Journal of Development and Agricultural Economics

Volume 7 Number 2 February 2015
ISSN 2006-9774

Academic Journals

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Vol. 7(2), pp. 48-54, February, 2015
DOI: 10.5897/JDAE2014.0617
Article Number:82B41C449827
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

To conserve or convert wetlands: Evidence from Nyando wetlands, Kenya

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Received 01 November, 2014; Accepted 15 January, 2015

Wetland resources of Nyando Wetlands support important economic and ecological activities. However, it is faced with multiple pressures from different anthropogenic Activities within the wetlands and upstream. The Nyando wetlands are facing increasing threats of reclamation for agriculture. This is bound to intensify as population pressure increases. The question therefore is; should Nyando Wetlands be conserved or converted? Using market and contingent valuation methods, within the benefit-cost analysis framework, an economic valuation was carried out to determine the benefits of conserving or converting the Nyando wetlands. The results revealed that Nyando Wetlands yield a flow of economic benefits of the consumptive goods and services estimated at about US$ 1.5 Billion (US$ 62,500 / Ha / year) with an infinite present value of US$ 75.5 Billion at 2% discount rate. Thus the reclamation of the wetlands would imply high economic costs to the government and local communities. To reduce the pressure of reclamation, it is suggested that educational campaigns on the importance of wetlands be carried out.

Key words: Wetland value, market price, contingent valuation, goods and services.

INTRODUCTION

Kenya's wetlands[1] occupy about 3 to 4% of the total landmass, which is approximately 14,000 km^2 of the land surface and increases up to 6% in the rainy seasons (Government of Kenya, 2008). Wetlands goods and services satisfy various objectives of different users: Food security and cash income (fishing, hunting and agricultural production), health (drinking water and hygiene), recreation and culture (spiritual enrichment, cognitive development and aesthetic experience) (McCartney and Van Koppen, 2004). Wetlands generate a huge variety of plant, animal and mineral products used and valued by people all over the world, whether in local, rural communities or in far-off cities in foreign countries (Ramsar, 2011). Because of their socio-economic importance, wetlands have attracted significant portions of human populations who survive by exploiting their resources, through different resource utilization activities, often driven by economic and financial motives (Kirsten, 2005). Such reliance on natural resource exploitation for livelihood, always poses a great danger to the resources, more so if their value is not known or appreciated by the

[1] The Environment Management and Coordination Act 1999 (EMCA) defines wetland as "an area permanently or seasonally flooded by water plants and animals.

stakeholders.

Nyando wetland is one of the largest and economically important deltaic wetland ecosystems fringing the Lake Victoria and covering about 10,000 Ha (Wandinga and Makopa, 2001) and performs important ecological, hydrological and socio-economic functions. However in recent years, the Nyando Wetlands have been facing increasing threats from agricultural activities like livestock grazing, reclamation for rice growing and other seasonal crops among others. This stems from the increasing human population within the wetlands; 316 persons per km^2 (Government of Kenya, 2010). In addition, wetlands are perceived to have little or no economic value (Kirsten, 2005) and that no formal markets exist for their services to humanity (Jodi et al., 2005) hence making wetlands conservation not to be seen as a serious alternative compared to other uses that seem to yield more tangible and immediate economic benefits. As a result inadequate resources are fed into their management which breeds environmental degradation through inappropriate commercial exploitation of wetlands (Oglethorpe and Miliadou, 2000). Despite these threats, the Nyando wetlands still provide a substantial flow of ecosystem goods and services which forms the backbone of the wetland community livelihood. The value of this flow has, however, not been established and as a result, management decisions have not adequately considered the economic importance these goods and services provide to the local communities and the national economy. Thus valuation of the wetlands goods and services would help policymakers know whether to allow conversion or not. This paper therefore aimed at determining the economic value of Nyando wetlands in order to offer policy insights.

Attempts have been made in the past to put a monetary measure on the values of wetlands (Barbier, 1993; Turner, 1991). Various methods have been used to value wetlands resources such as Contingent Valuation Method (CVM), Travel Cost Method (TCM) and Replacement Costs among others (Perman et al., 1997; United Republic of Tanzania, 2003). Globally, economic value of wetlands and their associated ecosystem services has been estimated at US$14 trillion annually (Millennium Ecosystem Assessment, 2005). Some wetlands have been valued across the globe. However, the valuation has been based on specific goods and services. For example, agriculture, fishing and firewood provision of Hadejia-Nguru Wetland in Nigeriawas valued at approximately US$34-54/ha (Barbier et al., 1997), agriculture in Nakivubo Wetland in Uganda was estimated at US$500/ha (Emerton et al., 1999), grazing in Zambezi Basin wetlands ranged in value from US$16/ha in the Barotse Wetland to US$97/ha in the Caprivi Wetland (Turpie et al., 1999), harvestable resources in the Olifants River catchment in South Africa was estimated at US$1-14/ha/year (Palmer et al., *2*002), and grazingin wetlands of southern Africa was US$257-343/ha among others. In Kenya, three ecosystem valuation studies have been done. These studies are wildlife viewing in Lake Nakuru National Park estimated at US$ 7.5 -15 M (Navrud and Mungatana, 1993) using CVM and TCM, Tana Delta (Emerton, 1994) and Yala Wetlands estimated at US$ 120.4 M (Ikiara et al., 2010) by use of both CVM and market price. These studies aimed at carrying out an economic valuation with a view of quantifying the economic benefits accruing from various wetlands in the world so as to facilitate optimal and informed decisions about wetland management for a sustainable future. They also highlighted potential economic losses that could arise from continued degradation and thus giving an impetus for wise use of the wetland resources by the communities.

METHODOLOGY

Study area, sampling procedure and data

The Nyando wetlands covers an area of 3,600 km^2, situated within the Winam Gulf between longitudes 34°47"E and 35°44"E, and latitudes 0°07"N and 0°20"S and about 750,000 people reside within it (Raburu et. al., 2012). It can be grouped as Lacustrine Wetlands (lake like), Riverine Wetlands (those associated with the rivers and streams), Palustrine Wetlands (swamps), a combination of Riverine / Palustrine Wetlands and Manmade Wetlands (created by man). It was formed during the Miocene period (about 20 million years ago) as a result of vertical upwarping of the African surface and the resultant sagging of the great ridge center (Bugenyi, 2001) and has within it some of the most severe problems of agricultural stagnation, environmental degradation and deepening poverty found anywhere in Kenya (Abila and Othina, 2005; Schuyt, 2005). It was reclaimed for agricultural production during the 1940's. The land remained under intensive agricultural activities for 15 to 20 years before the prolonged rains of 1963 (*Uhuru* rains) that caused floods due to overflow of Nyando River. The Nyando River drains into the Winam Gulf of Lake Victoria and is a major contributor of sediment, nitrogen and phosphorus to Lake Victoria. There are three Agro ecological Zones (Lower midland zone 3, 4, and 5). The mean annual temperature ranges between 20 to 30°C while the mean annual rainfall range between 1,000 and 1,800 mm (Government of Kenya, 2005). The rainfall is bi-modal with long rains (March to June) and short rains (October to November) (Government of Kenya, 2005). The flood-prone lakeshore area is mostly used for subsistence production of maize, beans and sorghum, combined with commercial production of sugar cane and irrigated rice.

Across-section survey was used between May 2011 to August 2011 in which information relating to the economic valuation of wetland goods and services was collected from a cross section of the population involved in the different resource utilization activities. This research design was considered because it permits the

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collection of various wetland value attributes at a given point in time. 11 enumeration sites were purposively selected which had 20,479 households (Government of Kenya, 2010) adjacent to each other around the Gulf. This sampling technique was employed because Nyando wetland communities were not homogenous in terms of wetland utilization, conservation challenges, socio-economic values attached and development concerns and threats. Respondents were proportionately selected according to the household size per location to give each household an equal opportunity of response. The mean Household size was 6 (SD 2.75) persons with mean farm size at 2.9 (SD 2.2) acres. About 72% undertook farming as the main occupation with about 78% not going past primary level, that is, 8 years of basic education. About 95.6% enjoy the wetland benefits and about 96.4% agreeing that the wetland was being degraded.

In each location, line transect sampling was then employed to determine the movement path during data collection. Line transect is a sampling technique by which scientists record data regarding communities in an ecosystem. This method of sampling involves only a small section of large natural area, yet produces an accurate representative sampling of the biotic and abiotic parts of that community. The path started from the wetland to riparian areas with each targeted household separated by five homesteads along the transect path. Line transect sampling is reliable, versatile, and easy to implement method to analyze an area containing various objects of interest. A sample size of 270 was obtained (Mugenda, 2008), 277 questionnaires were administered and 274 used in analysis.

The first step in the valuation process involved the identification of wetland goods and services yielded by Nyando Wetlands. A workshop to provide basic information about the consumptive wetland goods and services was held. All the goods and services identified were listed in the questionnaire for valuation during the survey. The following valuation techniques were selected; (a) The market price method was used to value wetland goods traded in the open market with direct use value. These goods included crops, livestock fodder and feeds, fish, domestic water and forest and non-forest products whose subsistence consumption values and gross values were obtained to assign monetary values to benefits derived from the consumptive wetland resources of Nyando. (b) The CVM was considered to value wetland services for which people had some knowledge about and therefore could estimate their value, willingness to pay, in a hypothetical market, Conservation Trust Fund. The CVM is a survey-based technique where a sample of the population is asked a series of questions about their willingness-to-pay for various hypothetical programs (payment vehicle) that change environmental services (Lantz et al., 2010). This study used iterative bidding game as an elicitation mechanism to elicit WTP with a Conservation Trust Fund as the payment vehicle. The limitation of the bidding game is normally the starting point bias as this study started at Ksh 1,000. The contingent valuation scenario was that despite of the goods and services communities derive from the wetland, degradation was still eminent. To curb the problem, conservation, wise use and rehabilitation measures were to be implemented by Non Governmental Organization (NGO) through a monthly contributory Conservation Trust Fund. The limitation of such a scenario might be that little attention to the economic theory of household decision making could have been considered.

Structured questionnaires were administered to respondents to elicit quantitative data on the consumptive resources. The survey established details on each of the resources harvested, the amount harvested annually, the quantity sold as raw produce and the selling price per unit, the number of products produced from natural products and the amount sold and the selling price of these. Data was also obtained on the areas of land cultivated, the type of crops grown and amounts harvested, as well as livestock numbers and production among others. These were triangulated with in-depth Interviews and Focus Group Discussions (FGDs) with various key informants and members of the various resource user groups to gain insights on how the wetland was utilized. In addition, the study considered on secondary data sources to augment the primary data.

Descriptive statistics were used to explain key consumptive goods and services. On the other hand, the estimation of value of the key components of direct consumptive use values for a typical household was used to calculate the annual value of the Nyando wetlands. The Direct Use (consumptive) Value of Nyando wetlands products were calculated using the formula:

$$CV = \sum_{i=1}^{N} \gamma \, (P * T * H)$$

Where, CV = consumptive value in Kenya shillings (Ksh); γ - Percentage of households collecting a particular wetland product; P = mean value of wetland product collected per trip; T = mean number of trips made per HH for wetland product collection per year, and H = total number of households

For an estimation of the wetland's present value of finite annual streams of environmental net benefits, the following formula was used:

$$PV = \beta \, (1+r)^n - 1/r(1+r)^n$$

Where; β = stream of annual consumptive use values; r = the discount rate, and n = number of year under consideration

For the infinite annual streams of environmental goods and services case, the assumption was that the stream of benefits would flow constantly in the future due to sustainable utilization. In this case the PV of these future benefits was obtained through a simple expression that emerges when n approaches infinity (Pearce et. al., 1995 and United Republic of Tanzania, 2003). That is;

$$PV = \beta / r \quad n \rightarrow \infty$$

RESULTS

Key consumptive wetland resources

Virtually all the households living within the Nyando wetland derived a number of direct uses for their livelihoods. Maize was the most dominant crop at the locations with about 77% of the households growing it and identified by the Focus Group Discussion as the staple crop together with sorghum (36.8%). Beans were grown by 35.65% households while kales by 27.95%, indigenous vegetables by 27.05%, rice by 25.9% and tomatoes by 18.05% among others.

Fishing was being carried out by 33.6% of the households while livestock kept were cattle (77%), goat (56%), sheep (54%), donkey (2%) and local chicken (86%). Fodder is consumed by cattle, goat, sheep and donkey while feeds by chicken. Livestock water use depended on the number of livestock kept. Most animals consumed water from the source hence *ad libitum*. On the other hand, households in Nyando wetland get water from surface water sources like Rivers, wells/pans, lake and vendors.

Forest and non-forest consumptive values were also common (Figure 1). Wood was being used as firewood, charcoal and construction. Wood for firewood was the common forest product derived from the wetland by

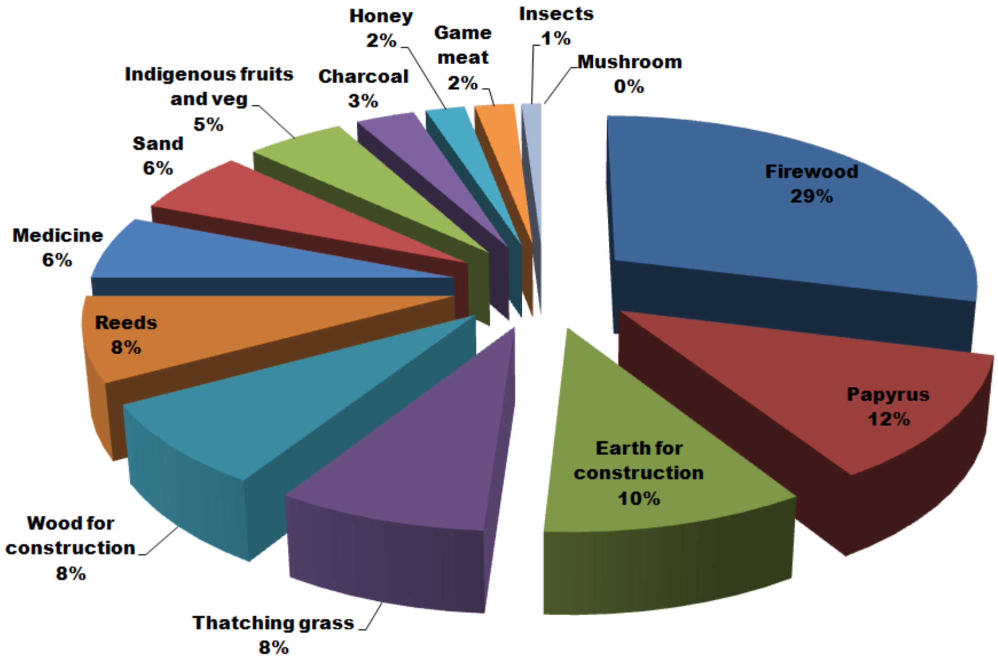

Figure 1. Forest and non-forest consumptive goods in Nyando Wetlands.

Table 1. Sum of consumption goods and service

Consumptive goods and services	Category	Value (Ksh)
Crops		2,402
Livestock	Fodder	2,494
	Feeds	320
Water	Domestic	1,365
	Livestock	1,065
Fish		132,242
Forest and non-forest products		3,449
Non-marketed		38
Total (Ksh)		**143,376**
Total (US$)		**1,509**

1 US$ = Ksh 95.

about 85% of the households using it as a source of energy with a share of 29% of the total forest and non-forest products in the wetlands. Others were medicinal plants, indigenous foods, game meat, earth for construction, grass for thatching and fodder, honey and insects and among others. Mushroom had the least share.

Economic value of consumptive wetland resources

The aggregated economic value of consumptive wetland goods and resources per annum was obtained by summing up the value of crops, livestock, water, fish, natural goods and unpriced benefits (Table 1). The aggregated economic value of consumptive wetlands resources was estimated at Ksh 143.4 Billion (US$ 1.5 billion) or Ksh 6 Million/Ha/year (US$ 62,500/Ha/year). At 2% discount rate, the infinite wetland consumptive resources economic value was about Ksh 7.2 Trillion ((US$ 75.5 Billion) while at 15% discount rate yielded about US$10.1 Billion.

Economic value of fish accounted for about 92% of the total consumptive economic value while Food provision value of Nyando wetlands was estimated at US$ 1221.8/Ha/year.

DISCUSSION

Many wetlands have been shown to provide substantial value in spreading risk by providing resources that enable households to broaden their activity portfolios (Turpie et al., 1999; Schuyt, 2005). Nyando wetlands is most valuable as it provides many benefits; crops, water, fodder and fish among others, to the livelihoods of the surrounding and far off communities in terms of its use values and an opportunity to spread risk as well as functioning as a safety net. Complete dependency on natural resources for livelihoods is a sign of extreme poverty and deprivation (Béné, 2003; Kangalawe and Liwenga, 2005) hence loss of Nyando Wetlands could affect the welfare of the communities living around them. However, the U-shaped relationship between household incomes and the amount of resources harvested (Narain et al., 2005) implies that tackling poverty may reduce environmental degradation up to a point after which there will be increased environmental degradation (Mwakubo and Obare, 2009). There is a need, therefore, to strengthen Nyando community livelihood enhancement measures in order to reduce reliance on wetland resources. This may be done through the promotion of efficient harvesting technologies that would not only increase the value of raw wetland resources, but also provide the much needed employment and alternative incomes to the population engaged in wetland exploitation (Mathoko et al., 2009; Macharia et al., 2010).

The estimated economic value (US $ 62,500/Ha/Year) was relatively higher compared to similar African case studies, whose value varies between US$ 45 to 90/Ha/year (de Groot, 2006) hence plausible (Stuip et al., 2002) given its close proximity to Kisumu City with diverse resource utilization activities that command higher returns. Food provision value of Nyando wetlands (US$ 1221.8 /Ha/year) fell well within the range of suggested values in De Groot et al*.* (2002) of $6 to 2761/Ha/year. The economic value of fish accounted for 92% of the total estimated value concurring with empirical findings in Turpie (2000) and Ikiara et al. (2010); in which fishing was the most significant wetland service contributor to household income. Loss of the estimated economic value of consumptive goods and services in Nyando Wetlands could be an economic problem because important values would be lost, some perhaps irreversibly. The value would help policy development to curb conversion and over-exploitation of Nyando wetlands as any development decision would have to consider economic costs of conversion or degradation. The policy option here could be to undertake cost-benefit analysis for any proposed wetland investment in Nyando Wetlands. This suggests that preservation may not be advocated as a policy because development option would be sacrificed hence reduced welfare.

Conservation and sustainable utilization of these natural stocks of capital is critical to the survival of the present and future generations. Although higher discount rate, like 15% for this study, may be favoured given that it discourages investment (and by implication environmental damage) in the present, it is unfair for the future generation given that it yielded an infinite value of about US$10.1 Billion. Nyando wetlands have an intrinsic value, that it has long-term life support system hence reason enough to protect it. A low discount rate of 2% was therefore preferred, although it reduces the welfare of the current generation, yielding infinite value of US$ 75.5 Billion. Therefore, wetlands management decisions on the overall economic efficiency of the various competing uses of the Nyando Wetlands resources to improve the community's welfare would be necessary. This would require enhanced promotion of education and public awareness on wetland resources and values to encourage understanding and participation of the public, private sector, local authorities, NGOs and other interested parties through all appropriate means. In addition, economic value could also be sustained by levying tax or charge to polluters such as the industries within the Nyando wetlands. Such economic incentives could be used for conservation and protection measures. On the other hand, provision of awards for wetland conservation could also be enhanced. Such awards could be such as a provision of compensation for suspension of unsustainable activities.

According to Balmford et al. (2002), the total economic value of intact wetlands far exceeds that of converted wetlands. Consequently, the estimated consumptive value of goods and services in this study would certainly be higher if the Nyando wetland was still intact. However, since it is being converted, its value is significantly lowered, a situation that has over time created long term 'national capital debts, which are being paid at a high cost through expenditures on programs that aim towards wetland restoration, management and sensitization. In the face of this, immediate conservation and sustainable utilization of these natural stocks of capital is critical to the survival of the present and future generations. This is because a great deal of wetland economic benefits (over US $ 1.5 Billion) accrues at the Nyando wetland community, particularly the subsistence level. Although this may not be feasible to the Planning Units, it ought to be taken as a substantial amount (Emerton et al., 1998; Karanja et al., 2001), whose loss through unsustainable wetland utilization would make Nyando wetland communities poorer. In other words, the government will have to meet the costs of providing the socio-economic needs of the population that were initially provided by the wetland freely or at a lower cost. These are reflected in terms of all foregone subsistence livelihood products, incomes and employment losses, in favor of unsustainable wetland utilization activities or development projects which only offer short term solutions to important social economic problems (Gumm, 2011).

In conclusion, this study gives a valuable insight into the livelihood supporting goods and services provided by the Nyando wetlands. It highlights the considerable economic value that Nyando wetlands contributes towards the local economy and, it is hoped, this direct consumptive use value will inform decisions and justify investments of financial resources to promote the more sustainable use of the Nyando wetlands. Any further significant loss or continued degradation of the wetland and their inherent values would be economically disastrous for Kenyan economy. The infinite present value is meant to meet the intergenerational efficiency objective. This calls for conservation rather than conversion being experienced.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support of Nyando Wetland Resource Utilization Project.

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Vol. 7(2), pp. 55-60, February, 2015
DOI: 10.5897/JDAE2014.0579
Article Number:A50593849830
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

Technical efficiency of maize production in Ogun State, Nigeria

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Received 09 May, 2014; Accepted 12 January, 2015

This study examined the technical efficiency of maize production in Ogun State, Nigeria. Primary data were collected for this study using a multistage sampling technique to select 100 maize farmers from the study area. The data were analysed using descriptive statistics, gross margin analysis and stochastic production frontier. The socio-economic characteristics of respondents as evident from the data analysis revealed that 73% were males with an average age of 50.1 years. Most (85%) of them were married with average household size of 6 people. Also, 89.0% had below secondary school education and 84.8% were full time farmers while 55.0% were engaged in inter-cropping activities. The mean total variable cost per hectare was estimated as ₦109,599.17 per year while the mean total revenue per hectare was ₦111,436.00. The gross margin per hectare was estimated as ₦1, 836.83. The significant variables affecting maize production were seeds (α0.05), herbicide (α0.10), labour (α0.01), and farm size (α0.05), while the factors affecting inefficiency were household size (α0.05) and educational level (α0.01). The study recommended that provision should be made by governments and other stakeholders in the agricultural sector to provide farmers with access to affordable inputs such as seed, herbicides as well as making provision for alternative source of family labour.

Key words: Technical efficiency, maize production, Ogun State, Nigeria.

INTRODUCTION

Maize and other cereals constitute important sources of carbohydrate, protein, vitamin B and mineral. It is a staple food crop for most sub-Saharan Africans including Nigeria (Zalkuwi et al., 2010). It is one of the most abundant food crops in Nigeria. According to FAO (2013), Maize (9,180,270 tonnes) has been rated as the second grown food crop in Nigeria after Cassava (52,403,455 tonnes) then followed by Sorghum (6,897,060 tonnes) and Rice (4,567,320 tonnes). Due to its high adaptability and productivity, the cultivation of maize spread rapidly around the globe and currently it is being produced in most countries of the world (Anupama et al., 2005). It provides food for man and feed for livestock. Maize is an important food crop grown on a large scale in Nigeria, Ghana and to a lesser extent in Sierra Leone (Oladipo et al., 2008). The global output of maize in 2011 was recorded to be 883,460,240 tonnes and Nigeria produced about 9,180,270 tonnes, which constituted about 1.04%

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of the world's production. The world maize production ranking for year 2011 shows that Nigeria was ranked 14th position (FAO, 2013).

The need for improved technology has risen in recent years due to the geometrical increase in population rate and consequently, the forces of demand for maize relative to supply are evident in frequent rise in price of maize. This has a great effect on the food security status of Nigeria, given its importance as a staple crop. The production of maize is affected by the development of advanced technologies, as fertilizer, hybrid seeds, pesticides, herbicides and better management practices which remains a limiting factor for developing countries.

One of the strategies for increasing agricultural productivity is the use of improved technology. But no matter how productive the technology may be, optimal productivity can only be obtained when the technology is efficiently used. Due to inadequate knowledge about the optimum level of farm resources and their efficient utilization, high risk of uncertainties often characterize the entire process of production. Therefore, this research seeks to determine the profitability and technical efficiency of maize production in Ogun State, Nigeria.

Stochastic frontier production function

Ojo (2004), used stochastic frontier production function and confirmed the presence of technical inefficiency effect in yam production and suggested that production, productivity and technical efficiency would be improved if those variables with negative elasticities of production are improved upon. According to Battese and Coelli (1995) the stochastic frontier production function postulates the existence of technical inefficiencies of production of firms involved in producing a particular output. Since the Stochastic frontier production framework (SFPF) was developed by Aigner et al. (1997) and Meeusen and Broeck (1977), evaluating the efficiency of individual firm and industry has become popular with the increasing availability of firm level data and growing capacity of computer to process them. The most common approach to estimate stochastic frontier production function is to specify a deterministic production plus a random, symmetric, firm-specific error term. This frontier represents the largest production for individual firm. Associated with firms is a second, non-negative error term, denoted as the technical efficiency term. Total production for each firm is defined as the frontier minus the inefficiency (Dhawan and Jochumen, 2012). The stochastic frontier production postulates the existence of technical inefficiencies of production of firm involved in producing particular output. Battese and Coelli (1995) and Ajibefun (2002) stated that the stochastic frontier production function has the advantage in that it allows simultaneous estimation of individual technical efficiency of the respondent as well as determinants inefficiency.

The idea of frontier production can be illustrated with a farm using n inputs ($X_1, X_2 \ldots\ldots\ldots X_n$) to produce output Y. Efficient transformation of inputs into outputs is characterized by the production function f(X), which shows the maximum output obtainable from various input vectors (Oyewo, 2011). The Stochastic frontier production function, assumes the presence of technical inefficiency of production. Hence, the function is defined by:

$$Y_i = f(X_i, E) \exp(V_i - U_i) \quad i = 1, 2, 3, \ldots\ldots\ldots n$$

Where V is a random error associated with random factors not under the control of the farmer. The model is such that the possible production Yi is bounded above by the stochastic quantity $f(X_i, E) \exp(V_i)$, hence the term stochastic frontier.

The random error Vi is assumed to be independently and identically distributed as N(0,Φ2V) random variables independent of Ui s. Technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology.

Technical Efficiency: (TE) =Yi/Yi*dfdfd

$$TE = f(X_i, E) \exp(V_i - U_i) / f(X_i, E) \exp(V_i)$$

$$TE = \exp(-Ui)$$

Where, Yi is the observed output and Yi*, the frontier output.

METHODOLOGY

This study was conducted in Ogun State, Nigeria. Ogun State is situated within the tropics, with a total land area of 16,762 square km which lies within latitude 6°20' South and 7° 58' North in the tropics and longitude 2° 40' West and 4° 35' East of the Greenwich Meridian, and has an estimated population of 4,054,272. The state borders Lagos state to the south, Oyo and Osun states to the North, Ondo state to the east and the republic of Benin to the west. A multistage random sampling technique was used for this study. The first stage involves purposive selection of one Local Government Area from each of the four ADPs zones in Ogun State (Abeokuta, Ilaro, Ijebu-ode and Ikenne). The second stage involves a random selection of one rural community in each of the Local Government Areas. Finally, a systematic random sampling technique was adopted to randomly select 25 respondents from each of the community. As a result one hundred farmers were used for the study. Primary data were collected from the selected farmers through a well structured questionnaire which was randomly administered to farmers. The data collected were subjected to descriptive analysis, gross margin analysis and Cobb Douglas stochastic frontier production functions.

Model specification

The stochastic Frontier Production Function proposed by Battese and Coelli (1995) which assumes the existence of technical inefficiency of different firms in production will be adopted for this study. This is depicted using the model below.

$Y_i = f(X_i, \beta_i) \exp(V_i - U_i); i = 1,2,\ldots\ldots n$ (1)

The functional form of this model to be used in estimating the level of technical efficiency is the Cobb-Douglas type (Bravo-Ureta and Evenson, 1994):

$\text{Ln } Y_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4$ +------Write the equation till the last variable written below. $V_i - U_i$ (2)

Where: ln = natural logarithm, i = 1, 2, 3, 4….6, Y = Maize output (kg), X_1= Seeds (kg), X_2 = Fertiliser (kg), X_3 = Insecticide (litres), X_4 = Herbicides (litres), X_5 = Labour (family + hired in man-days.), X_6 = Farm size (Ha), β_0 = Constant term, β_i = parameters to be estimated, V_i = Symmetric error associated with uncontrollable factors related to production process, U_i = Inefficiency component of error term.

Inefficiency model

$U_i = \delta_o + \delta_i Z_i$

Where: U_i = Technical inefficiency, $_o$ = Constant tern, δ_i= Coefficient to be estimated, Z_1 = Gender, Z_2 = Age (in years), Z_3 = Household size, Z_4 = Level of Education, Z_5 = Farming Experience, Z_6 = Age squared.

The value of U_i may be obtained from the observable value of $V_i - U_i$ with the assumption that the composed error $V_i - U_i$ is known and is the best predictor for technical efficiency. The prediction which is presented in Battese and Coelli (1995) is estimated at the maximum likelihood estimates of the parameters of the full frontier inefficiency model stated above.

RESULTS AND DISCUSSION

Tables 1 and 2 revealed that the socio-economic characteristics of respondents as evident from the data analysis revealed that 73.0% were males with an average age of 50.1 years. Most of them were married (85%), 63.0% had between 5 and 8 persons in their household, with an average of 6 people. Majority (89.0%) had below secondary school education and 84.8% were full-time farmers while 55.0% were engaged in inter-cropping activities. Table 3 shows the mean total variable cost per hectare is estimated as ₦109, 599.17 while the average total revenue is ₦111,436.00. The gross margin per hectare was estimated as ₦1, 836.84. This shows that profitability of maize farming was relatively low in the study area.

Estimated production function

The maximum likelihood estimate (MLE) of the stochastic frontier model of maize farmers is presented in Table 4. The sigma-square (δ^2) estimate of 1.43 ($\alpha_{0.01}$) attests to the good fit and correctness of the model. Also, the gamma (γ) estimate of 0.79 ($\alpha_{0.01}$) shows the amount of variation in output resulting from the technical inefficiencies of the farmers. This means that 79% of the variation in farmer's output was due to technical efficiency.

The results reveal that the variables as seeds, herbicide quantity, labour, farm size are factors which positively influence the quantity of outputs of maize. The seed variable had a positive sign which is statistically significant ($\alpha_{0.05}$). This indicated that a percentage increase in the quantity of seed planted would result in 0.21% increase in maize output. This finding corroborates with Shehu et al. (2007) and Oyewo (2011). The elasticity of seed equals 0.21 indicating inelasticity of seed in the production process; thus the importance of the input in maize production cannot be over-emphasised.

The estimated coefficient of herbicides which is another significant factor is at $\alpha_{0.10}$. This means that an increase in the quantity of herbicide used by the maize farmers will lead to increase in the quantity of output of maize produced by the farmers. The elasticity of herbicide equals 0.10 which also shows herbicide inelasticity indicating its invaluable nature as input in maize production. Labour is positively correlated and significant ($\alpha_{0.01}$), with an elasticity of 0.41 while farm size also have positive estimated elasticity of 0.19 implying that increase in these variables will also increase the quantity of maize produced. The mean technical efficiency of the farmers was estimated as 0.69 indicating relatively high efficiency of maize production within the ambit of production resources available in the study area.

Sources of inefficiencies

The sources of inefficiency were examined simultaneously and the results as specified by the maximum likelihood parameter estimates are presented in Table 4. The results of the inefficiency model show household size ($\alpha_{0.05}$) and educational level ($\alpha_{0.01}$) of the respondents are significant determinants of technical inefficiency. The sign of the variables in the inefficiency model is very important in explaining the observed level of technical efficiency of the farmers. A negative sign implied that the variable had the effect of reducing technical inefficiency, hence increasing farmers' production efficiency, while a positive coefficient indicate that the variable has the propensity of increasing inefficiency, thus reducing farmers' production efficiency. These indicate therefore, that increase in household size would significantly increase production efficiency. This juxtaposes the fact inherent in many literature that farmers usually rely on household labour to boost production given it availability, less cost and ease of manipulation to suit different farm activities. The fact that improvement in education reduces maize production efficiency leaves a worry as it does not conform to the *a priori* expectation. This may probably mean that non-formal education provided by extension officers, which directly impinges positively on the production process, would have been better captured in the model instead.

Table 1. Distribution of respondents by socio economic characteristics.

		Frequency	Percent	Mean	Standard deviation
Gender	Female	27	27		0.45
	Male	73	73		
Marital status	Single	8	8		0.71
	Married	85	85		
	Widow	4	4		
	Separate	3	3		
Age group(years)	30 or less	14	14	50.1	16.03
	31 to 40	23	23		
	41 to 50	15	15		
	51 to 60	17	17		
	61 to 70	19	19		
	Above 70	12	12		
Household size group	4 or less	22	22	6	2.43
	5 to 8	63	63		
	9 to 12	13	13		
	Above 12	2	2		
Farming exp group	10 or less	37	37	20.15	14.08
	11 to 20	23	23		
	21 to 30	19	19		
	41 to 50	15	15		
	Above 50	6	6		
	Total	100	100		
Level of Educational	No formal	21	21.0		1.17
	Primary	43	43.0		
	Secondary	25	25.0		
	NCE/OND	8	8.0		
	HND/BSC	3	3.0		
Total		**100**	**100**		

Source: Field survey 2013.

Conclusion

This study examined the technical efficiency of maize production in Ogun state, Nigeria with the aid of stochastic production frontier model. The estimated gross margin implies that profitability of maize farming in the study area was relatively low. The maximum likelihood estimate (MLE) revealed that efficiency of maize production in the study area is significantly influenced by seed; herbicide, labour and farm size. However, the mean technical efficiency was 0.693 which indicates that production can still be increased by 30.9% using available technology.

This means that substantial opportunities should be explored to increase productivity and income of such farmers through availability and efficient utilization of productive resources.

RECOMMENDATIONS

In order to meet up with the goal of improved productivity of maize production in Ogun state, this study recommends the following:

(i) For an effective improvement in the level of efficiency among the maize farmers, provision should be made by governments and other stakeholders in the agricultural sector to provide farmers with access to affordable inputs such as seed, herbicides as well as making provision for

Table 2. Distribution of respondents by production characteristics.

		Frequency	Percent	Mean	Standard deviation
Mode of farming	Full time	56	56		0.50
	Part time	44	44		
Fund source	Bank loan	1	1		0.61
	Esusu	6	6		
	Personal	88	88		
	Friend	1	1		
	Money lender	2	2		
	Others	2	2		
Cropping pattern	Sole cropping	45	45		0.50
	Inter cropping	55	55		
Variety	Local	36	36		0.65
	Improved	52	52		
	Both	12	12		
Maturity period	2.5	4	4	3.07	0.30
	3	86	86		
	3.5	2	2		
	4	8	8		
Farm size group(Ha)	0 through 1	55	55	1.63	2.67
	1.1 to 2	26	26		
	2.1 to 3	6	6		
	3.1 to 4	6	6		
	4.1 to 5	7	7		
Total		**100**	**100**		

Source: Field survey 2013.

Table 3. Gross margin per hectare for maize production in the study area.

Variable	Minimum (₦)	Maximum(₦)	Mean(₦)
Total Variable cost (TVC)	5,700.00	1,105,935.00	109,599.17
Total Revenue (TR)	10,270.00	500,000.00	111,436.00
Gross Margin (GM)			1836.83

Source: Computed from Field Survey, 2013.

Good Agricultural Practises (GAP). Also, the government should introduce the farmers to access non-formal education more, through extension education and establishment of demonstration farms to boost their productive capacity.
(ii) A land redistribution policy that will increase the farm size of farmers (since they are mainly small scale farmers) will boost maize production. And also policies that will encourage the expansion of existing farm lands that are not currently under cultivation should be formulated. This could be through the provision of support such as low interest funds for the purchase or development of such farm lands through the Nigerian Agricultural Bank.

Conflict of Interest

The authors have not declared any conflict of interest.

Table 4. Maximum likelihood estimates of the stochastic frontier production function.

Variable	Parameters	Coefficient	Standard-error	t-ratio
		Efficiency		
Constant	B	5.867892	0.44569592	13.16568500
Seeds	X_1	0.21037706**	0.1072168	1.9621651
Fertiliser	X_2	-0.030510525	0.033871828	-0.90076405
Insecticide	X_3	0.049002906	0.07446027	0.65810812
Herbicide qty	X_4	0.10201794*	0.05685250	1.7944321
Labour	X_5	0.41538462***	0.16329108	2.54382920
Farm size	X_6	0.19385539**	0.09890650	1.95998620
		Inefficiency		
Gender	Z_1	-0.322718	0.89506359	-0.3605526
Age	Z_2	0.003763	0.067568225	0.05569144
Household size	Z_3	-0.178588**	0.10595548	-1.68549870
Educational Level	Z_4	0.19328224***	0.061632006	3.13606930
Farming Experience	Z_5	0.042178	0.0299376	1.40887790
Age squared	Z_6	-0.001338	0.0013587638	-0.98505757
Diagnostic statistics				
Sigma square	δ^2	1.430479***	0.4556956	3.1391109
Gamma	γ	0.78534257***	0.11442896	6.8631451
Log likelihood		-100.75684		
Mean		0.69		

Source: Computed from Field Survey 2013, *** Parameters significant 1% probability level, ** Parameters significant at 5% probability level, *Parameters significant at 10% probability level.

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academicJournals

Vol. 7(2), pp. 61-71, February, 2015
DOI: 10.5897/JDAE2014.0605
Article Number:9D9232649833
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

Economic impact of climate change and benefit of adaptations for maize production: Case from Namibia, Zambezi region

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Received 9 September, 2014; Accepted 26 November, 2014

The aim of this research is to examine the impact of climate change in maize farmers' livelihood in Zambezi region, Namibia and benefit of adaptation. Trade-off analysis–multidimensional (TOA-MD) model was presented as a method for evaluation with a combination of simulated baseline production and future simulated yield using Decision Support Systems for Agro-technology Transfer (DSSAT) in maize production system, under five different climate scenarios of Global Circulation Models (GCMs). Even though the magnitude and the impact of different GCMs differs, the projections shows to have a negative economic impact with the highest going up to 76% and lowest to be around 46% loss without any adaption strategies in the Zambezi region. Adaptation strategies and some policy options were tested. The analysis suggests that the introduction of an irrigation system may be sufficient to offset the negative effects of climate change. Since various assumptions and uncertainties are associated with using the proposed approach and results should be interpreted with caution. Despite these limitations, the methodology presented in this study shows the potential to yield new insights into the way that realistic adaptation strategies could improve the livelihoods of smallholder farmers. To safeguard the limited productive assets of rural Namibian's, the study suggested policy aim to target pro-poor disaster management and other adoption mechanism is very important. Apart from protecting productive resources of the rural population, policy should target the diversification of the rural economic environment and strengthen rural-urban linkages.

Key words: Climate change, trade-off analysis–multidimensional (TOA-MD), maize, Namibia, Zambezi.

INTRODUCTION

Although, agriculture sector in Namibia contributes only about 4.1% to the gross domestic product (GDP), however it is regarded as an important part of the economy because it employs 37% of the work force, and sustain 70% of Namibia's population fully, or to a large extent, depend on agriculture for their livelihoods (CBS, 2012). As a comparison, fishing and fish processing contributed 3.6%, while the mining and quarrying industry

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still remained the highest contributor at 12.4% in 2010 (CBS, 2012).

Crop farming takes place in communal and commercial areas, with the former highly dependent on the rainfall condition. The combination of long dry spells, floods and the persistence of swarms of red-billed quelea birds during critical stages of crop development led to depressed crop yields. In 2007, the total cultivated area was estimated at around 500000 hectares planted, yet there is a potential to increase the land under cultivation (MWAF, 2009).

Namibia is believed to be known as the most vulnerable countries to climate change in Sub Saharan Africa. As it is characterized by semi-arid to hyper-arid conditions and highly variable rainfall; though small stretches of the country (about 8%) are classified as semi-humid or sub-tropical (MWAF, 2009). Rainfall distribution across the country varies from an average of <25mm per year in some parts of the Namibia Desert to 700mm in some parts of the Caprivi Strip, in the North East. The potential implications of climate change in Namibian small holder agriculture have received more attention in the last decade and several efforts have been made to characterize the impact. However, the methods used to date to assess impacts of climate change on smallholder agriculture are less suited to assess socio-economic impacts. To date, integrated climate change impact assessment that consider climate, biophysical and economic models have not been established for small holder agriculture in Namibia.

Study on impact of climate by Desert Research Foundation of Namibia (DRFN)(2008) indicated detected that trends in rainfall is typically more difficult, especially in highly variable arid climates such as Namibia. Considerable spatial heterogeneity in the trends has been observed, but it appears as if the northern and central regions of Namibia are experiencing a later onset and earlier cessation of rains, resulting in shorter seasons in most vicinities.

Description of the study area

The Zambezi Region, until 2013 known as the Caprivi Region, is one of the 14 regions of Namibia, located in the extreme north-east of the country (Figure 1). It is largely concurrent with the Caprivi Strip and takes its name from the Zambezi River that runs along its border. Katima Mulilo is the capital (17.5000° S, 24.2667° E). The climate of the region is characterized by summer rainfall (October to March), with an average rainfall of about 700 mm per year. In summer, January is the month with the highest average maximum temperature (30°C), and winter in July has the minim lowest average temperature of around 2.5°C.

Zambazi region domintley consisting of varying from sand to clay, at one end of the spectrum are heavy soil with high content of clay in areas which are regulary flooded, that is the hydromorphic and organic clay soils. Those areas flooded most frquently hold water for the longest period, and often have a high content of organic materal dervied from decmposed reeds, sedges and other plants that grow in the water. Eastern Zambazi larglery clay-loam and West part of the region more sandy type soil. Genearlly speaking, the region dominated by clay-loam soils (about 35% of the area) and sand (about 50%) (Mandleson, 2011), of all economic activities agricutlure is the most important source of liveslihood the region livelihood depend on farming (both crops and livestock). Large areas have been cleared to plant crops, the continous increasing number of livestock population in the area create heavy grazing on the enviroment.

Due to relatively high rainfall compared to the other regions; as it has been mentioned on the above rainfall, distribution across the country varies from an average of <25 mm per year in parts of the Namibia Desert to 700 mm in some parts of the Zambezi Strip. Secondly, due to existence of perennial rivers in the region, this provides potential for introduction of small scale irrigation systems in the area.

METHODOLOGY

Overall, the project has three crosscutting themes that emphasise on: uncertainty, aggregation across scales, and representative agricultural pathways (RAPs). The uncertainty explores component of the uncertainty cascade. The aggregation across scales connects local, regional, and global agricultural information (Antle, 2011b). The RAPs processes develop scenarios that connect the representative concentration pathways and the socio-economic pathways (SSPs) that are needed to be included in the model. In this integrated climate change impact assessment research, there are three core questions need to be answered:

1. What is the sensitivity of current agricultural production systems to climate change? Current production system (1980 to 2009 Climate) and future climate current production system (2040 to 2069 Climate), without any adaption and RAPs effect,
2. What is the impact of climate change on future agricultural production systems? (Current production system with future trend on prices and technology on the production system, in addition to considering the effect of RAPs,
3. What are the benefits of climate change adaptations? Future climate production system that includes trend on future climate-adapted production system.

Figure 2 presents the general description of the entire project data processing and methodological framework on the climate assessment: blue colour coded shows the economic component, red for the climate component, green data process for crop modelling and white colour combine both crop and economic modeling. For this report results from the economic modeling only reported indicated blue colour.

Climate data

Due to insufficient data observation from Zambezi region Katima Mulilo station, AgMERRA data were used from Rundu weather around 500 km distance from the study area (climate data was

Figure 1. Geographical location of the study areas (Source: Google Earth (2014).

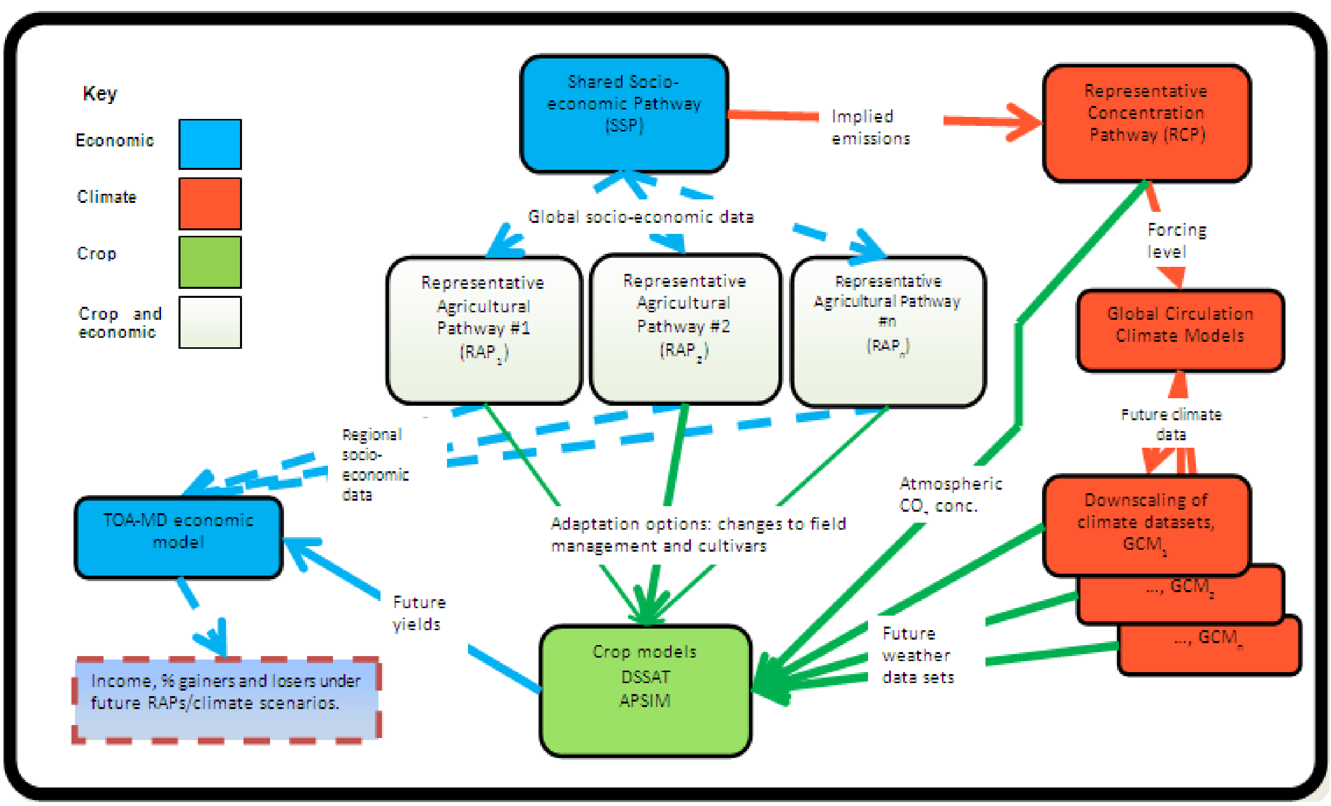

Figure 2. Integrated climate assessment methodological framework (Source: Developed by the research team).

collected by the Namibia weather center). At each location, changes from current climate (1980 to 2010) to near future (2010 to 2040), mid-century (2040 to 2070) and end of century (2070 to 2100) were computed for representative concentration pathways RCP4.5 and RCP8.5. The representative concentration pathways (RCPs) describe the heating effects of atmospheric greenhouse gases (GHGs) at the end of 2100. Twenty global circulation models (GCMs) were used to compute twenty delta changes in monthly temperatures and monthly rainfalls, hence producing 20 possible future weather scenarios per baseline per time period per RCP per station. However, as part of larger fast-track project objective, a first phase presented here consisted in using five of those GCMs only.

Crop data

From different source of literature review and through consultation of agricultural extension officers, the commonly used crop management practices of Zambezi region such as, planting data, soil depth, fertilizer application and harvesting date were used as an input for crop modeling. The physical and chemical properties of the dominant soils information were collected from the data base of Namibia Agricultural research center and some literature review (Mandleson, 2011). In this study, the decision support systems for agro-technology transfer (DSSAT) are used to model the day by day bio-physical growth of maize crops. The model is supported by data base management programs for soil, weather, crop management and experimental. Since the end result of this study was economic analysis, climate and crop results are not reported

Socio-economic data

The data for Zambezi region originate from the project 'Diversified Agriculture and Livelihood Support Options (DALSO) under the Red Cross initiative collected for which farm survey data were collected in 2012 (Mbai et al., 2013). For this analysis, a selection of 191 farms was extracted from the database for complete data (quantities and prices). For inputs (such as seeds, labor, fertilizer, and manure) assumptions were made for the number of families involved or employed during the season for labor; whereas all farmers used manure as their fertilizer. Livestock income calculated based on the potential hiring of oxen, that is the maximum farmer can hire out would be twenty oxen per season, as plough done in four pair.

Methodology for socio-economic impact

For the analysis of climate change economic impact and adaptation strategies, this study used the Tradeoff Analysis model for Multi-Dimensional Impact Assessment (TOA-MD). This model has been used for the analysis of technology adoption (Antle and Validivia, 2006; Nalukenge et al., 2006; Antle and Stoorvogel, 2006, 2008; Immerzeel et al., 2008; Claessens et al., 2008; Antle, 2011b; Antle and Valdivia, 2011) provides an overview of the methodology, and present a validation of the TOA-MD approach against more complex, spatially-explicit models of semi-subsistence agricultural systems.

In the TOA-MD model, farmers are assumed to be economically rational. This meant that thery make decisions based on maximizing expected value and presented with a simple binary choice: they can continue to operate with production System 1, or they can switch to an alternative System 2 (Antle and Valdivia, 2011). The logic of the analysis is summarized as follows: farmers are initially operating a base technology with a base climate. This combination is defined as System 1. System 2 is defined as the case where farmers continue using the base technology under a perturbed climate. If some farmers are worse off economically under the perturbed climate, they are said to be vulnerable to climate change. Overall vulnerability can be measured by the proportion of farmers made worse off, and can also be defined relative to some threshold, such as the poverty line, in which case it says how many more households are put into poverty by climate change (Antle and Valdivia, 2011).

The simulation model uses data on the spatial variability in economic returns to represent heterogeneity; such as heterogeneity in soils, climate, transportation costs, and the farm household's characteristics.

It is necessary to distinguish between three factors affecting the expected value of a production system: the production methods used, referred as the technology, and the physical environment in which the system is operating, for example, the climate, and the economic and social environment in which the system is operated. This is the socio-economic setting that we shall refer to as a Representative Agricultural Pathway (RAP) (Antle, 2011b).

$$\omega = \text{System 1 value} - \text{System 2 value}$$

$$= (P_1 Y_1 a_1 - C_1) - (P_2 Y_2 a_2 - C_2) \quad (1)$$

Where: P, price in System 1 and System 2 respectively; Y, production (Yield) System 1 and System 2 respectively; a, land use; C, Production cost in System 1 and System 2 respectively; ω, the difference between System 1 and System 2.

$$\omega = V_1 - V_2 = \text{losses from CC}$$

$$V_1 = \text{Value of CClim+XTech}$$

$$V_2 = \text{Value of FClim+XTech} \quad (2)$$

$$\mu_\omega = \mu_1 - \mu_2 \quad (3)$$

$$\sigma_\omega^2 = \sigma_1^2 + \sigma_2^2 - \sigma_1 \sigma_2 \sigma \beta_{12} \quad (4)$$

μ_1 & σ_1 from observed of System 1, but for System 2 derived using Random Relative Yield Model

$$C_2 = K_2 y_2 \quad (5)$$

So $V_2 = (P_2 y_2 a_2 - K_2) y_2 = \gamma y_2$

let $y_2 = y_1 + \varepsilon = (1 + \varepsilon / y_1)\, y_1 = R\, y_1$
define $R = y_2 / y_1$ = relative yield
Then $v_2 = \gamma\, y_1 R$

It is important to take note "γ" is estimate from survey data, whereas, R is estimate using crop models. Since relative yield is assumed to be representative from the heterogonous population it is expected to be normally distributed.

Define: y_1 = actual crop yield in current climate
s_1 = simulated crop yield with current climate = $b_1\, y_1$
s_2 = simulated crop yield with changed climate = $b_2\, y_2$

Since we do not know y_2 so we use crop sim models to estimate it!
Assume $b_1 = b_2$ then

Table 1. Summary statistics of the data used for the TOA-MD model.

EAST Caprivi	**System 1**	**System 2**	**RAP 1 (%)**
Farm characteristics	**Mean (STD)**	**Mean (STD)**	
House hold size (persons)	4.89 (2.30)	4.89 (2.30)	
Non-Ag income (Rs.)/year	8937 (4085)	8937 (4085)	
Farm size (ha)	4.15 (4.78)	4.15 (4.78)	
Total farm size	382.2	382.2	
Population of farmers	69200	69200	
Poverty level/year	4536	4536	
Crops/maize			
Yield/ha (kg)	350.54 (126.5)	238.65 (84.84)	
Gross revenue/ha (Rs.)	1400 (455.6)	950.2 (468.07)	
Variable cost/ha (Rs.)	466.22 (151.5)	317.40 (112.85)	
Net return/ha (Rs)	935.95 (316.35)	637.2 (226.5)	
Price (Rs./kg)	4	4	
RAPS			
Land size			70
House hold size			60
None Agric income			40
Price			130
Variable cost			140
Herd size			50%

$R = y_2/y_1 = s_2/s_1$ (estimated from crop models!)
$y_2 = R\ y_1$
data for y_1 and R at a representative sample of sites, then
y_2 = climate perturbed yields = R x y_1

Furthermore, Antle (2011a) show that in an economic adaptation analysis, accurate measurement of the economic, environmental and social impacts of technology adoption must take into account the statistical correlation between factors affecting adoption (For example, economic returns) and the other outcomes of interest. The TOA-MD model is designed to incorporate these correlations into the simulation of impacts on farm income and income-based poverty. In climate change assessment, the TOA-MD model implies that not all farms are affected in the same way – in most cases, some farms lose and some farms gain from climate change. Similarly, some farms may be willing to adopt technologies that facilitate adaptation to climate change, while others will not. The TOA-MD model allows researchers to simulate the impacts of the full range of adoption rates from zero to 100% (Claessens et al., 2008).

RESULTS AND DISCUSSION

Table 1 presents the Namibia case study, the farm systems characterizing for CCSM4 of the Global Circulation Models (GCMs) as an example. On average, those five climate scenarios is predicted to be hotter in the future (+2.0 to +3.5^{o}C), with greater variability in rainfall. Future rainfall/precipitation projections are less consistent, with different climate models revealing different projections in the Southern Africa region.

Question 1: What is the sensitivity of current agricultural production systems to climate change?

The results of the sensitivity of current production systems to future climate change are presented in Table 2. The results show that future climate change is projected to be detrimental to crop production in the Zambezi region (Caprivi) in Namibia. Crop yields are expected to decrease by 11 to 23% due to expected changes in climate 71 to 77% of the farmers in the Zambezi region are expected to lose. Furthermore, Table 3 presents the predication of the model to the farmers' net welfare. The model predicts the net crop revenue would drop ranges from 38 to 108%, this would yield impacts on mean return would be range from -35 to -60%. Whereas analysis on per capita income (PCI) shows decreases of 38 to 98% due to climate change, while poverty analysis shows that all the farmers below the poverty line would increase ranges from 18 to 46%. The results imply that current crop production systems are sensitive to the effects of climate change.

Question 2: What is the impact of climate change on future agricultural production systems?

Table 4 presents the impact of climate change on future

Table 2. Sensitivity of current agricultural production systems to climate change.

Stratum 1	CCMS4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	East	West	East	West	East	West	East	West	East	West
Observed mean yield (maize) (kg/ha)*	350.54	359.79	350.54	359.79	350.54	359.79	350.54	359.79	350.54	359.79
Mean yield change (crop name) (%) [defined as: (mean relative yield -1)*100]	-11	-13	-23	-19	-8	-7	-23	-12	-14.7	-17
Losers (%)	74.15	75.88	76.27	76.5	71.96	73.65	75.74	75.7	76.31	76.7
Gains (% mean net returns) - old	2.32	2.37	2.35	2.57	2.25	2.34	2.58	2.32	2.29	2.32
Losses (% mean net returns) - old	-39.55	-42.77	-48.75	-50.38	-32.36	-35.05	-53.75	-41.13	-47.26	-45.07
Gains (% mean net returns) - corrected	8.97	9.84	9.92	10.96	8.04	8.87	10.63	9.54	9.68	9.98
Losses (% mean net returns) - corrected	-53.34	-56.37	-63.92	-65.85	-44.96	-47.59	-70.96	-54.33	-61.93	-58.76
Observed net returns without climate change (NAD/ha)	5,614.64	5026.002	5,598.73	5054.545	5,483.08	3081.273	5646.119	5007.621	5582.315	4999.697
Observed net returns with climate change (NAD/ha)	60.68	-110.245	-430.34	-328.511	805.17	1920.942	-479.7	-36.0319	-394.48	-237.014
Observed per-capita income without climate change (NAD/Person/Year)	3,630.90	3089.925	3,626.93	3097.158	3598.072	4991.862	1819.377	3085.267	1811.417	3083.259
Observed per-capita income with climate change (NAD/Person/Year)	2,245.08	1788.308	2,122.56	1732.995	2430.845	413.1373	1055.122	1807.115	1065.755	1756.182
Projected poverty rate without climate change (%) **	25.66	33.51	25.61	33.29	26.37	33.8	12.69	33.63	12.85	33.64
Projected poverty rate with climate change (%) **	56.31	76.63	60.51	79.82	50.65	70.15	30.55	75.6	30.08	78.17

* Normalised. ** Poverty line: NAD2454 per capita per year (exchange rate against USD 1$ equivalent to NAD10 (Namibian Dollar)).

Table 3. Impact of climate change to return per capita income and poverty line.

Impact	CCMS4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	East	West	East	West	East	West	East	West	East	West
Net impact (% mean net returns)	44.36	46.53	54.00	54.89	36.93	38.73	60.33	44.79	52.25	48.78
per capita income (PCI)	38.17	42.12	41.48	44.05	32.44	91.72	42.01	41.43	41.16	43.04
Poverty	30.64	43.12	34.89	46.54	24.28	36.36	17.86	41.97	17.23	44.53
Net revenue	98.92	102.19	107.69	106.50	85.32	37.66	108.50	100.72	107.07	104.74

crop production systems in the Zambezi region (Caprivi) region. The results show that about 38 to 65% of the farmers will lose as a result of climate change. Also, future climate change with RAPs and global trend expected to results in decreases in mean yield decrease from -3 to 17%, this would impact net revenues mixed impact for some climate scenarios provided positive and negative net impact. From example, GFDL-west, HadGEM_2ES (west and east), MIROC-5 (East) and MPI-ESM (East) projected to be positive net revenue; whereas, the remaining scenarios would be projected to be negative impact. As indicated in Table 5 with regards to welfare analysis that includes Per Capita Income (PCI) poverty line indicated that climate change will adversely affect livelihoods of Zambezi (Caprivi) substance farmers. For example poverty is expected to reduce marginally in GFDL (west), HadGEM_2ES (west) and MIROC-5 (west) by 1.78, 4.96 and 0.97% respectively. Whereas, for the remaining climate in the model project, there would be adverse effect, especially, GFDL (East) showed hard hit which is estimated to be around 49%;

Table 4. The impact of climate change on future agricultural production systems.

Stratum 1	CCMS4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	East	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**
Projected mean yield (maize) (kg/ha)	350.54	359.79	350.54	359.79	350.54	359.79	350.54	359.79	350.54	359.79
Mean yield change (crop name) (%) [defined as: (mean relative yield -1)*100]	-11.00	-13.00	-23.00	-19.00	-7.81	-3.00	-23.00	-12.00	-15.00	-17.00
Losers (%)	53.63	53.70	64.65	46.43	56.50	54.32	37.63	52.10	41.90	58.29
Gains (% mean net returns) - old	5.50	6.65	3.87	7.24	5.09	5.78	9.63	5.99	8.70	4.81
Losses (% mean net returns) - old	16.86	19.04	24.29	13.13	18.74	17.19	10.64	15.50	12.71	18.44
Gains (% mean net returns) - corrected	11.86	14.36	10.94	13.52	11.71	12.65	15.44	12.50	14.98	11.53
Losses (% mean net returns) - corrected	31.43	35.44	37.57	28.27	33.16	31.65	28.28	29.75	30.33	31.64
Projected net returns without climate change (NAD/ha)	8,271.68	6,967.43	8,715.93	6,548.04	6,560.45	5,986.71	5,661.81	6,476.75	5,364.18	7,121.20
Projected net returns with climate change (NAD/ha)	5,621.76	5,970.61	3,283.36	6,612.08	7,527.96	6,878.76	8,879.11	6,361.17	9,087.60	5,080.61
Projected per-capita income without climate change (NAD/Person/Year)	4,293.88	3,581.92	4,404.73	3,475.64	3,866.90	3,333.38	3,642.67	3,457.57	3,568.40	3,620.89
Projected per-capita income with climate change (NAD/Person/Year)	2,294.71	3,732.60	1,711.24	4,003.53	2,770.35	4,116.16	3,107.48	3,897.56	3,159.51	3,356.69
Projected poverty rate without climate change (%) **	21.80	28.48	20.24	30.21	26.80	32.47	29.76	30.38	30.75	27.86
Projected poverty rate with climate change (%) **	53.71	31.00	69.39	28.43	43.37	27.51	37.27	29.41	36.40	35.61

* Normalised. ** Poverty line: NAD2454 per capita per year (exchange rate against USD 1$ equivalent to NAD10 (Namibian Dollar)).

Table 5. The impact of climate change on future agricultural production systems.

Impact	CCMS4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	East	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**
Net impact	19.57	21.08	26.62	14.74	21.45	19.01	12.84	17.25	15.35	20.11
PCI	46.56	4.21	61.15	15.19	28.36	23.48	14.69	12.73	11.46	7.30
Poverty	31.92	2.53	49.15	1.78	16.58	4.96	7.52	0.97	5.65	7.75
Net revenue	32.04	14.31	62.33	0.98	14.75	14.90	56.82	1.78	69.41	28.66

Table 6. The benefits of adoption of climate change adaptations on future agricultural production systems.

Stratum 1	CCMS4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	East	West	East	West	East	West	East	West	East	West
Mean yield change (crop name) (%) [defined as: (mean relative yield -1)*100]	249	196	218	199	322	-3	263	178	248	160
% adoption rate	74	69	70	54	70	77	74	70	75	67
Projected net returns without adaptation (ZAR/ha)	-40	1004	545	3349	-374	126	-410	1082	-217	1891
Projected net returns with adaptation (NAD/ha)	8508	6749	7953	5080	10117	7216	8046	6595	8702	5983
Projected per-capita income without adaptation (NAD/Person/Year)	2220	2071	2366	2665	2137	1848	2128	2090	2176	2295
Projected per-capita income with adaptation (NAD/Person/Year)	3015	4061	2876	3356	3416	4258	2900	3996	3063	3738
Projected poverty rate without climate change (%) **	57	63	52	44	59	71	60	62	58	55
Projected poverty rate with climate change (%) **	37	24	40	33	30	23	39	25	36	27

* Normalised. ** Poverty line: NAD2454 per capita per year (exchange rate against USD 1$ equivalent to NAD10 (Namibian Dollar)).

while PCI which is also in the model provided mixed results.

Question 3: What are the benefits of climate change adaptations?

Table 6 shows the benefits of adoption of climate change adaptations on future crop production systems in Namibia (Zambezi region). The adaptation package analysed for this study included the introduction of irrigation as adaptation measures and also RAPs included in the model.

The results show adoption ranging from 54 to 77% of the adapted crop production system under climate change. In addition, the mean yield changes shows an increase ranging from 160 to 322% increase (with exception HadGEM_2ES_West shows 3% reduction). This shows the option of irrigation usage, even over a much smaller land area, would lead maize production to increase at least five-fold while also providing an opportunity for different crop varieties to be grown throughout the year. The overall effect would be to uplift the livelihoods and food security of those living within the study area. From this study, it can be concluded that the introduction of an irrigation system would compensate for the negative effects of climate change. Furthermore, net returns per farm increases by 18 to 29% as a result of adopting the adaptation package.

The results also show that poverty levels decreases by about 12% minimum and 39% maximum when farmers adopt the adaptation package and PCI increases by ranges from 22 to 130%. Generally, the adoption of the adaptation package helps to reduce the negative impacts of climate change of crop production systems in the Zambezi region in Namibia. However, further analysis would be required to test different adaptation packages and RAPS on future crop production system (Table 7).

In summary, Figure 3 presented the impact of climate change on the net impact of farmers return for those three different core questions for WEST Zambezi. As shown in the figure for core question-1 it shows the change in climate for future (but without RAPs and adoption), under this scenario the net impact would be a loss of range from 35 to 46% for the East part of the region under those five different GCMs. For core question-2 that is with changed climate in future, without any adaptation measures, but with some policy change and impact of global market trend. Under this consideration the impact of climate change on the farmers' net return projected to be a loss of up to 6% on their net return (with only FGDL climate scenario yields 3% gain on the net return). When considering the adaptation for

Table 7. Impact of climate change with adaptation strategies to return, per capita income and poverty line.

Impact	CCMS4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	East	West	East	West	East	West	East	West	East	West
Mean yield change	260	209	241	218	329	0	286	190	263	177
Per capita income (PCI)	36	96	22	26	60	130	36	91	41	63
Poverty	-20	-39	-13	-12	-29	-49	-21	-37	-22	-28
Net returns	-21141	572	1360	52	-2806	5636	-2060	509	-4101	216

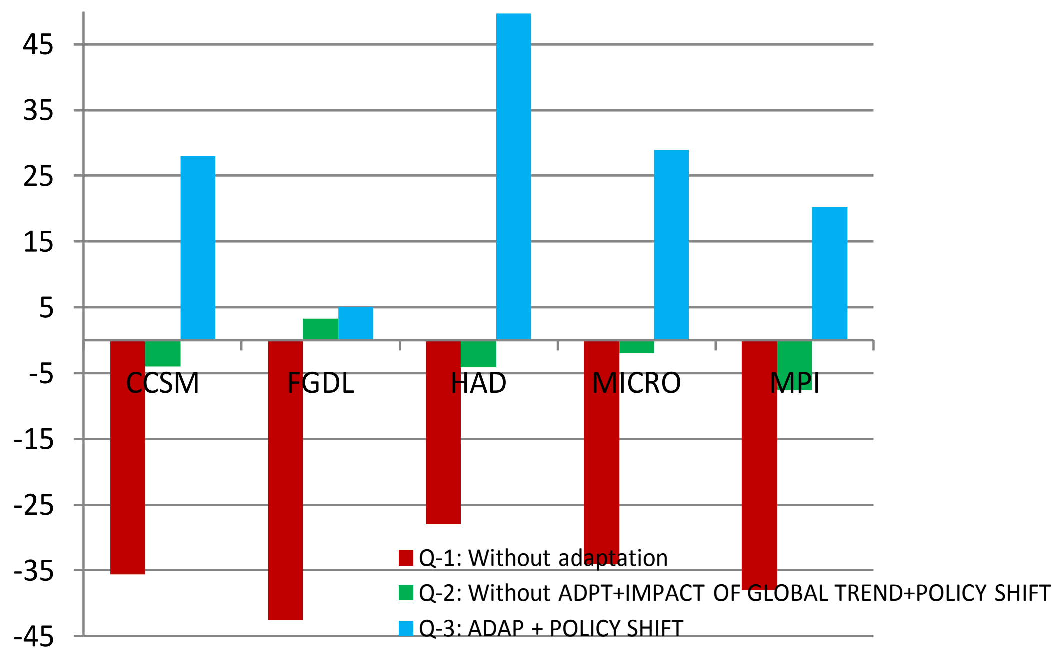

Figure 3. Percentage of net impact of change (for three different core questions) under different five GCMs for Zambezi region (West Zambezi).

inclusive policy shift which yield a positive and potential offset in the impact of climate change, farmers would gain up 45% of those different climate scenarios.

Similar study from IPCC (2014) reported that, there would be an increase in temperatures and changes in precipitation are very likely to reduce cereal crop productivity in Africa (specifically worst in the South-West of Southern Africa). This will have strong adverse effects on food security. New evidence is also emerging that high-value perennial crops could also be adversely affected by temperature rise. Pest, weed and disease pressure on crops and livestock is expected to increase as a result of climate change combined with other factors. Moreover, new challenges to food security are emerging as a result of strong urbanization trends on the continent of Africa and increasingly globalized food chains, which require better understanding of the multi-stressor context of food and livelihood security in both urban and rural contexts in Africa.

Figure 4 presented the impact of climate change on the net impact of farmers return for those three different core questions for EAST Zambezi. As shown in the figure, it is different from the WEST presented earlier.

Conclusion

Vulnerability and adaptation assessments, particularly at the local level, face limited knowledge about exactly what to adapt to Namibia's natural variability and only exacerbates the shortcomings of global and regional climate models which allow only for broad statements of change. With a view of current technology and future climate change challenges the comprehensive climate assessment was done.

In this study, the TOA-MD model was presented as a method to evaluate the impacts of climate change and the economic viability of adaptation strategies using the kinds of data that are typically available for semi-subsistence systems are important. The method was applied to the maize production systems of the Zambezi region, in Namibia. With a combination of simulated

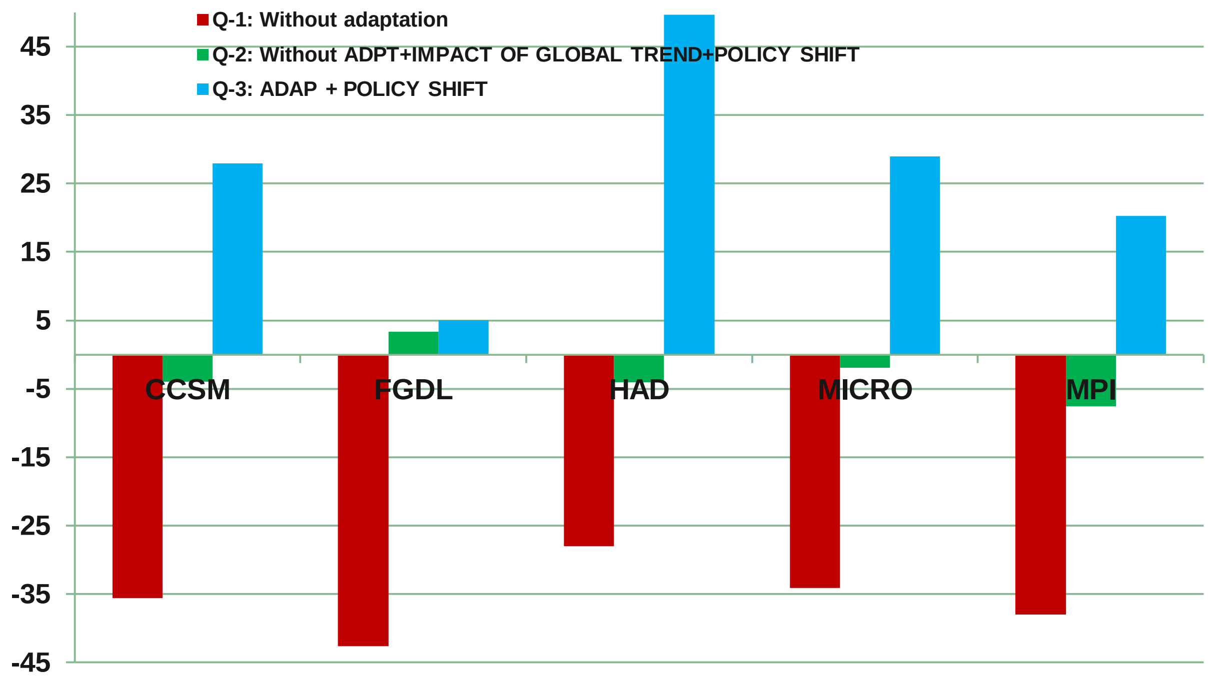

Figure 4. Percentage of net impact of change (for three different core questions) under different five GCMs for Zambezi region (East Zambezi).

baseline production and future simulated yield using DSSAT in maize production system, under five different climate scenarios to achieve those three core questions of the study. The Economic impacts of climate change to 2050 were analyzed. Even though the magnitude of climate impact differs under different GCMs climate change is projected to have a negative economic impact with the highest going up to 76% and lowest to be around 46% loss without any RAPs and adaption in the Zambezi region. Adaptation strategies were tested for the introduction of irrigation system and by introducing socio-economic scenarios based on Representative Agricultural Pathways.

Highly variable climatic conditions and the risk of extreme events: it is important that policy be developed to safeguard the limited productive assets of rural Namibian's by means of targeted, pro-poor disaster insurance schemes. Apart from protecting productive resources of the rural population, policy should target at the diversification of the rural economic environment and strengthen rural-urban linkages. These policy directions should receive adequate attention during the formulation of a rural development policy and strategy, which is currently lacking in Namibia's policy framework. A national debate to clarify the expectations of the agricultural sector to national development, also in lieu of climate change, should be initiated to streamline policies aimed at the sector. Outright conflicting goals prevail which further undermine the potential of this vulnerable sector as well as the sustainable use of the environment.

Conflict of interest

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

This research was sponsored by the USDA and UK-AID, further we would like to acknowledge the coordination and leadership of Agricultural Model Inter-comparison and Improvement project (Agmip) from Colombia University and also the technical support of NASA.

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Vol. 7(2), pp. 72-79, February, 2015
DOI: 10.5897/JDAE2014.0616
Article Number:4E2E1D949839
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full Length Research Paper

A comparative analysis of technical efficiency of smallholder tobacco and maize farmers in Tabora, Tanzania

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Received 29 October, 2014; Accepted 15 January, 2015

The study presented here considers the relative efficiency of planting tobacco and maize in the tobacco-producing Tabora region of Tanzania. The study used a 2013 survey that was conducted among smallholder farmers in the Tabora region. The aim was to investigate whether farmers are better off planting tobacco or maize. The paper briefly reviews the importance of agriculture in general and tobacco planting in particular on the Tanzanian economy. The paper then reviews the methodology used in the analysis, The Frontier Production Function. The findings show relative inefficiency in both tobacco and maize production. When the two are compared, one finds a statistically significant higher efficiency in the production of maize compared to tobacco. In other words, maize farmers can produce the same output utilizing 76.83% of the current input, while the corresponding value for tobacco is 73.89 percent. After generating the efficiency index of each farmer and for each crop, a multiple linear regression was estimated to identify significant determinants of efficiency. For the production of maize, five significant explanatory variables were identified (gender, age, education, household size, and farm size). For tobacco production, five explanatory variables including the variable "feeling sick while curing tobacco" were significant. In other words, the efficiency equation for maize has significantly better fit. In general, the efficiency indicators suggest that Tanzanian small scale farmers are more productive planting maize than tobacco.

Key words: Frontier, efficiency, tobacco, maize, Tanzania.

INTRODUCTION

The agricultural sector in Tanzania plays an important role in the overall economy through its significant contributions to rural employment, food security, and provision of industrial raw materials for other sectors in the country; thus, the performance of the overall Tanzanian economy is driven by the performance of the agricultural sector (Ministry of Agriculture, Food Security and Cooperatives 2008). Agriculture in Tanzania employs the majority of the poor and has strong consumption linkages with other sectors. In 2011, the agricultural sector contributed approximately 51% of foreign exchange, 75% of total employment, and 27.1% of the

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Gross Domestic Product (GDP) (World Bank, 2013, 1996, 1994, 1991). Smallholder farming dominates agricultural production, and a large proportion of that farming is for subsistence. Since poverty is predominantly a rural phenomenon, and agriculture is a major economic activity for the rural population, it follows that success in poverty reduction depends critically on the performance of the agricultural sector. In terms of growth, the sector has achieved significant success in recent times, growing an average of 4.1% from 1998 to 2007.

Tobacco is one of the cash crops that helps generate foreign exchange earning in Tanzania. Tanzania ranks as a third African country after Malawi and Zimbabwe that is a major producer and exporter of tobacco. Tobacco is also consumed by Tanzanians with a prevalence rate of 10.8% (World Bank, 2013).

Before one considers a comparative efficiency of tobacco and maize production, it may be in order to highlight the health, social economic and environmental consequences of tobacco production. The negative health consequences of tobacco production such as the effect of curing, the high dependence on family and child labor and other hazards of being engaged in tobacco farming have been widely covered (Kagaruki, 2010; Mangora, 2005)

In the major tobacco-producing region of Tabora and other places in the country, government, extension agents, and companies are encouraging farmers to produce more tobacco by making credit available to purchase fertilizer and seeds. However, efficiency in the production of tobacco leaves a lot to be desired. Setting aside the negative health consequences of tobacco production and consumption, a benefit-cost analysis of tobacco farming may show that tobacco farming may not be a better option for small-scale farmers. Tobacco cultivation is labor intensive--farmers are in the field for 10 hours a day for 10 months a year from plowing the land to harvesting the crop. On the other hand, the gestation period for annuals such as maize or groundnuts is less than four months with relatively less labor input. In other words, it is possible with maize and groundnuts to have two or more harvests per year.

We hypothesize that farmers would be better off planting crops other than tobacco and that tobacco production is less efficient than the production of some other crops. This study compares production efficiency between tobacco and maize in the Tabora region of Tanzania. The aim is to investigate whether tobacco farmers would be better off growing maize, the main staple in the Tanzanian diet.

Objectives

The main objective of this study is to empirically determine and compare the efficiency of tobacco and maize farming in Tanzania. Specifically, the study seeks to:

1. Estimate frontier production functions for maize and tobacco and identify which is more efficient, and
2. Analyze the determinants of “Frontier” based efficiency for the two crops. .

Motivation

The motivation for this study is that both tobacco and maize production are important in the economy of Tanzania in general and in the Tabora region in particular. The market value for one kg of tobacco is three times that of maize. On the other hand, tobacco farming is more labor intensive and hazardous. It may not be sufficient to compare the gross revenue from tobacco with that of maize and conclude that farmers are better off cultivating tobacco. Setting aside the negative health consequence of tobacco production and consumption, one should also take into account the cost of production and compare the net revenue. Alternately, one may compare efficiency in the production of maize and tobacco. The main reason for choosing maize efficiency with tobacco is the fact that that Tanzania is the largest producer of maize in Africa after Nigeria. In 2012 4.21 million hectare was planted with maize. This constitutes 70% of total acreage in the country (DTMA, 2014)

The study also is warranted because few studies exist on technical efficiency in the Tanzanian agricultural sector (Msuya and Ashimogo 2006; Msuya et al., 2008), and none in the area of tobacco production. Therefore, an empirical study to investigate technical efficiency in tobacco and maize cultivation in Tabora is a necessary first step in the national effort of improving resource use in the agricultural sector. Findings from the study will help to improve resource use efficiency in specific production areas, increase the contribution of agriculture to GDP, and enhance the earnings of small-scale farmers in the study area.

REVIEW OF ANALYTICAL FRAMEWORK

Methodological review

This study employs the stochastic frontier production function as proposed by Battese and Coelli (1992). The application of the function is in accordance with the early applications of Aigner et al. (1977) which originally developed the model to handle cross-sectional data. The tool has gained prominence in econometric and applied economic analysis in the last two decades. In Tanzania, few studies have applied this tool in the analysis of production functions especially in the agricultural sector.

This study applies the stochastic frontier approach for two main reasons: First, the method is capable of capturing measurement errors and other statistical noises influencing the shape and position of the production frontier (Battese, 1992; Msuya et al., 2008). Battese extensively described techniques (deterministic versus stochastic, parametric versus nonparametric) that could be used to measure relative efficiency. Second, the technique better suits agricultural production largely influenced by random exogenous shocks like the one in Tanzania. This technique assumes that farmers may deviate from the frontier not only because of measurement errors, statistical noise, or any nonsystematic influence, but also because of technical efficiency.

Model specification

The methodology that is being adopted here is based the concept of frontier production finction. The model decomposes the error terms into two, namely, the standard error term and an efficiency component. The latter measures the relative efficiency of each farmer in the study. This efficiency indicator gives a value between zero and one. Zero is given to the farmer who is completely inefficient and one if he is completely efficient. Once farmers are given this efficiency score, the model tries to identify the determinants of efficiency. These determinants are nothing but the characteristics of farmers such as age education, household size etc. A summarized theoretical specification of the model is given below

Following Battese and Coelli (1992), the production function can be specified as follows:

$$Y_i = f(X_{i,}\beta) + e_i; \quad i = 1, 2, ..., N \qquad (1)$$

Where Y_i represents the previous potential output level (harvest) from the farms, X_i is a $(1 \times k)$ vector of inputs and other explanatory variables associated with the i^{th} farm. β is a $(k \times 1)$ vector of unknown parameters. The error term, e_i is composed of two independent elements, that is, $e_i = v_i - u_i$, with the v_i term being a random (stochastic) error associated with random factors not under the control of the farmers. It is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$, where σ_v^2 stands for the variance of stochastic disturbance v_i. u_i captures technical efficiency and is a nonnegative one-sided component associated with farm-specific factors. It is distributed independently from and identically to v_i. If farmers achieve their maximum output, then they would be technically efficient and this means that $u_i = 0$. u_i is associated with the technical inefficiency of the i^{th} farm and defined by the truncation (at zero) of the normal distribution $N(z_i\delta, \sigma_u^2)$, where z_i is a $(1 \times m)$ vector of explanatory variables associated with technical inefficiency of production of farmers, and δ is an $(m \times 1)$ vector of unknown coefficients.

Following Battese and Coelli (1992), Shapiro and Muller (1977), the stochastic frontier production function can be specified in terms of the original values as follows:

$$In\ Y_i = f(X_i, \beta)\exp(v_i - u_i) \qquad (2)$$

The model is such that the possible production Y_i is bounded above by stochastic quantity, $f(X_i, \beta)\exp(v_i - u_i),$ hence the term stochastic frontier.

The technical efficiency of an individual farm from the above specification can be defined in terms of the observed output to the corresponding frontier output, given the available technology (Amos, 2007). The technical efficiency (TE) is thus empirically measured by decomposing the deviation into a random component (u) (Ojo, 2003; Amos, 2007).

$$TE = \frac{Y_i}{Y_i^*} = \frac{f(X_i, \beta)\exp(v_i - u_i)}{f(X, \beta)\exp(v_i)} = \exp(-u_i) \qquad (3)$$

Where Y_i is the observed output and Y_i^* is the frontier output, v_i is a standard error term while μ_i is a measure of efficiency that follows a truncated normal distribution. This is such that $0 \leq TE \leq 1$. If farmers achieve their maximum output, then they would be technically efficient and this means that $u_i = 0$.

Study area

The data for this study were collected in Tabora, one of the major tobacco-producing regions in Tanzania. The units of observation are small-scale farmers. Even though tobacco is the major crop cultivated, farmers also are engaged in the production of other crops especially maize, a major staple in the diet of Tanzanians.

Tabora is a region in the central-western part of Tanzania. With a population of about 2.2 million (National Census, 2012), the region is the 24th most densely populated with 30 people per square kilometer and a land area of 76,151 square kilometers representing 9% of the land area of Mainland Tanzania. The climate of the area is highly favorable for the agrarian activities of the population, which grows crops including maize, groundnuts, beans, cassava, and tobacco. The annual rainfall is between 700 and 1000 mm, with the daily mean temperature around 23°C (The Planning Commision of

Table 1. Summary statistics of respondents' characteristics.

Variable	Observations	Mean	Percent
Quantity of harvest (Kg)			
Tobacco	259	1022.69	
Maize	252	1176.26	
Age (years)	134	58	
Household size (Number)	289	6	
Farm size (Acres)	306	9.6	
Education level	306		
No Education	45		14.71
Primary Education	226		74.83
Secondary and above	32		10.46
Gender	306		
Male	227		74.19
Female	79		25.81

Source: Survey data (2013).

Tanzania, 1998).

The data for this study were collected from randomly selected small-scale farmers in 2013. Data were collected with the use of a structural questionnaire designed for collecting information on output, inputs, prices of variables, and some important socioeconomic variables on the farmers. The sample size is 306 farmers; some respondents responded to only some of the questions thus causing a reduction in the number of observations for particular variables. Table 1 presents summary statistics of selected variables.

Table 1 shows the average age of a farmer involved in tobacco and maize cultivation in the Tabora region is 58 years. In other words, farmers are mature and should be able to make rational decisions about the daily operations of their farms. The mean household size appears to be relatively high; mean acreage planted is 9.6, while mean harvest per acre is 1022.96 for tobacco and 1176.26 kg for maize. Only 10.46% of the population appears to have a high level of education, while 25.81% are female-headed households, higher than the national average.

MEASUREMENT OF VARIABLES AND METHOD OF ANALYSIS

Quantity of output and inputs

These include the amount (in kg) of each crop (tobacco and maize), area cultivated in acres, family and hired labor, monetary value of fixed assets and fertilizer input.

Socioeconomic characteristics

These variables include gender, age (years), level of education, household size and farm size (acres). These variables will act as explanatory variables while estimating the equation on the determinants of efficiency.

A two-stage frontier production function will be estimated. In other words, the following Cobb-Douglas frontier production function is estimated

$$LnY = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \nu_i - \mu_i \qquad (4)$$

Where: In, denotes natural logarithms; Y is total amount of harvest of each crop expressed in kilograms; X_1 is labor input in man days; X_2 is area of land cultivated in acres; X_3 is proportion of fixed assets used; X_4 is cost of fertilizer, pesticides, and fungicides; v_i is independent and identically distributed random errors $N(0, \sigma_v^2)$. These are factors outside the control of the smallholders. u_i is nonnegative random errors or technical efficiency effects

The second stage of the analysis investigates farm-and farmer-specific attributes impact smallholders' technical efficiency. The inefficiency function can be expressed as:

$$u_i = \alpha_0 + \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_4 z_4 + \alpha_5 z_5 + \alpha_6 z_6 + w_i \qquad (5)$$

Where: $\alpha_{i's}$ is inefficiency parameters to be estimated; z_1 is gender of the farmer (1=male, 0 female); z_2 is age of the farmer; z_3 is dummy variable for smallholder level of education (1= if the farmer has formal education and 0 if otherwise); Z_4 is household size (number of people staying together); Z_5 is farm size in acres; Z_6 is air breath (feeling sick) of the person while curing tobacco; this variable used only in the tobacco equation (1 = feeling sick, 0 =

Table 2. OLS and MLE of the production function for tobacco and maize cultivation in Tabora region.

Variable	Tobacco		Maize	
	OLS	**MLS (Half-normal)**	**OLS**	**MLS (Half-normal)**
Loglabor	0.134(0.0768)*	0.0184(0.0438)*	0.0654(0.0960)	0.0385(0.0728)
Logarea	0.678(0.1580)***	0.932(0.126)***	0.648(0.1630)***	0.972(0.0870)***
Logasset	0.0542(0.0345)	0.171(0.0021)***	0.026(0.0467)	0.0111(0.0398)
Logfertilizer	0.00478(0.0123)	0.0280(0.0122)**	0.0673(0.0331)**	0.0350(0.0112)***
Constant	5.046(0.6820)***	4.894(0.0840)***	5.088(0.5700)***	6.364(0.3830)***
R-sq	0.431		0.277	
F(4, 164)	6.38***		9.01***	
$In\sigma_v^2$		-3.525(0.3014)		-5.112(1.0370)***
$In\sigma_u^2$		0.412(0.1090)***		0.224(0.1230)*
σ_v		0.0022(0.0030)		0.0776(0.4020)
σ_μ		0.8137(0.0443)		1.1186(0.0686)
$\sigma_S^2 = \sigma_v^2 + \sigma_\mu^2$		0.6622(0.0720)		1.2574(0.1508)
$\lambda = \sigma_\mu / \sigma_v$		0.0036(0.0443)		14.4144(0.9355)
LR test of $\sigma_\mu = 0$		87.82***		29.58***
Observations	169	169	190	190

*** p<0.01, ** p<0.05, * p<0.1. Values in parenthesis are standard errors for the ML estimation and robust standard errors for the OLS regression.

otherwise); z_7 is Dummy variable assuming a value of 1 if land is owned by farmer and 0 otherwise (rented); w_i is an error term that follows a half-normal or a truncated distribution.

The source of data, the sampling method as well as the sample size is already discussed previously. The specified models namely Cobb-Douglas production frontier defined in Equation (4) and the inefficiency model defined by Equation (5) are estimated using Ordinary Least Square (OLS) as well as the Maximum Likelihood (ML) method (Greene, 2007).

RESULTS AND DISCUSSION

The maximum likelihood estimation shows the presence of technical inefficiency effects in both tobacco and maize cultivation by smallholder farmers in Tabora region. In other words there is a significant level of inefficiency in both tobacco and maize production process. This result is confirmed by the statistical significance of the coefficients of $In\sigma_u^2$ as well as the log-likelihood ratio test of the overall maximum likelihood estimation. The highly significant value of $In\sigma_u^2$ suggests the domination of the inefficiency components of the error term for both tobacco and maize. With the exception of land area, all the other significant elasticities suggest values that are too small confirming the inefficiency in the production process.

In general, the results in Table 2 show a positive relationship and statistical significance between the levels of output (for tobacco and maize) and labor input, area of land cultivated, proportion of fixed assets used, and cost of fertilizer. This scenario is expected as the level of output depends to a certain extent on the quantities of these inputs used. However, this relationship can only exist up to a level that is considered optimal. After reaching this level, farmers will be operating at a suboptimal level (Amos, 2007).

Levels of technical efficiency

Once we estimate the frontier production function and establish the existence of technical inefficiency, the next step is to estimate the frequency distribution of technical efficiency (one minus inefficiency) indices. Table 3 presents the results.

Table 3 shows that the predicted technical efficiencies range between 0.000 and 0.9999 for tobacco farmers and between 0.003 and 0.91 for maize farmers. The mean efficiency for tobacco farmer is 73.9%, while that of maize farmer is 76.8% suggesting that tobacco farmers are less efficient than maize growers. The table also shows the t-test results for equal mean efficiencies with the null hypothesis of no significant difference in the mean technical efficiencies between tobacco and maize

Table 3. Frequency distribution of technical efficiency estimates and two sample t-test with equal mean efficiencies.

Efficiency level	Tobacco		Maize	
	Frequency	Percentage	Frequency	Percentage
<0.1	1	0.59	1	0.53
0.11-0.20	0	0.00	0	0.00
0.21- 0.30	0	0.00	1	0.53
0.31-0.40	1	0.59	5	2.63
0.41-0.50	2	1.18	9	4.74
0.51-0.60	3	1.78	10	5.26
0.61-0.70	25	14.79	25	13.16
0.71-0.80	62	36.69	61	32.11
0.81-0.90	45	26.63	31	16.32
>0.91	29	17.16	47	24.74
Observ.	169	100.00	190	100.00
Mean	0.7389		0.7683	
Min.	0.0000		0.0000	
Max.	0.9999		0.9926	
Two sample t-test with equal mean efficiencies				
Null hypothesis			$H_0 : Difference\ in\ mean = 0$	
t-value		-2.94***		

*** p<0.01, ** p<0.05, * p<0.1.

Table 4. Determinants of technical efficiency.

Variables	Tobacco	Maize
Gender	0.0152(0.0239)	0.0146(0.0363)***
Age	0.0009(0.0009)*	0.0011(0.0014)***
Noneduc	-0.0008(0.0659)	0.0149(0.1070)***
Primeduc	-0.0309(0.0649)*	0.0045(0.1000)***
Hhsize	0.0017(0.0049)**	-0.0026(0.0070)***
Farmsize	0.0009(0.0016)*	-0.0006(0.0019)***
Airbreath	-0.0249(0.0105)**	
Constant	0.7495(0.0985)***	0.515(0.1860)***

*** p<0.01, ** p<0.05, * p<0.1; Standard errors in parentheses.

cultivation. The null hypothesis is rejected at a 1% level of significance showing that the mean technical efficiencies of tobacco are significantly lower compared with those of maize. In other words, tobacco farmers can produce the same output with only 73.9% of current inputs compared to a corresponding value for maize of 76.8%.

The determinants of efficiency

The efficiency effect model (Equation 5) tries to identify the socioeconomic determinants of efficiency among tobacco and maize farmers in the study area. The results are given in Table 4. According to the data in Table 4, age, primary educational attainment, household size, farm size, and air breath (sickness caused by the process of curing tobacco) are the major determinants of efficiency of tobacco farmers; only age, household size, and primary educational attainment of farmers significantly caused inefficiency in maize cultivation. While variables such as no educational attainment and air breath reduced the efficiency level of tobacco farmers, other variables including primary educational attainment, household size, and farm size increased the efficiency level of tobacco farmers. On the other hand, farm size and no educational attainment reduced the efficiency of maize farmers in the model. Other variables increased the efficiency of maize farmers.

These results are plausible given that the majority of

farmers in the study are old and may not be willing to try or adopt new innovations or some may be less efficient in supervising their farms. Concerning household size, the major reason farmers have many household members is to provide farm labor. Thus the bigger the household size, the more labor is available for farming operations, hence increasing the efficiency of farmers.

Technical efficiency should increase with the farmers' level of education because being educated or being able to read or write increases the possibility of learning new farming techniques that will likely increase the efficiency of farmers. The negative coefficient of primary educational attainment indicates that farmer's education is an important variable in enhancing maize cultivation in Tabora. Previous studies obtained similar statistically significant results (Msuya and Ashimogo, 2006; Amos, 2007; Msuya et al., 2008).

The signs for the gender coefficient though not significant show that male farmers are efficient in tobacco and maize cultivation. Some studies have found similar results (Kibaara, 2005; Msuya et al., 2008). However, other studies have also reported no statistically significant results for the effect of gender on efficiency (Tchale and Sauer, 2007). Therefore, this study contributes to the ongoing debate on the role of gender in smallholder efficiency.

DISCUSSION

The issue of whether farmers are better off producing tobacco compared to other annuals and perennials has been addressed in many instances. When the earnings from tobacco are compared to the earnings from other crops such as maize, the former is much higher than the latter. This scenario is reversed when the corresponding input costs are considered. In other words, when net earning is estimated on per acre or per manpower, it appears that farmers in the study region are better off engaged in cultivating non-tobacco annual or perennial crops. Moreover, this finding does not take into consideration various health hazards associated with tobacco production.

In this study we tried to compare the production efficiency of tobacco and maize and were able to establish that producing tobacco is not a worthwhile undertaking compared to producing maize. Farmers in the Tabora region are relatively more efficient producing maize than producing tobacco.

When the determinants of efficiency were estimated for tobacco growers, the effect of tobacco curing reduces efficiency significantly. The findings from this study should enable policy makers to reconsider the prevailing notion that farmers are better off engaged in the production of tobacco and that the foreign exchange earning of the country is enhanced by producing tobacco. Many studies have already indicated that the negative health, social, economic and environmental consequences of cigarette consumption and tobacco production as being significant. In this exercise we have tried to show that inspite of preferential treatment given to tobacco farmers in terms of fertilizer, better seeds, credit and market facilities. Tobacco growers appear to be less efficient. They ought to opt for alternative crops.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

This study was supported by a grant from United States National Institutes of Health – Fogarty International Center and National Cancer Institute R01 TW009295

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Vol. 7(2), pp. 80-84, February, 2015
DOI: 10.5897/JDAE2014.0476
Article Number:D861FD349843
ISSN 2006-9774

http://www.academicjournals.org/JDAE

Journal of Development and Agricultural Economics

Full length Research Paper

Competitiveness of cocoa-based farming household in Nigeria

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Received 28 March, 2014; Accepted 20 August, 2014

Nigeria is the third largest producer of cocoa in Africa producing about 6% of the total World production. The objective of this study is to assess the competitiveness, comparative advantage and effect of government policies on cocoa production in Ondo State, Nigeria. The analysis was conducted for sole and intercropped cocoa production systems. Primary and secondary data were utilized for the study and were analyzed using the framework of the Policy Analysis Matrix (PAM). The results of the PAM indicated that the two production systems were profitable, competitive and have comparative advantage. Private profitability recorded in sole cropping was ₦69,986.13 against ₦91,246.33 that was obtained in the intercropping system. Social profitability for sole cropping was ₦121,865.14 while ₦158,989.10 were obtained in intercropping system. The values of the Nominal Protection Coefficient for output (NPCO) were 0.89 and 0.78 for sole and intercropping systems indicating that the farmers were taxed. This was further confirmed by the values of Nominal Protection Coefficient for input (NPCI) which 1.37 and 1.39 were for both sole and mixed production system respectively. Also, the Effective Protection Coefficients (EPC) for both productions were 0.72 and 0.65 respectively, indicating the presence of taxes.

Key words: Cocoa, competitiveness, farming household, policy analysis matrix, Nigeria.

INTRODUCTION

The contributions of cocoa to the Nation's economic development are vast (Olayide, 1969; Olayemi, 1973; Abang, 1984; Folayan et al., 2006) and in terms of foreign exchange earnings, no single agricultural commodity has earned more than cocoa (Nkang, 2009). The cocoa subsector offers quite a sizeable number of employments, both directly and indirectly. It is an important source of raw materials, revenue to governments of cocoa producing states and a significant contribution to the Gross Domestic Product GDP (Central Bank of Nigeria, 2007). Nigeria ranked among one of the highest cocoa producer in the world.

Nigeria is the third largest producer of Cocoa in Africa producing about 6% of the total world production behind Ivory Coast which produces 43% of the world's cocoa and Ghana with about 14% of the world's output. At present the production capacity of Cocoa in Nigeria has reached about 385,000 tonnes per annum, an increase of 215,000 t from year 2000 production level (Erelu, 2008). But with the increase in production the disposition has placed Nigeria the fourth highest cocoa producing nation in the world after Ivory Coast, Indonesia, and Ghana.

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Mainly, small holder farmers grow cocoa and these small holders whose average farmstead is 2 ha, account for about 60% of Nigeria's output (Nkang, 2009). Apart from being the major source of income for the farm families, it is raw material for the beverage industry and agro commodity marketing firms. The average delivery per farmer is less than 5 bags (roughly 300 kg ha^{-1} of cocoa) per person. In terms of capacity, Ondo State is rated as the largest cocoa producing state in Nigeria (Oluyole and Sanusi, 2005).

Cocoa is the second major non-oil foreign exchange earner in Nigeria after leather. It is produced in 16 states of the federation namely Ondo, Cross River, Oyo, Osun, Ekiti, Ogun, Edo, Kogi, Akwa Ibom, Delta, Abia, Kwara, Ebonyi, Rivers, Taraba and Adamawa with an annual production of 400,000 metric tons; however 98% of this is exported. It provides means of livelihood, sustenance and employment opportunities to over five million Nigerians, in the year 2005 alone; export revenue from the sale of cocoa amounted to US$136.7 million.

Prior to the Structural Adjusted Programme (SAP), cocoa marketing was carried out by the erstwhile highly regulated commodity marketing boards, which were known to pay farmers far less than the export price of cocoa (Folayan and Sanusi, 2007). After abolition of the marketing board structure, cocoa production has still not fared better and is evident in the declining production trend reported earlier. One of the possible reasons for this was the nature of investment in cocoa production, as some worry has been expressed as to whether the returns from cocoa were not being threatened by suchfactors as rising costs of production, price instability and differences in management systems and perhaps declining productivity due to ageing trees. Generally, if investment in cocoa production were attractive, the farmers/investors would allocate scarce resources to cocoa farming. Most individual investors and even governments have only a vague idea of the potential of the cocoa industry and as such are sometimes slow in committing investment funds into the subsector (Nkang, 2009).

MATERIALS AND METHODS

A multi-stage sampling procedure was adopted. The first stage involved purposive selection of the three local government areas known to be the largest Cocoa producing areas in the state which are Ondo, Ile Oluji and Idanre Local government area of the study area. The second stage was random selection of three villages in each local government area while the last stage was random selection of twenty Cocoa farmers in each village making total number of 180 respondents.

Data collection

Primary and secondary data were the main source of data used for this study. A structured, open-ended questionnaire was used to obtain the information from respondents in the study area. Primary data collected were cost of input used and cocoa yield obtained for both sole cocoa production and mixed production. Secondary data was collected on social cost of inputs, Free on Board (FOB) price of cocoa at international market from Ministry of Agriculture, planning, research and statistics, Central Bank of Nigeria.

Method of data analysis

The analytical tool was Policy Analysis Matrix Model (PAM). PAM model was employed to analyze comparative advantage as well as policies effect on cocoa production. Nominal Protection Coefficient (NPC) and Effective Protection Coefficient (EPC) together with Domestic Resource Cost Ratio (DRC). The PAM was developed by Monke and Pearson (1989) and augmented by Masters and Winter-Nelson (1995), for measuring input use efficiency in production, comparative advantage, and the degree of government interventions. The basis of the PAM is a set of profit and loss identities, that is, it is a matrix of two-way accounting identities (Nelson and Panggabean, 1991). Furthermore Monke and Pearson (1989) established the basic format of the PAM, as shown in Table 1.

The data in the first row of the PAM table provide a measure of private profitability. The private profitability demonstrates the competitiveness of the agricultural system. The second row of the PAM is used to calculate social profits. Social profits are those profits calculated at efficiency (shadow) prices. Positive social profit indicates that there is a positive valuation of output and is an incentive to the farmers. The third row shows the difference between the private valuation and social valuation.

If I is positive, it means the producers are paid above the world price for their output and producers do not need to sell their products to international market but to local market.

If I is negative, producers are paid lower than the world price for their output. In order to gain more profit, they can sell directly to the international market and not to local market.

If J is positive, it means the tradable inputs used in production are costly at local market and it will increase their profitability if they can import such inputs.

If J is negative, tradable inputs used are costly at international market. It is advisable to purchase inputs at local market than importing.

If K is positive, it means non-tradable inputs used in production are costly at local market.

If K is negative, it means non-tradable inputs used are cheap at local market.

If L is positive, it means it is profitable to obtain inputs at local market and sell the products at local market If L is negative; it is profitable to import inputs and sell the product at international market.

Measure of protection

Nominal Protection Coefficient (NPC)

The NPC is calculated by dividing the revenue in private prices (A) by revenue in social prices (E). It can be calculated for output and input.

$NPC_1 = P_i^d / P_i^w$

Where NPC_i nominal protection coefficient of the commodity i, P_i^d = domestic price of commodity i and P_i^w = world reference price of commodity i, adjusted to transportation, handling and marketing expenses.

In the PAM context,

Table 1. Basic format of PAM.

		Value of input		
Prices (Accounts)	**Value of output (Revenue)**	**Tradable input cost**	**Non-tradable input cost (Domestic factor)**	**Profit**
Privates prices	A	B	C	D
Social prices	E	F	G	H
Policy transfer (divergence)	I	J	K	L

Source: Monke and Pearson (1989). A = revenues evaluated at domestic prices of the output; B = Cost of Tradable Input evaluated at Domestic Price*;* C =Cost of Non Tradable Input evaluated at Domestic Price*;* D = A – (B + C) = Private Profitability*;* E = revenues evaluated at border prices of the output*;* F =Cost of Tradable Input evaluated at International Price*;* G= Cost of Non Tradable Input evaluated at International Price *;* H = E – (F + G) = Social Profitability*;* I = A – E = Output Transfers*;* J = B – F = Input Transfer*;* K = C – G = Factor Transfer*;* L = D – H = Net Policy Transfers.

NPC (on output) = A/E

NPC (on input) = B/F

If NPCO = 1, the domestic market price equals world price and therefore, there is no protection and the price is efficient. If NPCO > 1, there is positive protection of output. If NPCO < 1 there is negative protection on output. If NPCI= 1, the domestic cost of input equal world price of input. If NPCI > 1, the domestic cost of input is expensive compared to imported inputs and it is preferred to use import for production, If NPCI < 1, it is profitable to use domestic input.

Effective Protection Coefficient (EPC)

The EPC is defined as the ratio of value added in private prices to value added at social prices. It measures the ratio of value added at domestic prices (A - B) to value added at world reference prices (E - F). Conceptually this ratio can be written as:

$$EPC_i = V_i^d / V_i^w$$

Where, EPC_i = Effective protection coefficient of commodity I; V_i^d = Value added at domestic prices and V_i^w = Value added at world reference prices.

Using PAM elements, EPC = (A – B) / (E – F), If EPC > 1, means net subsidy to value added, If EPC < 1 means net tax to value added, If EPC = 1 means no value added.

The EPC ignores the transfer effects of factor market policies like NPC.

Data for calculating efficiency prices of land, labour and capital

The major tradable inputs are seedlings, fertilizers, chemicals. The non-tradables are land, labour etc, and other production costs goes to land and labour which are non tradable inputs. For sole cropping system, this study used an average yield of 404.94 kg/ha while average yield of 243.44 kgs/ha was used for mixed cropping. The sole cropping system comprised of 898 cocoa trees per hectare, while in intercropping system, there is 500 trees of cocoa with a total of 550 stands of plantain and banana per hectare.

The PAM constructed for this study made use of farm level budget value obtained from two production system (sole and intercropping system). In order to compute social price of input and output, world reference price and subsidized prices were used. The FOB price was obtained from international trade statistics, 2010. The world prices was adjusted for transportation and handling cost in order for it to be comparable to world prices.

According to Yao (1993), the social valuation of labour was obtained by dividing labour into peak season and off peak season components and the wage rate of labour in the peak season is the opportunity cost of labour for the period considered. The opportunity cost of labour in the off season is half the prevailing wage rate. Therefore social price of labour is:

$$SP_L = \frac{Wp + 0.5Wo}{2}$$

SP_L = social price of labour; Wp = prevailing wage rate in peak season, and Wo = prevailing wage rate in off season

The study makes use of ₦930 as the private cost of labour which is the average cost of labour obtained from farmers. Social price of land was obtained by using the government rental value on land. Private costs of tradable input used were obtained from market and agro allied shops. For the tools used in production, the depreciation cost was calculated by assuming salvage value to be zero. The average cost of such tools less salvage value divided by the average life span was used to get the depreciation for tools used in production. This study made use of US$3250 for the output which was the average of the price for both systems. The intercropped products were also valued by making use of Cameroon price. Banana is US$200 per tonne, plantain is US$150 per tonne while pineapple is US$0.38 per kilogram. All these cost were converted to Naira and the handling cost, transportation to port and charging cost were deducted before they were used in the analysis.

RESULTS AND DISCUSSION

Competitiveness of cocoa production

The study examined two cocoa production systems (Sole Production and Mixed Production in Ondo State, Nigeria). The result of the analysis (Tables 1 and 2) showed that cocoa production system is profitable and highly competitive in the two systems of production due to private

Table 2. Policy analysis matrix for sole cocoa production system.

Item	Revenue (₦/ha)	Cost of tradeable Inputs (₦/ha)	Domestic factors (₦/ha)	Profit (₦/ha)
Private price	174,630.38	70,443.16	34,201.09	69,986.13
Social price	195,383.55	51,253.89	22,264.52	121,865.14
Effect of policies and other divergences	-20,753.17	19,189.27	11,936.57	-57,879.01

Source: Field survey, 2011.

Table 3. Policy Analysis Matrix for Mixed Cocoa Production System

Item	Revenue (₦/ha)	Cost of tradeable Inputs (₦/ha)	Domestic factors (₦/ha)	Profit (₦/ha)
Private price	169241.52	54198.88	23791.31	91,246.33
Social price	215793.13	38918.35	17885.68	158989.10
Effect of policies and other divergences	-46,551.61	15280.53	5910.63	-67,742.77

Source: Field survey, 2011.

profitability that are positive in the two systems. The private profitability recorded in sole cropping was₦69, 986.13 while ₦91, 246.33 was recorded in the intercropping system. However the result showed that intercropping system was more profitable than sole cropping system. This may be through the advantage of having other products apart from cocoa beans which increased income for mixed cocoa producers. This agreed with findings of Neptune and Jacque (2007), they found out that cocoa production is profitable, internationally competitive and had comparative advantage in Trinidad and Tobago.

Social profitability is also positive in the two systems studied. The social profitability recorded in sole cropping was ₦121,865.14 against ₦158,989.10 that was recorded in the intercropping system. At the social profit, mixed cropping has edge over sole cropping due to its highest profit. The positive social profit indicates that the state is using scarce resources efficiently in the production. The positive social profit means that the domestic resources are been efficiently utilized in the production of Cocoa.

Similarly, the output transfer was negative. The output transfer for sole production was - ₦20,753.17 while - ₦46, 551.61 was recorded for mixed production. This shows that producers were receiving a price lower than what could have earned at international market. Input transfer was positive in the two systems. Tradable input transfer was ₦19,189.27 and ₦15,280.53 for the sole and intercropping system indicating that the farmers are paying more for the input compared to what is obtained in the international market. The non tradable transfer for both systems was ₦11,936.57 and ₦5,910.63 for sole and intercropping system. The profit transfer for both system were negative - ₦5, 7879.01 was recorded for sole production while - ₦67,742.77 was recorded for intercropped system. This shows the amount producers are earning is less than what is obtained in the international market**.**

Summary of the ratio of protection coefficient of Cocoa production are shown in Table 3. The result reveals that the Nominal Protection Coefficient for output in the two production system is less than one. NPCO for sole production was 0.89 while 0.78 was obtained for the intercropped system. This indicates that there is negative protection of output. This also implies that domestic farm gate price is less than the international price for cocoa and policies are decreasing the market price by 0.11 and 0.22 for sole and intercropping system below the international price respectively.

The Nominal Protection Coefficient on input is greater than one. NPCI for sole was 1.37 and 1.39 for intercropped system. This indicates that policies increase tradable input cost by 37% for sole and 39% for mixed system above world prices. It also means that producers were taxed.

The effective protection coefficients were less than one in both productions (Table 4). EPC for sole system was 0.72 and 0.65 for mixed system; this indicates that producers were taxed with 26% and 33% on value added at world reference prices.

The output transfer for both sole and intercrop system were - N20753.17 and - N46551.61. Tradable inputs transfer were N19189.27 and N15,280.53 for both sole and intercrop system. Non tradable input transfers for sole and mixed system were N11,936.59 and N5,910.63. The indicators of policy effects and comparative advantage result for both systems were recorded as follows: NPCO was 0.89 and 0.78 for sole and intercrop system, NPCI was 1.37 and 1.39 for sole and intercrop system. EPC was 0.72 and 0.65 for sole intercrop system. DRC was 0.15 and 0.10 while SCB was 0.38 and 0.26 for sole and intercrop system.

Table 4. Four indicators of policy effects and comparative advantage.

Indicator	Sole production	Mixed production
Nominal protection coefficient of output (NPCO)	0.89	0.78
Nominal protection coefficient of input (NPCI)	1.37	1.39
Effective protection coefficient (EPC)	0.72	0.65
Private profitability (N)	69986.13	91246.33
Social Profitability (N)	121865.14	158989.10
Domestic Resource Cost (DRC)	0.15	0.10
Social Cost-Benefit Ratio (SCB)	0.38	0.26

Source: Field survey, 2011.

Conclusions

1. Cocoa production is privately and socially profitable in the study area.
2. There is negative protection on output and policies are decreasing the market price below international price.
3. Policies also increase tradable input costs which shows that producers were highly taxed on tradable inputs purchased. Farmers were also taxed on value added at World Reference Price.

RECOMMENDATIONS

1. Replacement of aging cocoa plantation.
2. Increased planting density per hectare should be encouraged.
3. Incentives for improving productivity (e.g improving public and farm infrastructure) will help farmers to boost their income.
4. Policy on tax for tradable input have to be reviewed in a way that farmers will be compensated for their production.
5. Government intervention is needed in raising commodity price to world price level which will reduce the poverty level of farmers in the country.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

Authors are grateful to Mr Adenowuro of the Ministry of Agriculture and Natural Resources. Also to High chief Oruwa Balogun of farmers congress Akure, Ondo State for their contribution towards the success of this work.

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