative offices (X_9). The adjusted coefficient of determination of 0.734 indicates that about 73.4% of the variability in income derived from cocoa farms is explained by the variables specified in the model.

$$Y_2 = -6.357 - \underset{(0.500)}{0.422\ln X_1} + \underset{(0.690)}{0.263\ln X_2^{**}} + \underset{(0.607)}{0.363\ln X_3} - \underset{(0.628)}{0.383\ln X_4} + \underset{(0.207)}{0.429\ln X_5^{**}} - \underset{(0.`391)}{0.383\ln X_6} + \underset{(0.694)}{0.187\ln X_7^{**}} + \underset{(0.421)}{0.134\ln X_8^{**}} - \underset{(0.578)}{0.383\ln X_9} \quad (5)$$

R2 = 0.857
R̤2 = 0.734

``` F-value = 53.8
N.B. *significant at 1% level; ** significant at 5% level

## CONCLUSION AND RECOMMENDATION

In spite of the fact that Nigeria's fortune in cocoa has considerably declined, the study has shown that the enterprise is still very profitable. Although the efforts of government to transform cocoa production through the Cocoa Renaissance Policy is laudable, the farmers involved are very old and very insignificant efforts have been put into developing new cocoa farms since the policy was introduced. There is thus the need to explore strategies that will attract young and educated Nigerians into the sector if the objectives of the policy is to be realized. The use of cooperative societies to target farmers is very important as the inputs obtained through this medium were cheaper than obtained in the open market. The cooperative societies also offer more services including credit and transportation than could be obtained even through public agricultural outlets. They also tend to be closer to the farmers, hence, greater attention should be focused on them to reach more farmers.

The major determinants of output and hence the quantum of cocoa available for sale through cooperative societies were family size, age of respondents, educational level of respondents, farm size, and experience of respondents in cooperation. Although large family sizes could significantly increase output through the supply of cheap family labour as revealed in this study, the large family expenditure that will be incurred in the process could be a major financial drain that could hinder ploughing back farm income hence, the need for enlightenment campaign among farm households to reduce family sizes. This should be complemented by accessing farmers with farm implements that can substantially reduce labour requirements especially for weeding and harvesting. As farmers age, production will decline hence the need to attract younger, able bodied and educated farmers to the sector. Farm size among the cocoa farmers was above national average and is very significant in determining output. Policy efforts should also focus on increasing the yield of cocoa per hectare to further enhance output.

### Conflict of Interest

The authors have not declared any conflict of interest.

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Crop residue usage and its determinants in Kano State, Nigeria

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This study examined crop residue usage and determined factors influencing the decision to allocate as well as the intensity of crop residue in Kano state, Nigeria. A multi-stage sampling technique was employed to select 160 farming households in three local government areas of the state. Data collected were analyzed with descriptive statistics and double hurdle Tobit model. The results of the study showed that on a general note, crop residues allocated for own animal feeding had the major share. Farmers preferred using crop residue for feeding than mulching. The allocation of the legume residues for feed purposes was about 64 percent; the share for cereal residues of animal feed was 26 percent. Other important competing uses of crop residue of legumes and cereals were also different. These included stall feeding, burning, house construction and fuel. About 17 percent of legumes residues are sold either on field or offsite. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). More of legume crop residue (CR) was used within the farm/community (88.9 percent) while only 11 percent was exported. The decision to adopt cereal crop residue as livestock feeds was positively and significantly influenced by age, education, access to credit facilities and quantity of cereal crop residue available to the farmers. On the other hand, decision to use legume crop residue was positively and statistically influenced by farm size and access to extension facilities. However, the intensity of use of both categories of residues was mostly determined by age, education and access to credit. Furthermore, results indicated that where both residues were available, farmers complemented the use of one with another. Concerted efforts should therefore be made at increasing awareness and education on the use of crop residues in the crop-livestock system. Similarly, facilitation of extension services in crop residue training and increased access to credit will reduce the degree of residue export from the system.

Key words: Double hurdle Tobit model, multi-stage sampling technique, legumes, cereal, crop residue.

INTRODUCTION

Background Information

Crop and livestock agriculture is important to the lives of most Nigerians. Fifty to eighty percent of Nigerians are involved in crop, livestock, or crop-livestock agriculture. Nigerian agriculture is dynamic. Farmers who were hitherto involved only in crop production have adopted crop-livestock production. Similarly, formally transhumant pastoralists are increasingly turning into agro-pastoralists (Agyemang et al., 1993). This change is largely spontaneous and is based on perceived reciprocal benefits that such a system offers. To meet the rapidly increasing demand for food by an ever-expanding human population (estimated at 2.5% annually) (Manyong et al., 2005), production from crop agriculture must expand by 4% annually while the production of food from animal agriculture must expand by more than 3% annually, between now and the year 2025. This will increase the pressure on land, leading to further intensification of land use. Under these conditions, full integration of crop and livestock production offers the greatest potential for increasing agricultural productivity, especially in the sub humid and wetter parts of the semiarid zones (Powell and Williams, 1995).

Crop residues from crop produced are of two general types: Those of the cereals (millet, sorghum, and maize) and those of the legumes (cowpea, groundnut, and soybean). The major crop residues which are grazed or stockpiled for ruminant feeding are millet and sorghum stalks, cowpea vines, cowpea husks, maize stover, maize husk, and groundnut haulms. The potential of cereal crop residues as animal feed is enormous if all the different types of cereal crops are considered and if appropriate methods of improving their nutritional value are employed. According to Lal (2008), the amount of crop residues produced was estimated at ~ 0.5 billion Mg in USA and ~ 4 billion Mg in the world. These residues contained ~ 11 × 106 Mg of NPK in USA and 81 × 106 Mg in the world. Legume crop residues, such as groundnut haulms, cowpea vines, and cowpea husks have higher crude protein content and are generally used as supplements in addition to the grazing of ranges and cereal crop residues (Singh et al., 2003).

The crop residues of cereals may be left in the field as grazing material for livestock. They may be used as mulch, transported to the homestead for stall feeding, used as fencing, building, or roofing materials, or as fuel. The legumes on the other hand could be harvested and conserved either for dry-season feeding for the farmers' animals or for sale to other farmers during the critical period of feed scarcity in the mid-to-late dry season (Singh and Tarawali, 1997).

Many authors including (McIntire and Gryseels, 1987; Latham, 1997; Erenstein and Thorpe, 2010; Moritz, 2010) had identified two major uses of crop residues - use as livestock and use as mulch and opined that residue use as livestock feed exerts a competitive pressure on residue use as soil mulch. However, literature is scanty on the drivers of crop residue usage particularly in northern Nigeria. Therefore, analyzing the potential tradeoffs in the allocation of these residues and the socioeconomic setups influencing the decision and extent of use in a mixed crop-livestock systems becomes imperative in the study area. Enhancing the level of awareness on possible tradeoffs between crop residue use for livestock feeds and other competing uses need to be fully understood by farmers and other stakeholders in crop-livestock system for better management and improved livelihood.

Pertinent questions that may arise include the following: What factors influence their allocation decision? What factors determine the extent of use of the main uses crop residues are allocated? This study attempts to examine crop residue usage and determine factors influencing the decision to allocate as well as the intensity of use to main uses in Kano State, Nigeria.

Theoretical framework

This work is conceived as an adoption study. Adoption has been defined as decision to use a new technology or practice by economic units on a regular basis. Akinola et al. (2011) defines adoption as 'the use or non use of a technology by a farmer at a given period of time. Bekele and Drake (2003) opined that adoption decision involves the choice of how much resource (that is, land to be allocated to the new and old technologies, if the technology is not divisible (e.g. mechanization, irrigation). However, if the technology is divisible (e.g. improved seeds, fertilizer and herbicides), the decision process involves area allocation as well as the level of use or rate of application). Therefore, the process of adoption involves the concurrent decision of whether to use a technology or not and the intensity of its use. Besides, before adoption choices are made, a farmer makes a set several interdependent decisions (Hassan, 1996). Based on these definitions, use or non-use of a technology with subsequent intensity of usage is purely an adoption decision and process. The usage of crop residues could be seen as adoption of crop residue either as an intensification technology that boost the availability of biomass and consequent release of nutrients to the soil or a technology used as means of producing/raising livestock (feeds) . This is in view of substantial efforts put in place through the System-wide Livestock Program (SLP) in encouraging a systematic approach to the use of crop residues as animal feeds or nutrient enhancing technologies.

Moreover, according to Adesina and Zinnah (1993) and Negatu and Parikh (1999), three main models are used in explaining adoption. The models are the innovation-diffusion, economic constraints, and technology characteristics-user's context models. The innovation–

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diffusion model is mainly based on the ideas of Rogers (1962). The model regards information dissemination as a key factor of adoption decisions. It assumes that the technology is appropriate for farmer's problem but access to information on the technology to the potential adopters is the main constraint to adoption. It therefore emphasizes that medium such as extension system, on-farm trials, experimental station visits and mass media are necessary for new technologies to be adopted (Negatu and Parikh, 1999; Langyintuo et al., 2005). On the use of crop residues, extension services and media had been engaged for the adoption of crop residue as mulching or animal feeds.

The economic constraint model assumes that resources such as capital, credit and land are important for adoption decisions. The pattern of distribution of these resource endowments among potential users determines the pattern of adoption of a technology (Adesina and Zinnah, 1993). The specific influence of these resources as they pertain to use and non-use and the intensity of use of crop residue are duly explained under the empirical model.

The technology characteristics-user's context model assumes that characteristics of a technology in an agro-ecological, socioeconomic and institutional context of the potential user are necessary factors of adoption. This model further explains the importance of the perception of the potential adopter regarding the characteristics of a technology as a component factor affecting adoption decisions. It emphasizes the importance of the involvement of farmers through a participatory approach in the technology development process with the aim of generating technologies with appropriate and acceptable characteristics (Negatu and Parikh, 1999; Udoh and Kormawa, 2009).

The nature and the associated characteristics of crop residue to a large extent will determine the decision to use crop residues for any purpose at any point in time. Therefore, these three theoretical bases support the conception of crop residue as an adoptable technology.

METHODOLOGY

Study area

The study area was Kano State. Kano State is a state located in North-Western Nigeria. Kano state borders Katsina State to the North-west, Jigawa State to the North-east, Bauchi State to the South-east and Kaduna State to the South-west. Kano State has been a commercial and agricultural state, which is known for the production of groundnuts as well as for its solid mineral deposits. The state has more than 18,684 km^2 of cultivable land and is the most extensively irrigated state in the country. The primary occupation of most of the inhabitants is agriculture in the form crop farming and animal husbandry. The cultivation of food and cash crops remain common engagements of the people (Olofin, 1987). The mean annual rainfall is about 850 mm. The rainfall is highest in August (single maximal) with a sharp decline in September and an abrupt end in October (Olofin, 1980).

Sampling technique and data analysis

A multi-stage sampling technique was used for this study. The first stage involved a purposive selection of Kano South senatorial zone comprising of 16 LGAs. The second stage was also a purposive selection of three LGAs namely, Albasu, Wudil and Garko based on the intensity of crop-livestock production management system, marketing and utilization prevailing in the area. The third stage involved proportionate sampling of eight (8) villages based on their population. The villages chosen were Fadisonka, Indabo, Lajawa, Lamire, Utai and Kausani in Wudil LGA. Kafin Malama was chosen in Garko LGA while Saya Saya was selected Albasu LGAs. At the household level, farmers were stratified into very poor, poor middle and wealthy based on the degree of ownership of livestock and landed properties. In each category, 5 households were selected to make 20 households per village. On the overall 160 households were interviewed using a structured questionnaire. The sample size could have presented a limitation on the ability of the study to capture effects adequately at household level. But in view of the concentration of households that use crop residue in the study area and fewness of villages in the Sahel region that practiced crop-livestock integration, the sample can to a large extent describe the scenario of crop residues usage. Data collected were analyzed using descriptive statistics and double hurdle model.

Econometric specification

Double hurdle model

This study used the double hurdle model which was originally proposed by Cragg (1971). This has been recently used in the study of agricultural technology adoption (Gebremedhin and Swinton, 2003; Simtowe and Zeller, 2006; Langyintuo and Mungoma, 2008; Asfaw et al., 2010). This model assumes that households must cross two hurdles or make two decisions in order to adopt a given technology, e.g., crop residue (CR). The first decision is to decide whether to adopt or not (probability of adoption). The second decision is about the share of land that the household will allocate for its cultivation (intensity of adoption) which is conditional on the first decision. The model allows for the possibility that the probability and intensity of adoption have different explanatory variables and even variables appearing in both may have different effects (Asfaw et al., 2010; Teklewold et al., 2006; Simtowe and Zeller, 2006; Langyintuo and Mungoma, 2008. The first hurdle, decision to adopt CR (*d*) is expressed as:

$$d^{*}=z_{i\,\alpha}+\varepsilon_{i.}$$
$$di=1 \text{ if } d_i^{*}>0 \text{ and } 0 \text{ if } d_i^{*}\leq 0 \qquad (1)$$

The second hurdle, intensity of adoption (y) is expressed as

$$y^{*}=xi\,\beta+\mu i.$$
$$yi=yi^{*} \text{ if } yi^{*}>0 \text{ and } di^{*}>0$$
$$yi=0 \text{ otherwise} \qquad (2)$$

Where d_i* is a latent variable that describes household decision to adopt CR, y_i* is a latent variable describing the intensity of adoption and y_i is the observed response on intensity of CR. z and x are vectors of variables explaining the decision to adopt and intensity of use of CR respectively. α and β are vectors of the parameters. ε_i is an error term with mean 0 and variance 1. μ_i is also an error term with mean 0 and variance σ^2. The two error terms are assumed to be independent. They are based on the assumption that the double hurdle model is equivalent to a combination of a probit model and a truncated regression. The two hurdles are normally estimated with the maximum likelihood method of probit regression for probability

Table 1. Description of key variables for regression.

Variable	Variable descriptions	Unit
HHHHAGE	Age of the household head in years	Years
HHEDU	Number of years of formal education completed by the household head	Years
HHSIZE	Number of people living together under the same roof and eating from the same pot	
EXTENSION	An ordinal measure of training on crop residue use. It is proxied by household possession of radio or mobile phone which are the reliable channels of communication in the study area; 1 if possessed, 0 if not	
CREDITAC	Access to credit measured by the farmer's access to a source of credit such as co-operative society at a reasonable cost. 1 if there was access, 0 otherwise.	
ELECTRICITY	Access to electricity. An ordinal measure 1, if there was access, 0 otherwise	
PLOTSIZE	Size of household farm land used for farming	ha
RENT	Value of land leased for agricultural purposes	Naira
TLU	Livestock holdings of the household as probable source of wealth	Tropical Livestock Units
QTLEGUMECR	Quantity of available legume crop residue	kg
QTCEREALCR	Quantity of available cereal crop residue	kg

of adoption using all observations. They also employ truncated regression using the non-zero observations (Gebremedhin and Swinton, 2003; Teklewold et al., 2006).

Empirical model

The empirical model employed for each of the two stages of the double hurdle model is as stated below:

$$Y_i = \beta_0 + \beta_1 HHHHAGE + \beta_2 HHEDU + \beta_3 EXTENSION + \beta_4 HHSIZE + \beta_5 TLU + \beta_6 CREDITAC + \beta_7 ELECTRICITY + \beta_8 PLOTSIZE + \beta_9 RENT + \beta_{10} QTLEGUMECR + \beta_{11} QTCEREALCR + \mu \quad (3)$$

The dependent variable is the proportion of cereal or legume crop residue used for feed The explanatory / independent variables included farmer, farm and institutional factors postulated to influence adoption of technologies. These variables include age of the household head in years (*HHHHAGE*), education of the household head *(HHEDU*) measured in years, number of people in the household (*HHSIZE*), livestock ownership *(TLU)* measured in Tropical Livestock Units, access to credit (*CREDITAC*), farm size of the respondents (*PLOTSIZE*) and extension services (*EXTENSION)* proxied with possession of radio or mobile phones via with the information relating to crop residue uses are disseminated Also included were the value for which land is leased for agricultural purposes *(RENT*) in Naira, quantity of legume crop residue (QTLEGUMECR) or/and cereal crop residue (QTCEREALCR) available (Table 1).

The rationale for inclusion of these factors was based on previous agricultural technology adoption literature and the analysis of these systems. The effect of age (*AGE*) on the use of crop residue could be negative or positive irrespective of intensification gradients and .manners of redistribution. Previous studies show that the age of individuals affect their mental attitude to new ideas and influences adoption in several ways (Feder et al., 1985; Nkonya et al., 1997; Oluoch-Kosura et al., 2001; Bekele and Drake, 2003). Younger farmers have been found to be more knowledge-able about new practices and may be more willing to bear risk and adopt innovation because of their longer planning horizons. The older the farmers, the less likely they are to adopt new practices as he gains confidence in his old ways and methods. On the other hand, older farmers may have more experience, resources, or authority that may give them more possibilities for trying a new technology. Thus for these study, there is no agreement on the sign of this variable as the direction of the effect is location- or technology-specific (Feder et al. 1985; Nkonya et al. 1997; Oluoch-Kosura et al. 2001; Bekele and Drake 2003).

Education (*HHEDU*) was hypothesized to positively influence the decision and proportion of residue that would be redistributed in the farm and in the system and negatively related to the export of nutrients from the systems. Education increases the ability of farmers to use their resources efficiently and the allocative effect of education enhances the farmer's ability to obtain, analyze and interpret information (Feder et al., 1985; Alene et al., 2000; Nkonya et al., 1997; Oluoch-Kosura et al., 2001).

Household size (*HHSIZE*) has been identified to have either posi-tive or negative influence on adoption (Manyong and Houndekon, 1997, Zeller et al., 1998; Oluoch-Kosura et al., 2001; Bamire et al., 2002; Bekele and Drake, 2003). However, larger family size could be associated with a greater labor force being available to the household for the timely operation of farm activities including crop residue use. More labor hours will be spent on transporting crop residue away from the farm. The study hypothesize that increased household size could favour export of crop residue away from the farm.

Institutional factors of training on crop residue use (*EXTENSION)* as well as access to credit (*CREDITAC*) are hypothesized to positively influence the redistribution of nutrients in the farm and in the systems. The training variable incorporates the information that the farmers obtain on their production activities on the importance and application of innovations through counselling and demonstrations by extension agents on regular bases. The effect of this information on adoption varies depending on channel, source, content, motivation, and frequency. The present study hypothesized that the respondents who frequently receive training have higher probability of adoption than those that do not (Adesina and Zinnah, 1993; Shiferaw and Holden, 1998; Oluoch-Kosura, 2001; Bamire et al., 2002; Mazvimavi and Tmomlow, 2009). Access to electricity (*ELECTRICITY*) is generally perceived to reduce the use of biomass such as CR for household energy (like fueling, burning). It is employed through the use of electric boiler and cooker especially for domestic purposes. However, such role depends on its affordability by rural households. It is hypothesized that access to electricity will reduce export of crop residue from the farm and thereby aiding redistribution of nutrients in the system.

The variable, credit access *(CREDITAC),* takes cognizance of farmers' access to sources of credit to finance the agricultural activities and thereby boosts farmers' readiness to adopt technological innovations. It is hypothesized that the variable has a positive influence on the probability of the adoption and use of improved technologies (Zeller et al., 1998; Oluoch-Kosura et al., 2001; Bekele and Drake, 2003). It is measured as a dichotomous variable with access being one, and zero for no access. It is expected to boost redistribution of nutrients within the farm or systems.

The variables *QTCEREALCR* and *QTLEGUMECR* are hypothesized to positively influence redistribution of nutrients within the farm and outside the systems as they indicate the level crop residue production. But availability of one in a given system may reduce the quantity of another needed at any point in time. Measure of livestock holdings possessed by the households (*TLU*) could be positively or negatively related to redistribution of nutrients in the farm because it can serve as a source of manure for increased crop residue production. The livestock can also feed on crop residue thereby exporting it away from the system. Ownership of larger number of livestock is expected to increase the demand for crop residue as feed. Moreover, the demand for crop residue as feed potentially on livestock type households keep (Erenstein and Thorpe, 2010).

The value for which land is leased or rented (*RENT*) is expected to be negatively related to the quantity of crop residue produced. And the lower the production of crop residue, tieless will be the quantity available for redistribution in or out of the farming system.

RESULTS AND DISCUSSION

Socioeconomics characteristics and asset ownership of farming households

According to Hassan and Babu (1991), the level of asset ownership in a household is an indication of its endowment. It provides a good measure of the state of households in times of food crisis, resulting from famine, crop failures, or natural disasters. In general, household capital assets or livelihood resources could be classified into five: Human assets (e.g. household labour capacity, family and non-family labour), natural assets (e.g. total and cultivated farm land), physical assets (e.g. ownership of cattle, bicycle, radio, television, etc,), financial assets (e.g. access to cash credit and remittances) and institutional/social capital assets (e.g. access to social networks and membership of associations) (Elis, 2000). Tables 2 and 3 show socioeconomics characteristics and asset ownership of farming households.

Age has been found to determine how active and productive the head of the household would be. Age has also been found to accelerate the rate of household adoption of innovation that in turn affects household productivity and livelihood improvement strategies (Derion and Kushmen, 1996). Average household head age was 45 years, which is still within economic active working life. The farming household size was relatively large with an average household size of 11. Large household size could provide family labour for the household especially where hire labour is scarce. It could also place higher burden on the household in term of feeding and sustenance demands of its members. In traditional agriculture, household labour endowment which can be a proxy to family size is an important factor when new technologies are introduced into an area. Availability of labour will go a long way to determine the adoption of such technologies. In the absence of sufficient family labour, the cost of hiring labour or opportunity cost of labour can hinder the adoption or promotion of new agricultural technologies. However, a person equivalent labour force was 4.5, indicating that children and old aged people characterized the family size. This might imply that thus hiring of labour for farm work will be a major alternative to meet labour demand of the farming households.

Education of the household heads is another socioeconomic feature which also fall under human capital: it is expected that the higher the level/years of education, the higher the probability of taking the right decision, read simple instruction relating to farming and take necessary precautions where necessary.

The level of education determines the level of opportunities available to improve livelihood strategies. The average year of education was 9 years, meaning that at least average household head could read and write. Extension services would also play a major role in building the knowledge stock of farming communities. They help farmers to translate research results into improvement in crop and livestock production and thus livelihoods. Visits by extension agents to farmers and participation in field day/training are cost effective ways of reaching out with the new technologies to a larger number of farmers. More than 70% of households had contact with farmers on various issues relating to crop livestock production and its technologies.

With respect to natural assets, 96% of the respondent own personal land while the average farm size cultivated was 4.5 ha. Average TLU per household which was based on ownership of ruminants was 5. This may suggest availability animal dung for farm manuring and other purposes that will help ensure soil fertility maintenance and management. It is also availability of CR from household farms to serve as feeds to livestock

Physical asset comprises the basic infrastructure required to support livelihoods in a given environment (rural or urban). These basic infrastructures include adequate water supply, sources of energy, secure shelter, and access to transportation and communication facilities. Table 3 indicates that majority of the household heads have basic assets and. On the average, 97% of the household heads owned houses. Seventy two percent have access to electricity power supply, 52% own mobile phone and 97% possessed radio. Majority of the respondents (97%) possessed radio. This implies that radio is the highest means of information/communication

Table 2. Socioeconomics characteristics and asset ownership of farming households.

Variable group	Variable's name	Variable's estimate (N =159)
Demographic feature		
	Gender percent	
	Male (%)	*99.4*
	Female (%)	*0.06*
	House head age- average	45±11.3
Livelihood capital		
Natural	Own land (percent hh)	96
	Farm size (ha hh-1)	4.5±3
	Livestock size (TLU hh-1)	5±4.5
	Good productivity plot (percent as perceived by farmers)	84.5
Human capital	Family size (head hh-1)	11.1±8.3
	Person equivalent labor force	4.5±2.9
	Average year of education	9.1±4
	Information from extension-percent	89.1
Physical (percent households)	Access to electricity	72.3
	Has radio	96.9
	Has mobile phone	51.6
	Own house	97.5
	Transport	
	motor mbike	50.4
	Car	1.3
	Power fodder chopper	12.0
	Manual fodder chopper	9.0
	Water sources	
	Well	94.0
	tube well	27.0
	River	27.0
	Pond	33.3
	Pipe borne	47.8
	Others*	14.5

Source: Field Survey (2011). Figures added represent standard deviations

available to farmers.

Information on farming activities including crop residues (CR) management could be accessed through radio. Communication on marketing of CR can be done using mobile phones. Although, very few farming household own car/vehicle, but majority 50% of them have motor bike, which can facilitate transportation for effective CR management. Only 12% had access to power chopper in their CR management. Table 1a reveals that 'well' and 'pipe born water' were the highest sources of water in the study areas. All the households have access to drinking water. However, water access for irrigational practices is absent across the project villages but 91 percent have access to water for livestock production. Grass is predominantly used for roofing (75%). Iron and asbestos roofing is employed by 11% while only 6percent used crop residue for roofing. On the other hand, majority (76%) used mud for their wall material; 14% claimed that their wall material is dried brick; 8% used bamboo/wood and only 1% used concrete.

With respect to social capital, quite numbers of the household heads are member of different agricultural associations. About 43% are member of crop association. This could be an avenue for accessing credit facilities among the members. It could be a forum for productive ideas in the farming activities especially on CR management. In the study area, for financial capital, crop, livestock, labor and business were the major sources of income. Business/self employment had the major share A significant proportion of households in the study areas

Table 3. Socioeconomics characteristics and asset ownership of farming households (hh).

Variable group	Variable's name	Value (N=159)
Social (Percent households)	Member of crop producer association	42.8
	Member of livestock producer association	16.4
	Member of dairy cooperative	3.8
Financial-income (Percent total household income)	Total farm income	37.5
	Crops, main products	15.5
	Crops ,residues	5.9
	Other feed or forage	4.7
	Livestock sales	10.1
	Dairy product sales	1.3
	Total non –farm income	62.5
	Agricultural labour	8.9
	Other non agric labour	7.9
	Regular employment	11.4
	Business/ self employed	24.6
	Remittances	8.8
	Other non farm income	0.9
Financial-access to credit (percent households)	Credits	28.3
	Savings	95.0
Financial-expenditure (Percent total)	Farm Expenditure	12
	Crop inputs	3.8
	other farm input	0.5
	harvesting/transp.	2.1
	Livestock inputs	2.6
	hired labour	3
	Non-farm expenditure	87.9
	Food	35.8
	Education	5.9
	Health	5.6
	Social events/leisure	9.2
	Transport	6
	Housing	15.9
	Others	9.5

Source: Field Survey, 2011.

reported an access to credit (28%) with the majority from informal sector (54%). About 97.4% of the respondent in Kano has cultivated a good habit of saving through acquisition of livestock (72.3%). Saving in banks is low (9.2%).

Information on crop residue and its technologies

The result shows that 89% of the household sold crop residue for monetary gains. Different storage type existed for crop residue; namely - field heap, home heap, room and hanger type. About 18% of the households heaped crop residue on the field. 49% of households heaped crop residue at home at the backyard, 34% of household kept crop residue in a room and about 9% of the household used hanger in storing crop residue. However, home heap constitutes the highest storage type used (49%). About 97% of household stored all part of cereal plant as crop residue. Only 3% of the households stored leaves as crop residue. About 85% of the households stored all part of legume plant but only 10% stored leaves as crop residue.

Crop residues uses and its determinants

Crop residue uses

Table 4 summarizes crop residues uses by type and

Table 4. Percent of crop residues uses by purpose and type.

Crop residue (CR) uses (%)	Cereals (N =159)	Legumes (N =159)
Within the farm (on farm)		
Stall feeding	26.15	63.52
Mulching	0.20	0.01
Grazed by own animals	0.96	2.29
Subtotal on farm	*27.31*	*65.82*
Within the system (on site)		
Grazed by others animals	0.17	0.02
Sold to others on field	7.09	13.58
Sold later	5.39	14.59
Subtotal on site	*12.65*	*28.19*
Outside the system (exported)		
Burnt	2.88	1.50
Used as fuel	41.52	1.86
Used for construction	10.80	1.02
Used for other purposes	4.84	1.61
Subtotal exported	*60.04*	*5.99*

Source: Field Survey, 2011

purposes. Ten purposes of legume and cereals residues uses, with three major grouping, were distinguished: (i) those that redistribute nutrient within the farm (e.g. mulching, and stall feeding and grazing by own animal); (ii) those that redistribute nutrients within the system (e.g. grazed by other animals; sold to others on filed; sold later), and (iii) those that export nutrient out of the system (e.g. burning, household fuel, construction and used for other purposes).

On a general note, crop residues allocated for own animal feeding had the major share. Farmers preferred using CR for feeding than mulching. The allocation of the legume residues for feed purposes was 63.52% while for cereal residues the share of animal feed was 26.15%. Other important competing uses of CR of legumes and cereals were also different. These included stall feeding, burning, house construction and fuel.

About 17% of legumes residues are sold either on field or offsite. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). More of legume CR was used within the farm/community (88.9%) while only 11% was exported.

Regression analysis

Adoption and intensity of use of cereal CR as livestock feeds

Factors determining farmers' decision of crop residues use are numerous and complex (Harries, 1999). This is particularly true in the early stage of crop livestock intensification systems where locally available organic resources are under competitive uses. Factors influencing adoption and intensity of adoption of cereal CR as livestock feeds are shown in Table 5. The decision to adopt cereal CR as livestock feeds was positively and significantly influenced by age, education, access to credit facilities and quantity of cereal crop residue available to the farmers. An increase in age by one year led to 5% increase in the probability of using cereal CR as feeds for livestock. However, a one year increase in education of average household increased the probability of using cereal CR as feeds for livestock by about 15%. On the other hand, a one percent increase in access to credit resulted in about 150% increase in probability of adopting cereal CR as feed. This might not be unconnected with increased production as a result of better funding ability of farming households.

As regard intensity of use of cereal CR for livestock feed, increase in farming experience used as proxied for age indicated that 1 year increased the quantity of cereal CR used for livestock feed by about 3%. Experienced household heads preferred using their CR for feeds than selling it. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Access to information made available by increased education has positive and statistical significant influence on the quantity of CR used for the feeding.

A one year increase in education increased the quantity of CR used for feeding livestock by about 8percent. Similarly, a one unit increase in access to credit increased the quantity of CR residue used for livestock feeds by about 30%. Access to credit will provide alternative means of

Table 5. Factors affecting adoption and intensity of use of cereal CR as livestock feeds.

Coefficient	First hurdle		Second hurdle	
Variable	**Coefficient**	**T-Value**	**Coefficient**	**T-Value**
CONSTANT	0.0034	0.59	-0. 0076	-0.02
AGE	0.0503***	1.70	0.0257*	5.59
EDUCATION	0.1506***	1.64	0.0782*	5.85
FAMILY SIZE	0.0326	0.61	-0.0005	-0.08
ELECTRICITY	0.3793	0.53	0.1605	1.38
CREDIT	1.5099***	1.93	0.3079*	2.8
PLOT SIZE	0.0114	0.23	0.0268*	2.69
QTCEREALCR	0.0202**	2.38	0.0061*	4.37
QTLEGUMECR	0.0165	0.76	-0.0095***	-1.75
TLU	-0.0429	-0.46	-0.0081	-0.56
EXTENSION	-	-	1.5271*	6.52
Number of observation	132		107	
Waldchi^2(14)	37.58		2329.280	
Log likelihood	-37.0157		-590.923	
Prob> chi^2	0.0006		0.0001	

*, **, ***, the estimate is significant at 1, 5 and 10%, respectively.
Source: Field Survey (2011).

Table 6. Factors affecting adoption of usage of legumes CR as livestock feeds.

Coefficient	First hurdle		Second hurdle	
Variables	**Coefficient**	**T-value**	**Coefficient**	**T-value**
CONSTANT	0.0006	0.93	0.0004	0.11
AGE	0.0005	0.03	0.0500*	7.50
EDUCATION	-0.0113	-0.15	0.1070*	3.72
FAMILY SIZE	-0.0106	-0.26	-0.0160	-1.15
EXTENSION	1.2420**	2.13	0.7030*	4.16
CREDIT	-1.0145***	-1.71	0.538*	2.70
QTLEGUMECR	-0.1162	-1.2	0.1030*	3.20
QTCEREALCR	0.0071	0.74	-0.004	-0.52
PLOT SIZE	0.1356*	2.63	-0.012	-0.74
RENT	0.2095	1.16	0.0000	0.11
TLU	0.0557	0.74	-0.0044	-0.52
Number of observation	127		127	
Wald chi^2 (11)	31.8		2329.280	
Log likelihood	-42.4734		590.923	
Prob > chi^2	0.0008		0.000	

*, **, ***, the estimate is significant at 1, 5 and 10%, respectively.
Source: Field Survey (2011).

of getting fund for energy, construction materials and other uses to which cereal CR were being used for. However, availability of alternate source of feed like legume CR has a negative influence on the quantity of cereal CR used for feeding. The use of legume CR as feeds complemented the probability of using cereal CR as feeds.

This may indicate that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 1% reduction in the quantity of cereal CR used for livestock feeds. The effect of TLU was negative and not significant.

Adoption and intensity of use of legume CR as livestock feeds

Factors influencing the adoption and intensity of adoption of legume CR were investigated. Table 6 shows factors influencing the adoption and intensity of adoption of legume CR. Extension facilities made available through the use of mobile phones and radio was a significant variable positively influencing decision to use legume CR as livestock feed and not for sales. One percent increase in access to extension facilities increased the probability farmers deciding to use legume CR as livestock feed by about 124%. This is because mobile phones provide a medium for farmer-to-farmer interaction through which information is spread on technological adoption. The size of land used by the household also has positive and significant influence on the decision to use legume CR as feeds for livestock. An increase in farm size by 1 ha increased probability of using legume CR as livestock feeds by about 14%. On the other hand, access to credit discouraged the used of legume CR for livestock feed. This might be because access to credit might provide money for another means of feeding livestock one unit increase in access to credit decreased the probability of using legume CR as livestock feed by about 100%.

Intensity of use of legume CR as livestock was influenced by age, education, extension and the quantity of crop residue produced on the farm. Increase age by 1 year increased the quantity of legume CR used for livestock feed by about 5%. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Education has positive and statistical significant influence on the quantity of legume CR used for the feeding. The better educated a farmer is the less he will want to sell his legume CR. A one year increase in education increased the quantity of CR used for feeding livestock by about 11%. Extension facilities also played significant role in influencing the quantity of legume CR used for livestock feed. Increase in access to extension facilities by 1 units increased the quantity of legume CR used by about 70%. Similarly, a one unit increase in access to credit increased the quantity of legume CR used by about 54%. This implied that access to credit will provided alternative means of getting fund for energy and construction materials. The use of cereal CR as livestock feeds also complemented the use of legume CR. This implies that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 0.4% reduction in the quantity of legume CR used for livestock feeds. Although, TLU was negative in the second hurdle, but it was not significant.

Conclusion

The potential of cereal crop residues as animal feed is enormous if all the different types of cereal crops are considered and if appropriate methods of improving their nutritional value are employed. Legume crop residues, such as groundnut haulms, cowpea vines, and cowpea husks, are high in protein and are generally used as supplements in addition to the grazing of ranges and cereal crop residues. This study examined crop residue usage and determined factors influencing the decision to allocate as well as the intensity of use to main uses in Kano State, Nigeria.

About 18% of the households heaped crop residue on the field. About 49% of households heaped crop residue at home at the backyard. About 34% of household kept crop residue in rooms while 9% of the household used hanger. However, home heap constitutes the highest storage type used (49%). About 97% of household stored all part of cereal plant as crop residue. Only 3%of the households stored leaves as crop residue. About 85%of the households stored all part of legume plant but only 10% stored leaves as crop residue. On a general note, crop residues allocated for own animal feeding had the major share. Farmers preferred using crop residue for feeding than mulching. The allocation of the legume residues for feed purposes was about 64% while for cereal residues the share of animal feed was 26%. Other important competing uses of crop residue of legumes and cereals were also different. These included stall feeding, burning, house construction and fuel. About 17% of legumes residues are sold either on field or offsite. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). More of legume CR was used within the farm/community (88.9%) while only 11% was exported.

The decision to adopt cereal CR as livestock feeds was positively and significantly influenced by age, education, access to credit facilities and quantity of cereal crop residue available to the farmers. Increase in farming experience 1 year increased the quantity of cereal CR used for livestock feed by about 3%. Experienced household heads preferred using their CR for feeds than selling it. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Access to information made available by increased education has positive and statistical significant influence on the quantity of CR used for the feeding. A one year increase in education increased the quantity of CR used for feeding livestock by about 8%. Similarly, a one unit increase in access to credit increased the quantity of CR residue used for livestock feeds by about 30%. Access to credit will provide alternative means of getting fund for energy, construction materials and other uses to which cereal CR were being used for. However, availability of alternate source of feed like legume CR has a negative influence on the quantity of cereal CR used for feeding. The use of legume CR as feeds complemented the probability of using cereal CR as feeds. This may indicate that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 1% reduction in the quantity of cereal CR used for livestock feeds.

The decision to adopt legume crop residue as livestock feeds is influenced by extension and farm size. Intensity of use of legume CR as livestock was influenced by age, education, extension and the quantity of crop residue produced on the farm. Increase age by 1 year increased the quantity of legume CR used for livestock feed by about 5%. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Education has positive and statistical significant influence on the quantity of legume CR used for the feeding. The better educated a farmer is the less he will want to sell his legume CR. A one year increase in education increased the quantity of CR used for feeding livestock by about 11%. Extension facilities also played significant role in influencing the quantity of legume CR used for livestock feed. Increase in access to extension facilities by 1 units increased the quantity of legume CR used by about 70%. Similarly, a one unit increase in access to credit increased the quantity of legume CR used by about 54%. This implied that access to credit will provided alternative means of getting fund for energy and construction materials. The use of cereal CR as livestock feeds also complemented the use of legume CR. This implies that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 0.4% reduction in the quantity of legume CR used for livestock feeds.

Concerted efforts should therefore be made at increasing awareness and education on the use of crop residues in the crop-livestock system. Similarly, facilitation of extension services in crop residue training and increased access to credit will reduce the degree of residue export from the system.

Conflict of Interest

The authors have not declared any conflict of interests.

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Agriculture – Industry linkages in the economy of Jammu and Kashmir India

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Agriculture serves as a primary sector of an economy which laid foundation for other sectors of an economy and with the support of industry sector the territory sector came in to existence. Thus the collective support of Agriculture and industry sector uplifts the economy and a sustainable growth of an economy is governed. The inter-linkage between Agriculture and industry sector from different aspects not only bring growth to these two sectors but economy as whole. Thus in this paper we try to analyze the Agriculture industry linkages in the economy of Jammu and Kashmir in order to see the impact of these two sectors on one others growth and on economy as whole and also to study the phase and status of these two sectors in the economy of Jammu and Kashmir. Our results suggest that there is positive and strong relation from Agriculture sector towards industrial sectors but from industry the linkages are deteriorating due to weak industrial infrastructure in the state. The agriculture sector helps industry sector to grow from income, raw material, labor force etc but from industry sector a small amount of industrial output and income went to Agricultural sector which result increasing pressure for income through services sector which is showing small amount of growth over the years.

Key words: Agriculture, linkages, industry, income, output and input.

INTRODUCTION

The Jammu and Kashmir economy depends mostly on traditional forms of occupation. The state is affected by continued violence and insurgency, the economy of Jammu and Kashmir is an undeveloped one. Economy of Jammu and Kashmir is unaffected and unaltered by modern day industrial developments and changing times, the indigenous traditional occupations of farming, animal husbandry and horticulture forms the backbone of the economy. Agriculture is main sources of livelihood in the state were 70% of population eke out their living from agriculture and 49% of total working force directly depends on this sector for their livelihood, the slow growth in agriculture and allied sectors is a major cause of concern. Industrialization is considered as modern way of development for a region but J & K has not been able to attract investments in this sector and remained an industrially backward state due to its unique economic disadvantages arising out of remoteness and poor connectivity and most importantly the political uncertainty. In this regard Agriculture industry linkage for such

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economy is important to be analyzed so as to generate a suitable growth with the collective efforts of these two sectors. Kuznets (1968); Kalecki (1976), Mellor (1976), Singer (1979), Adelman (1984), Ranis (1984), and Vogel (1994), highlighted the interdependence between agricultural and industrial development and the potential for agriculture to stimulate industrialization. They argue that agriculture's productive and institutional links with the rest of the economy produce demand incentives (rural household consumer demand) and supply incentives (agricultural goods without rising prices) promoting modernization. Satyasai and Viswanathan (1999) find that, in pre and early independence period the industry sector had a close relationship with agriculture due to the agro-based industrial structure. Saikia (2010) observes that Agriculture-industry linkages have been deteriorating over the years and there have been directional changes linkages were primarily from the Industry to Agriculture sector. Viswanathan (1999) found that the output elasticity of industry with respect to agriculture was 0.13 during 1950 to 1951 to 1965 to 1966. Jha (2010) analyze that the process of growth of Agriculture and Industry in tandem, reinforcing and reinvigorating each other's growth impulse, by resolving each other's potential realization problem. Bhaduri (2007) extend Kaldor's model by considering the role of agriculture surplus from the supply side as well as the importance of the demand side effects for industrial goods. Scitovski (1986) linkages concept has been recognized as playing a crucial role and providing substantial contributions towards guiding the appropriate strategies for future economic development. Vyas (2004) and Bathla (2003), the share of Agriculture in GDP, however, does not reflect adequately the role of Agriculture growth has played and will continue to play in Indian economy. Rangarajan (1982), Bhattacharya and Rao (1986), and Chowdhury and Chowdhury (1995), deteriorating linkages between agriculture and industry have been primarily credited to the deficiency in demand for agricultural products, decline in share of agro-based industries coupled with slow employment growth Sastry et al. (2003), for the period 1981 - 1982 to 1999 - 2000, found that the forward production linkage between agriculture and industry has declined, whereas backward production linkage has increased. They also found significant impact of agricultural output on industrial output, and that agriculture's demand linkage to industry has declined, while that of from industry to agriculture has increased. Thus this paper will through light on the status of Agriculture and industry and also show the Agriculture industry linkages in terms of income and output in Jammu and Kashmir.

Objective of the study

(1) To study the status of Agriculture and industry sector in Jammu and Kashmir Economy
(2) To analyze the Agriculture industry linkages in terms of Income and Output in Jammu and Kashmir economy.

MATERIALS AND METHODS

The study has used time series data covering thirteen years period from 1999-2000 to 2011-2012. This study analyzes the growth of Agriculture and Industry sector in economy of Jammu and Kashmir by compound annual growth rate. In this paper three simple logarithm regression equations has be used to analyze the linkages between Agriculture and Industry sector in Jammu and Kashmir that is,

$$LogY_{Ind.Inc} = \beta_0 + \beta 1 LogX_{Agri.Inc} + \mu \quad (1)$$

Where $Y_{Ind.Inc}$ =Dependent variable (Industry income), β_0 = Intercept, β_1 = Regression coefficient of X variable, $X_{Agri.Inc}$= Independent variable (Agriculture Income)

$$LogY_{Agri.Inc} = \beta_0 + \beta 1 LogX_{Ind.Inc} + \mu \quad (2)$$

Where $Y_{Agri.Inc}$=Dependent variable (Agriculture Income), β_0 = Intercept, β_1 = Regression coefficient of X variable.
To find the agriculture –industry linkages in terms of output the following regression has been used:

$Y_{Ind.Inc}$= Independent variable (Industry output)

$$Log\ Y_{Ind.Output} = \beta_0 + \beta_1 LogX_{Agri\ output} + \mu \quad (3)$$

Where $Y_{Ind.Output}$ =Dependent variable (Industrial output), β_0 = Intercept, β_1 = Regression coefficient of X variable, X= Independent variable (Agriculture output).

RESULTS AND DISCUSSION

Income growth and agriculture industry linkages

Mostly, the economy of Jammu and Kashmir depends on the traditional occupation which includes horticulture, animal husbandry and the most common one agriculture. This forms the economy of the state of India. This state is affected by the continuous insurgency and violence, the economy of J & K is not developed or you can say it is underdeveloped. However, in past few years, government of J & K has taken few important steps to enhance the financial conditions of Jammu and Kashmir as well as to improve the standards of living of local people with the result the Jammu and Kashmir state has not only maintained the increasing growth trajectory since 2009 to 2010 but also is showing increasing trend, when the growth rate clocked to over 6%. The J & K state has not only maintained the increasing growth trajectory since 2009 to 2010 but accelerated it further to new heights especially during 2010 to 2011 and 2011 to 2012 when the growth rate clocked to over 6%. The economy of Jammu and Kashmir has shown vibrant growth path during the recent years. Gross state domestic product (GSDP AT constant price 2004 to 2005) has increased

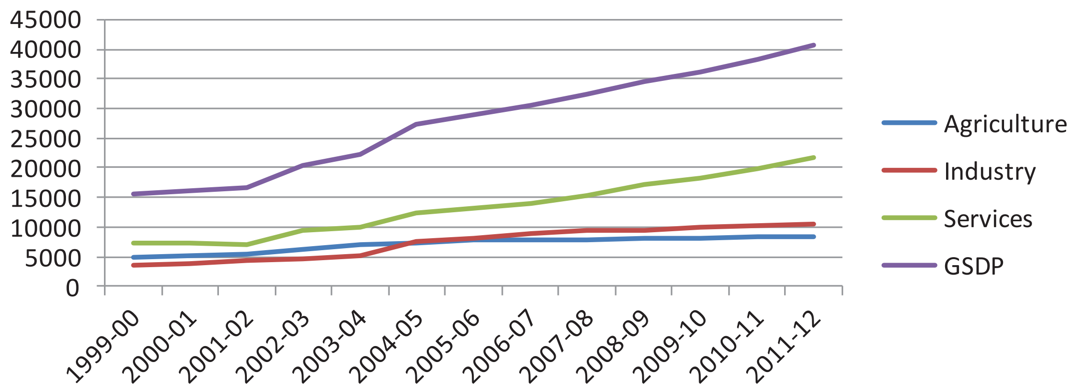

Figure 1. Sectoral income and GSDP of Jammu and Kashmir.

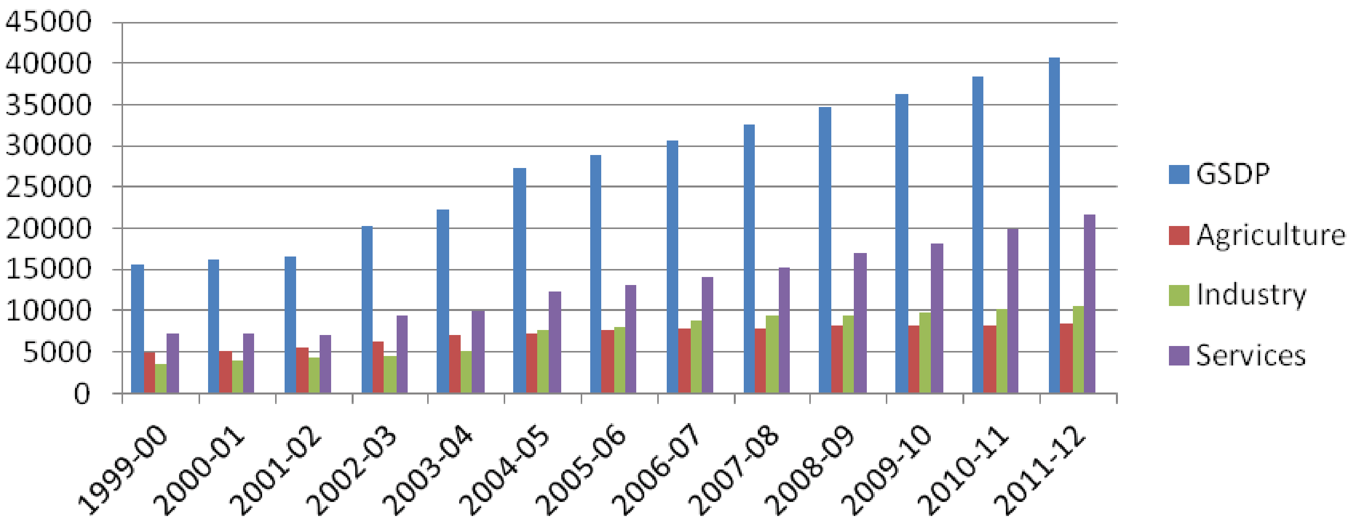

Figure 2. Sectoral income and GSDP of Jammu and Kashmir: Directorate of Economics and Statistics Jammu and Kashmir.

from Rs 15659.81crore in 1999-2000 to Rs40770.83crores in 2011 to 2012. The real GSDP grows around 6% average during 2011 to 2012, while as inflationary growth is 4.40 percentage points making an aggregate growth of 9.99% at current prices during the same period. In total GSDP agriculture contribute Rs8478.71crore in 2011 to 2012 which was Rs4902.80crore in 1999 to 2000. Similarly industry and services sector contributeRs10529.72crore and Rs 21762.40crore respectively in 2011 to 2012. As shown in Figure 1 the GSDP of Jammu and Kashmir and its sectoral share. Figures 1 and 2 sectoral income and GSDP of Jammu and Kashmir.

It is evident from the figure that the GSDP of the state is increasing year after year, though the rate of increase is low. The agricultural sector is increasing at decreasing rate and has remained constant in last few years. The services sector is the only sector which has shown the upward trend since the beginning of study period. The services sector is now the important component of GSDP growth in the state. As the industrial sector's income is increasing with growing upwards at constant speed and has maintained a higher trend of growth but the fluctuations are more in industry sector that Agriculture and services sector due to different prevailing situations in the state.

The state economy is growing at an average of 6.22%, while as the agriculture and industry sector is growing at 3.69 and 2.1% respectively. The GSDP of the state is showing increasing trend in reference period of 13 years. The growth of the economy is growing at very low pace but is growing. As far as agriculture is concerned it is not increasing well. In 2001 to 2002 it was growing at5 5.92% but it reduces upto 3.69% in 2011 to 2012 while as the industrial. As shown in Figure 3.

The growth rate of the economy of Jammu and Kashmir

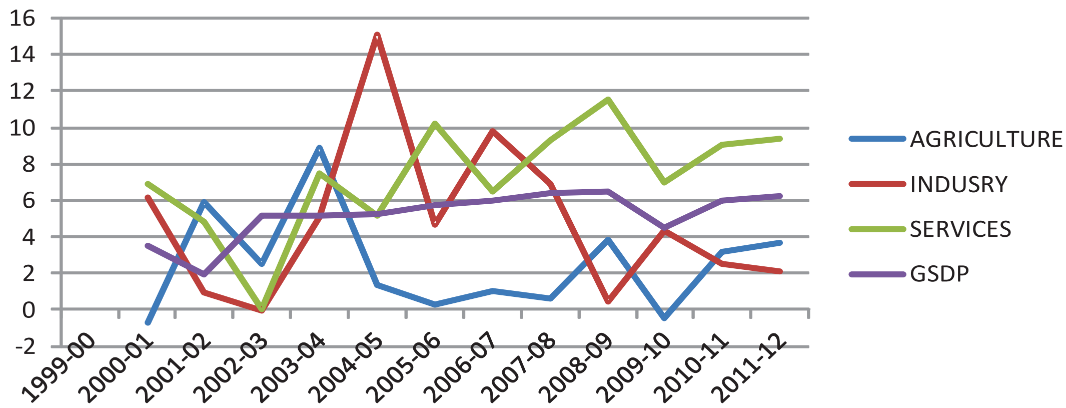

Figure 3. Directorate of economics and statistics Jammu and Kashmir.

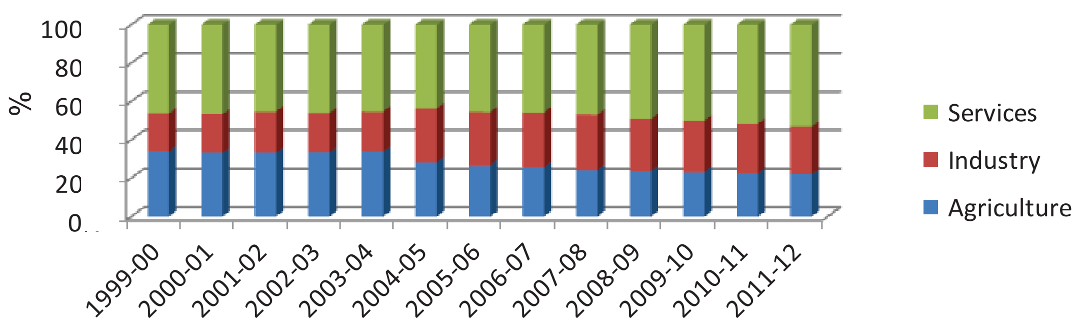

Figure 4. Directorate of Economics and Statistics Jammu and Kashmir.

Kashmir has shown irregularity and heavy fluctuation over the time. It is only services sector of the state that is positively increasing at increasing rate while as in industry and agriculture sector is more up and down. The instability in the growth of industry and agriculture sector can be seen in the growth of overall economy which shows that when there is positive growth in the Agriculture and industry sector of the state the economy in GSDP of the state grows accordingly and vice versa. As shown in Figure 4.

The sectoral contribution of different sectors of Jammu and Kashmir economy to GSDP is fluctuating over the years. When there is increase in income from agriculture, industry sector increases and similarly when there is growth in industry there is growth in agriculture sector and collectively increase GSDP. But from 2006 to 2007 it seems that there has been transformation, as with the decrease in income from agriculture the income from industry increases and when income from agriculture increases income of industrial sector decreases which results fluctuation in GSDP of the state.

As we deals with the Agriculture and industry sector we will obtain compound annual growth rate (CAGR) of these two sectors over the years. The compound growth rate of the income of these two sectors will give us accurate picture of performance of these two sectors in the study period with GSDP as well. Below is the compound growth rate of these two sectors with GSDP divided into three sub periods (Table 1).

The compound growth rate of agriculture in our first period of study period during 1999-2000 to 2004-2005 was 3.83 per annum which decreases to 1.82% in next period of seven years that is, from 2005-2006 to 2011-2012. In cumulative manner the agriculture in the period of thirteen years from 1999-2000 to 2011-2012 has attained annual compound growth rate of 2.77%. It shows slow growth rate through the study period. The compound growth rate of GSDP in Equation (1) period remain 4.04% annually in period from 1999-2000 to 2004-2005 and increases to 5.90% in Equation (2) period from 2005-2006 to 2011-2012. The compound growth rate of GSDP in the study period remains 4.69% that is most worried part of the economy.

It appears from the table that the industrial compound growth rate was high in first period and was higher than GSDP that is, 5.54% annually from period 1999-2000 to 2004-2005 and reduces in next period from 2005-2006 to 2011-2012 to 4.38. The compound growth rate of industry remains 4.92% annually in our study period. Thus in the study of thirteen years the industrial sector

Table 1. Compound Annual Growth rate period-wise.

Period	Agriculture	Industry	GSDP
1999-2000 to 2004-2005	3.83	5.54	4.04
2005-2006 to 2011-2012	1.82	4.38	5.90
1999-2000 to 2011-2012	2.77	4.92	4.69

Calculated from Table 1.

Table 2. The summary output of the regression model I.

Parameter	Coefficient	S.E	Crit.val(tab.val)	R^2
Intercept	-3.81	0.68	0.000(2.26 @)	0.91
Agri. Income	1.98	0.17		

At level of Significance 0.5.

has higher growth rate than GSDP which shows that in this period the industrial sector has boosted in economy while agriculture sector is losing its strength and is not able to sustain its growth.

Agriculture industry linkage in terms of income

To find out the influence of income growth in agriculture sector by industry sector and influence of income growth in industry sector by agriculture sector for analyzing the agriculture- industry linkage in terms of income to see whether the income growth of agriculture in GDP affects income growth of industry in GDP and vice versa. We have worked with two logarithm simple regression model for these two problems to identify the effect of these two sectors on one other in terms of income growth by them in the economy of Jammu and Kashmir. To explore exact relationship between Agriculture and industry we use simple logarithm regression function. The equation will follow whether the agriculture income growth in the state influences the industrial income growth in the state. Here we have to analyze how far the progress in the Agriculture income influences the progress the industry sector income. Equation (1) for this problem will be.

$$\text{Log}Y_{\text{Ind.Inc}} = \beta_0 + \beta 1\text{Log}X_{\text{Agri.Inc}} + \mu$$

Where $Y_{\text{Ind.Inc}}$ =Dependent variable (Industry income), β_0 = Intercept, β_1 = Regression coefficient of X variable, $X_{\text{Agri.Inc}}$= Independent variable (Agriculture Income).
For Equation (1) we hypothesis that:

Hypothesis 1

H_0: There is no linear relationship between industry income growth and agriculture income growth or agriculture income growth does not affect the Industry income growth in the economy of Jammu and Kashmir.

H_1: There is linear relationship between Agriculture income growth and Industry income growth Or Agriculture income growth affects the Industry income growth in the economy of J & K.

From Table 2 it can be seen that linkage between the agriculture and industry income has been highly significant during the period. The elasticity of industry GSDP income with respect to Agriculture GSDP income has been 1.98 which is significant. Equation (1) will be as:

$$\hat{Y}_{\text{Ind.Inc}} = -3.81 + 1.98X_{\text{Agri.Inc}} \quad (4)$$

The equation shows that the industry income will increase with respect to agriculture income as if an average one unit increase in income of agricultural sector will lead to more than a unit increase in the industrial sectors that is, 1.98%. Thus agricultural sector income has great linkage with Industry sector in terms of income. The intercept value is about -3.81 which implies that if Agriculture income is held at zero level, the Industry income growth will be negative as -3.81%. Thus this make a sense that in the state of Jammu and Kashmir Agriculture sector laid influence to growth of income in industry sector. The R^2 value of 0.91 means that 91% variation in Industry income is explained by Agriculture income growth.

Similarly to identify the influence of industry income on the progress of growth in agriculture sector income. Equation (2) for this problem is:

$$\text{Log}Y_{\text{Agri.Inc}} = \beta_0 + \beta 1\text{Log}X_{\text{Ind.Inc}} + \mu$$

Where $Y_{\text{Agri.Inc}}$=Dependent variable (agriculture income), β_0 = Intercept, β_1 = Regression coefficient of X variable, $X_{\text{Ind.Inc}}$= Independent variable (Industry Income).
For Equation (2) we hypothesis that:

Table 3. The summary output of the regression model II.

Parameter	Coefficient	S.E	Crit.val(tab.val)	R^2
Intercept	2.07	0.15	4.59(2.26 @)	0.92
Ind. Income	0.46	0.04		

At level significance 0.5.

Hypothensis 2

H_0: There is no linear relationship between agriculture income growth and industry income growth or industry income growth does not affect the agriculture income growth in the economy of Jammu and Kashmir.
H_1: There is linear relationship between Industry income growth and agriculture income growth or industry income growth affects the agriculture income growth in the economy of J & K.

From Table 3, it can be seen that linkage between the industry and agriculture income has been less significant during the period. The elasticity of agriculture income with respect to industry income has been 0.46 which is less significant than Industry elasticity by agriculture sector. Equation (2) will be as:

$$YAgri.Inc= 2.07 + 0.46XInd.Inc \quad (5)$$

The equation shows that the agriculture income will increase with respect to industry income as if an average one unit increase in industrial income will yield less than a unit increase in the agric sector that is, 0.46 thus agricultural sector has low level of linkages with agriculture sector in terms of income. Thus this make a sense that in the state of Jammu and Kashmir industry sector laid influence to growth of income in agriculture sector but magnitude is low. The R^2 value of 0.91 means that 91% variation in agriculture income is explained by Industry income growth. Now to test the null hypothesis we analyze the p value of the variable or function. As noted from the table that p value is 2.26 which is greater than 0.5 level of significance. Thus the null hypothesis is not accepted and we conclude that there is relationship between Industry income and agriculture income.

Agriculture-industry linkage in terms of output

The industrial sectors of the state are mainly constituted of medium and small scale industries. Khadi and village industries are main components of industry of the state. In other words we can say that the industrial sector of the state is of traditional based and of small scale nature with low expansion of heavy and large scale industries. The growth of the industrial sector is low because of many problems which results low production and less employment generation. Small scale units are mostly agro-based and Khadi and village are of cottage type industries based which is directly or indirectly connected with agriculture of the state or raw material from outside the state. In analyzing the linkage/relationship of agriculture and industry for future prospects for development of Jammu and Kashmir economy we have try to identify the cause and effect relationship between the agriculture output and industrial output in which we try to understand the dependence of industrial output on the agricultural output of the state in terms of value of final output in rupees. For that we need data for value output of industrial production of the state and the agricultural output respectively. The total industrial output value and total employment generated by total industrial sector of Jammu and Kashmir is shown in Table 4.

Now to understand agriculture-industry linkages in the economy of Jammu and Kashmir we will identify a simple logarithm regression model by which we identify the influence of agricultural output on growth performance of industrial output generated in Jammu and Kashmir which are mainly of agriculture based. This is worked by regressing agricultural and industrial production in terms of Rupees and in log values of those output values for thirteen years from 1999-2000 to 2011-2012. For that we have used simple logarithm regression function because the values are big in number. The equation of this model is:

$$\text{Log } Y_{\text{Ind.Output}} = \beta_0 + \beta_1 \text{Log} X_{\text{Agri output}} + \mu$$

Where $Y_{\text{Ind.Output}}$ =Dependent variable (Industrial output), β_0 = Intercept, β_1 = Regression coefficient of X variable, X= Independent variable (Agriculture output).

Table 5 shows the result of the model which shows the influence of agriculture output on industrial output. The regression results are as follows:

$$\hat{Y}_{\text{Ind.output}} = -13.43 + 4.45X_{\text{Agri output}}$$

The above results show that the elasticity of industrial output with respect to agricultural output is about 4.45 which suggesting that if total Agricultural output increases 1 percent on an average, the Industrial output will increase about 4.45%. The industrial output of the state is very responsive to change in agricultural output. Thus it seems that there is positive relationship between agriculture output and industrial output in the state of Jammu and Kashmir were the main pattern of industries

Table 4. Total capital invested value of output and employment generated by overall industrial sector of Jammu and Kashmir.

Year	Capital invested (In Lakhs)	Total value of output (In Lakhs)	Total employment (Lakh)
1999-2000	58,504	164,584	510976
2000-2001	56,383	134,272	521431
2001-2002	62,118	154,879	587286
2002-2003	66,281	175,631	548113
2003-2004	66,566	199,618	558660
2004-2005	130,430	396,342	574083
2005-2006	192,497	699,467	598671
2006-2007	282,050	1,157,433	597825
2007-2008	404,752	1,623,015	645075
2008-2009	398,911	1,349,375	658958
2009-2010	301,012	1,175,651	683676
2010-2011	285,589	1,008154	705341
2011-2012	299,234	1,110,392	729864

Economic survey of Jammu and Kashmir 2008-2009 and 2012-2013. Report by planning commission on impact of package for industrial development for special category states, Government of India. Report of the expert group to formulate a jobs plan for the state of Jammu and Kashmir 2011.

Table 5. The summary output of the logarithm regression model.

Parameter	Coefficient	S.E	P. value	R^2
Intercept	-13.43	2.64	0.0003	0.79
Agri. Output	4.45	0.68	4.55@	

At level of significance 0.5.

is agro-based. If we look upon the intercept value which is -13.43 which reflects that if agriculture output will be zero the Industrial output will be -13.43% which means negative growth in industrial output. The R^2 value is of about 0.79 implies that 79% of variation in industrial output is explained by agricultural output. Now to test null hypothesis of the function we analyze p value. As observed from the table that p value of the function is 4.55 which is greater than 0.5 level of significance. Thus calculated value is greater than tabulated value thus our null hypothesis is not accepted and thus we conclude that there is close and significant relationship between agricultural output and industrial output of Jammu and Kashmir State. Thus it is evident from the model that in Jammu and Kashmir the basic pattern of industrial sector is agro-based were the industries are mainly of small units.

Conclusion

The Jammu and Kashmir economy is going through the phase of transformation from agriculture to services sector, but this transformation will not be sustainable because industrial sector does not support the services sector and agricultural sector which is mostly important for smooth growth process of an economy which results that in last few years the economy of the state is losing share in Indian economy and declining growth of state economy. The change in the economy is strengthened because of higher trend of growth rate shown by the industry sector while as from agriculture sector it is low during the period of thirteen years. The regression models used to analyze the agricultural–industry linkages in terms of income has shown very much important facts it was found that the agriculture sector income of the state helps in development of the industry sector very much. In other equation it reflects that the Industry sector of the state has not been able to support the agricultural income growth in large manner. We found that Agriculture of the state is highly influencing the output of the state. The elasticity of Industrial output with respect to agricultural output has 4.45 which means that with 1% increase in agricultural output industrial output increases 4.45% this shows the dependency of Industry sector of the state on agriculture sector. Thus the pattern of industry sector of the state is of micro, small and medium type units or cottage type industry sector with full support from agriculture sector.

Thus in nutshell the agriculture-industry linkages in the economy of Jammu and Kashmir are weak while agriculture sector provide its support to industry sector but industry sector is not yet able to support agriculture sector results slow growth of agriculture sector and in reverse slow growth in industry sector as well which collectively reinforce the slow growth of economy of Jammu and Kashmir.

RECOMMENDATIONS

(i) The industrial infrastructure of the state is worst than other states of India so it should try to strengthen the infrastructure so that the linkage between agriculture and industry will improve.
(ii) The most important step which state should take to improve Agriculture-Industry linkages is to formulate essential policy for development of industry sector of the state.
(iii) The state should try to encourage the investors from outside the state as well as local investors to invest in the small and medium sized industry units of the state by offering incentive or other benefits.
(iv)The state should try to setup the industry units in rural areas to displace the people from agriculture to industry sector for employment purpose.

Conflict of Interest

The authors have not declared any conflict of interest.

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