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ARTICLES

Full Length Research Paper

Determinants of postharvest losses in tomato production in the Offinso North district of Ghana

Robert Aidoo*, Rita A. Danfoku and James Osei Mensah

Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

The aim of this study was to examine the determinants of postharvest losses in tomato production in the Offinso North district of Ghana. A standardized structured questionnaire was used to collect data from 150 farmers who were selected through a combination of purposive and simple random sampling techniques. We used descriptive statistics to summarize the characteristics of the respondents. Multiple regression analysis was conducted to examine the determinants of postharvest losses in tomatoes. A typical tomato farmer in the district was found to be a male of 44 years, married, with a household size of five and had attained basic level of education. On average, farmers cultivated tomatoes on a farm size of about 5 acres and had about 20 years of farming experience. The study showed that farmers obtained 1,159.21 kg of tomatoes in the major season and 962.78 kg in the minor season on an acre of land, out of which 40 and 14% were lost, respectively. From the perspective of the farmers, the primary sources of losses were rot and bruises caused by poor handling, diseases and pest attack. From the regression analysis, gender of the farmer, household size, farm size, days of storage, membership of Farmer Based Organization (FBO) and type of tomato variety cultivated were found to significantly influence the level of postharvest losses incurred. Female gender, farm size and days of storage were found to be positively associated with losses in tomato production. However, household size, membership of FBO and cultivation of improved varieties were found to reduce postharvest losses*, ceteris paribus*. Lack of storage facilities, high cost of production and limited access to credit were found to be the critical constraints faced by tomato farmers. The study recommended the formation and joining of FBOs, periodic training and education of farmers on the cultivation of improved varieties of tomatoes as well as training on proper handling of tomato fruits to reduce postharvest losses.

Key words: Tomato, postharvest losses, regression analysis, Ghana.

INTRODUCTION

Tomato is an important cash crop in the forest, transitional and savannah zones of Ghana (Norman, 1992). It forms a very important component of food consumed at the household level as evident in the fact that many Ghanaian dishes have tomatoes as a component ingredient (Tambo and Gbemu, 2010). Tomato production is a source of livelihood and income for a greater number of people in the Offinso North

district in Ghana as well as agents involved in its distribution and marketing throughout the country.

Vegetables like tomato are usually harvested when they are fresh and high in moisture and are thus distinguished from field crops, which are harvested at the mature stage for grains, pulses, oil seeds or fibre. This high moisture content of such vegetables makes their handling, transportation and marketing a special problem particularly in the tropics (Sablani et al., 2006).

The quality and nutritional value of fresh produce like tomato are affected by postharvest handling and storage condition (Sablani et al., 2006). Tomato losses can be caused by a wide variety of factors, ranging from growing conditions to handling at retail level. Many postharvest losses are direct result of factors such as high field temperatures on crops before harvesting, pests and diseases attack, among others.

In Ghana, there has been serious attempt at improving the production capacities of farmers to increase tomato production (Yeboah, 2011). However, the sector is plagued with huge levels of post-harvest losses. Robinson and Kolavalli (2010) indicated in their research report that postharvest losses are highest for tomatoes and lettuce which record up to 20% after 5 days of harvesting. Out of the 510,000 metric tons of fresh tomato fruits produced annually in Ghana, the country losses about 153,000 metric tons (30%). In 2011, the Offinso-North district produced about 19,550 metric tons of tomatoes but lost about 31% due to postharvest losses (MoFA, 2011).

The tomato production sector in Ghana has failed to reach its maximum potential in terms of yields as compared to other countries as well as improving the livelihoods of those households involved in the production of the crop. Average yields remain low, typically under 10 tons/ha, due partly to postharvest losses (Robinson and Kolavalli, 2010). Not only are these losses clearly a waste of food, but they also represent a waste of human effort, farm inputs, and scarce resources such as water (World Resource Institute, 1998).

Many factors have been hypothesized in the professional literature to be very important determinants of postharvest losses in tomato. Inappropriate storage facilities and rough handling during harvesting result in bruising and increased possibilities of contact of the produce with the soil which leads to contamination with organisms. Long distances from farms to markets as well as insufficient storage conditions can lead to losses to the tomato produce (Chandy, 1989). Adarkwa (2011) reported that improper harvest and postharvest practices result in losses due to spoilage of the product before reaching the market, and loss of quality attributes such as appearance, firmness, taste and nutritional value. A study by Babalola et al. (2010) showed that the longer the distance from farm to the market, the greater the losses experienced due to congestion of the tomato fruits and the resultant build-up of heat. Mujib et al. (2007) also

noted that type and quantity of labour used in harvesting played a vital role in postharvest losses. Skilled labourers pick and handle the produce with care and hence do little damage to the fruit. They, therefore, recommended the use of trained labourers if postharvest losses are to be minimized. Tomato fruits should be harvested at mature green state for long distance marketing and full ripen stage for fresh consumption in order to reduce postharvest losses (Moneruzzaman et al., 2009). The variety of tomato cultivated affects the level of postharvest losses experienced by farmers as different varieties have different characteristics such as firmness, disease resistance, among others, which impact on postharvest losses. Orzolek et al. (2006) recommended that tomato producers should harvest mature fruits in the morning when the temperature is cool to reduce losses.

In Ghana, attempts at explaining the underlying causes of postharvest losses in tomato production have largely remained in the realm of speculation and conjecture. However, empirical information on the main causes of these losses are required if solutions are to be found for this critical problem in tomato production. Therefore, this study was designed to examine empirically, the factors that influence the level of postharvest losses of fresh tomatoes at the farm level. Specifically, the study sought to determine the level of postharvest losses experienced by tomato producers and the key factors that account for these losses.

METHODOLOGY

Study area

The study was conducted in the Offinso North district of the Ashanti Region of Ghana. Offinso North is located in the extreme North-Western part of the region and lies within longitude 1°45'N and 1°65'W. The district has a population of about 56,881 (GSS, 2010), with a total land area of 1,008.3 km². The current farming population is around 30,000 comprising 15,030 males and 14,970 females. The district lies within the wet semi-equatorial zone of Ghana with a bi-modal rainfall regime and a mean monthly temperature of 27°C. Offinso North district is the leading tomato producing district in the Ashanti region. Tomato is grown all over the district with heavy concentration at Akomadan, Afrancho, Nkenkaasu, Asuoso, Nsenua and Mantukwa communities. The average annual production is over 19,000 metric tons of tomato fruits. Each year over 30% of tomato fruits goes waste with some farmers refusing to harvest due to very low market price for the commodity. Total land area under tomatoes cultivation is estimated at about 20,049 ha. Tomato is produced throughout the year in the district in valley bottoms and with small scale local irrigation schemes (MoFA, 2011).

Method of data collection and analytical procedure

Primary data was obtained from tomato farmers through personal interviews with the use of a standardized structured questionnaire. In consultation with Agricultural Extension Agents (AEAs) at the district, a list of communities noted for tomato production was prepared and a simple random sampling technique was used to

Table 1. Summary statistics of the socioeconomic characteristics of respondents.

Variable	Minimum	Maximum	Mean	Std. deviation
Age (years)	19.00	62.0	44.00	9.44
Household size	1.00	13.00	5.00	1.82
Years of education	0.00	19.00	5.00	4.16
Annual income (GH₵)	478.00	8000.00	3303.40	1880.45
Farm size (Ha)	0.20	8.00	2.12	1.84
Land owned by household (ha)	0.00	18.00	7.75	4.68

Source: Survey Data (2013).

select six communities including: Akomadan, Afrancho, Nkenkaasu, Asuoso, Nsenua and Mantukwa. A list of tomato producers at the community level was obtained and a systematic random sampling technique was used to select 25 farmers from each community. The questionnaire used for the interview sought information on general characteristics of respondents, production information, postharvest losses and constraints faced by tomato producers. Interviews were done in the local language in order not to create any language barrier. Key informant interviews (with Agricultural Extension officers and Researchers at Crops Research Institute) were also conducted to gather technical information on tomato production in order to verify and validate the accuracy of some information supplied by farmers.

Descriptive statistics such as arithmetic mean, standard deviation as well as frequency distribution tables and charts were employed to summarize the characteristics of the respondents. Economic value of fresh tomato fruits lost was obtained by multiplying the physical quantity of fruits lost by the average prevailing market price. Multiple regression analysis was employed to determine the main factors that influence postharvest losses. The model used was specified in the double logarithmic form as:

$$Ln\ PHL = b_0 + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 + b_4 LnX_4 + b_5 Ln\,X_5 + b_6\,Ln\,X_6 + b_7\,LnX_7 + b_8\,LnX_8 + \mu$$

Where Ln denotes natural logarithm; PHL = postharvest losses (kg); X_1 = time of harvest after maturity (days); X_2 = type of labour used for harvesting (1 = family labour; 0 if otherwise); X_3 = time between harvesting and selling of produce (days); X_4 = variety of tomato grown (1 = if Improved variety; 0 if otherwise); X_5 = farm size (acres); X_6 = distance from farm to market (km); X_7 = member of Farmer Based Organization (FBO) (1 = Yes; 0 = No); X_8 = Quantity of fruits harvested (kg); μ = error term.

The double logarithmic functional form is usually preferred in empirical analysis since coefficients are easy to interpret; it also has the added advantage of reducing the incidence of multicolinearity. The model was estimated using the ordinary least squares method. A five-point likert scale was used to assess the constraints faced by tomato producers in the district.

RESULTS AND DISCUSSION

Characteristics of farmers

Tomato production in the Offinso district was found to be dominated by males; only 23% of the respondents were females. However, most of these males work together with their spouses on their tomato farms. A typical tomato farmer was found to be about 44 years, with basic level of education and a household size of five people (Table1). Out of about 7.6 ha of farm land owned by a typical farmer, about 2.1 ha were put under tomato cultivation, implying that farmers are largely small to medium scale producers. Annual income at the household level was estimated to be GHC3303.40 (US$1573.05) which translates to about GHC660.68 (US$314.61) per capita per annum. It can be inferred from the figure that on average tomato farmers are quite poor since they live under US$2.00 per day per capita.

Causes of postharvest losses

Farmers were provided with several options to select the main cause of postharvest losses in tomato production. From their ranking, postharvest losses resulted largely from rot and bruises (mechanical damage) which were mainly caused by on-farm activities (Figure 1). Farmers reported that rot resulted from over-use of spraying chemicals (herbicides and insecticides), excess watering and contact of fruits with the soil. Bruises, however, resulted from poor staking and poor handling during harvesting and sorting. From the perspective of the farmers, the three most critical secondary factors that impacted heavily on postharvest losses in tomato production were lack of ready market for produce, unreliable means to transport produce to market and longer distances from producing centres to market centres (Table 2). It can be inferred from the table that farmers consider marketing issues as the main cause of postharvest losses in tomato production. Things within their control such as time of harvest, type of variety grown and harvesting technique adopted were rather considered to have low or minimal impact on postharvest losses.

Analysis of tomato output, revenue and postharvest losses

Table 3 summarizes information on production, losses and revenues obtained from tomato production during the 2012 cropping season (Detailed results are in the Appendix). The results indicate that the average land
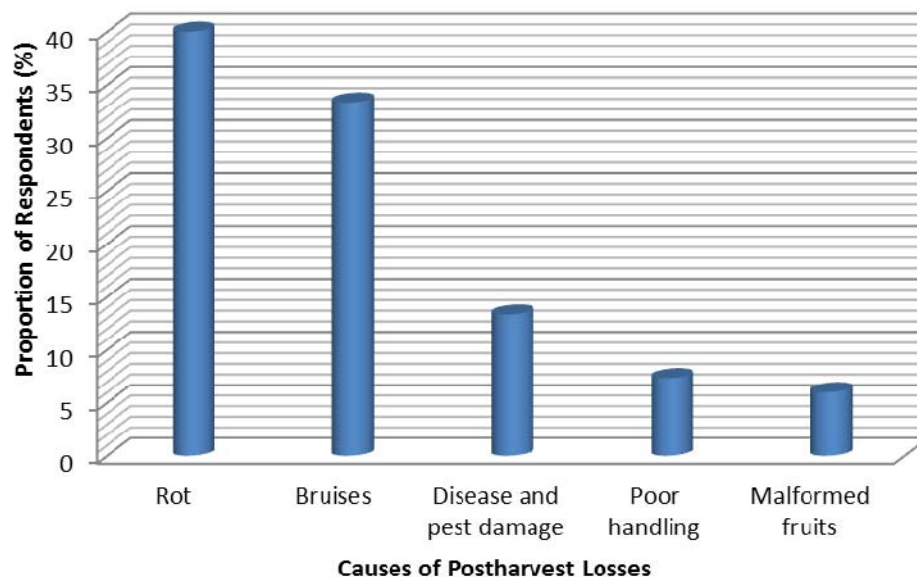
Figure 1. Primary causes of postharvest losses in tomato production. **Source:** Generated from field data (2013).

Table 2. Contribution of secondary factors to postharvest losses.

Factor	Very high (5)	High (4)	Moderate (3)	Low (2)	Very low (1)	Mean score	Rank
Lack of market avenue	91	44	14	1	-	4.50	1st
Unreliable means of transport	21	65	48	14	2	3.59	2nd
Longer distance to market	6	67	48	22	7	3.30	3rd
Untimely harvest	3	45	75	24	3	3.14	4th
Type of variety used	14	18	92	26	-	3.13	5th
Poor harvesting technique	15	33	66	27	9	3.12	6th

Source: Generated form field data (2013).

Table 3. Analysis of tomato output and postharvest losses for the 2012 cropping season.

Variable	Major season	Minor season
Land area (ha)	2.12	2.02
Output (kg)	6,143.80	4,871.68
Quantity of output lost (kg)	2,437.46 (39.7%)	690.83 (14.2%)
Quantity sold(kg)	3,706.34	4,180.77
Unit price (GH¢ /100 kg)	56.51	97.33
Revenue obtained (GH¢)	2,094.45	4,069.22
Value of losses (GH¢)	1,377.41	672.39
Potential revenue (GH¢)	3,471.86	4,741.61

Source: Generated from field data (2013).

area put under tomato cultivation was about 2 ha during both major and minor seasons. On average, the total output of fresh tomato obtained in the major season was 6,143.80 kg compared to 4,871.68 kg in the minor season. Average yield was estimated at 2,898 kg/ha for major season and 2,412 kg/ha for the minor season. Quantity of output lost during the major season was 2,437.4 kg and its value in monetary terms was GH¢
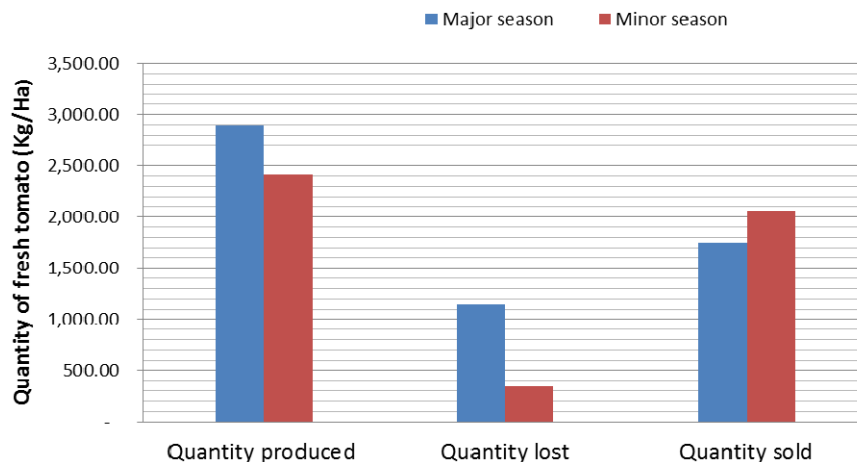
Figure 2. Analysis of tomato yield and postharvest losses per hectare. **Source:** Generated from field data (2013).
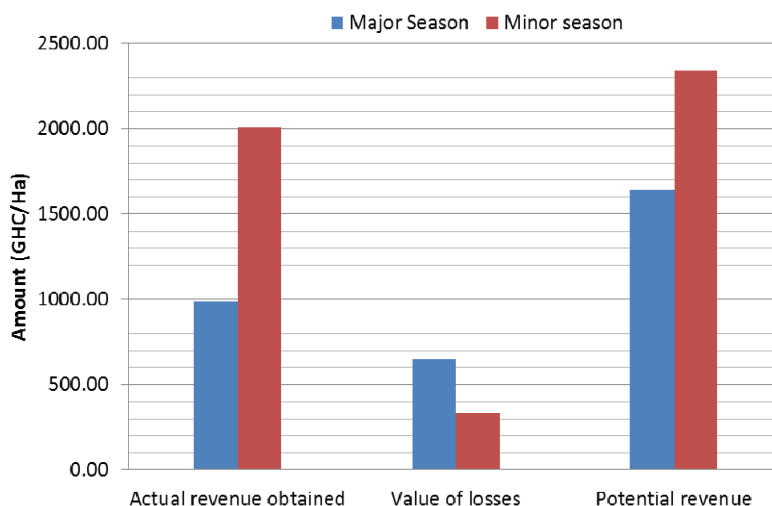
Figure 3. Analysis of actual and potential revenue from a hectare of tomatoes. **Source:** Generated from field data (2013).

1,377.41. This represents a loss of 40% of the harvested produce. Quantity of output lost during the minor season was 690.83 kg, which was valued at GH¢ 672.39, representing about 14% of the harvested produce. On average, quantity sold during the major season was found to be 3,706.34 kg valued at GH¢ 2,094 and that for the minor season was 4,180.77kg at a value of GH¢ 4,069.22.

Potential revenue that could have been generated in the absence of postharvest losses was estimated at GH¢ 3,471.86 for the major season and GH¢ 4,741.61 for the minor season. This means that farmers lost about 40% of the potential revenue from tomato production during the major season and 14% during the minor season.

Figures 2 and 3 indicate that on per hectare basis, quantity of tomato fruits lost during the major season was about 1,150 kg, valued at about GHC649.72. In the minor season, only about 341 kg of tomato fruits (valued at GHC332.21) was lost per hectare cultivated. This implies that due to postharvest losses, tomato farmers received only 60% of the potential revenue during the major season and 86% during the minor season per hectare (Figure 3).

Determinants of postharvest losses

Table 4 gives a summary of the results obtained from the multiple regression analysis. The adjusted coefficient of determination (R^2) was 0.42 indicating that 42% of the variation in the quantity of tomato fruits lost during and after harvesting was explained by the specified variables

Table 4. Regression estimates of the determinants of tomato losses.

Variable	Coefficient	Std. error	t	p>t
Constant	6.0879***	0.2463	24.72	0.000
Gender (1 = male; 0 = female)	-0.2675***	0.0951	-2.81	0.006
Ln Household Size	-0.0638**	0.0242	-2.63	0.010
Ln Education (years.)	0.0158	0.0117	1.35	0.181
Ln Farm size	0.0312**	0.0147	2.12	0.036
Ln Days to storage	0.0551**	0.0243	2.27	0.025
Ln Extension contact (per month)	-0.0145	0.0132	-1.10	0.276
Membership of FBO (1 = yes 0 = no)	-0.6081***	0.0988	-6.15	0.000
Ready market (1 = yes; 0 = no)	-0.0978	0.1097	-0.89	0.374
Ln Distance to market	0.0049	0.0151	0.32	0.744
Improved variety (1 = Yes; 0 = No)	-0.1505*	0.0884	-1.70	0.091

R^2 = 0.424; F= 9.78; (Significant at 1%); SER = 0.127 (*, ** and *** denote 10, 5 and 1% significant levels, respectively)
Dependent variable: $Ln\_$ quantity of tomato fruits lost.

in the model. The F-statistic was found to be significant at 1%, which implies that all the explanatory variables had a significant joint impact on the level of tomatoes lost after harvest.

Gender and household size were the demographic variables that had a significant effect on postharvest losses in tomato production. Female farmers were found to be more prone to high levels of losses than their male counterparts. This contradicts the findings of Babalola et al. (2010) who concluded that there was little or no gender inequality in tomato farming and hence no effect of gender on postharvest losses. Tomato harvesting is very labour intensive. Generally, male-headed households tend to have many man-hours available and more time for tomato harvesting and other farm activities compared to their female counterparts who are naturally not too strong but also have household/family responsibilities to attend to. All things being equal, women tend to use longer period for fruit harvesting which then causes high levels of postharvest losses.

Household size was found to have a significant negative relationship with the level of postharvest losses incurred. Farmers who had larger household sizes tended to have lower levels of postharvest losses because they have relatively high amount of family labour that help with tomato harvesting for the process to be faster and efficient, *ceteris paribus*. Farm size had a significant positive effect on the level of postharvest losses recorded by farmers. Larger farms usually have higher output levels which require high amount of labour for harvesting and carting. When the household has labour constraint and there is a little delay from traders, huge volumes of tomato fruits are usually lost by farmers. This finding is consistent with findings of Babalola et al. (2010) who reported that the larger the area put under cultivation the higher the quantity harvested and chances of losses due to poor handling and lack of proper storage. Increase in the quantity of fruits to be harvested as

a result of larger farm size results in increase in postharvest losses because of poor storage facilities and the high labour requirement to carry out the harvesting on time.

The number of days harvested tomato fruits are stored till time of sale was also found to have a significant positive effect on losses experienced. This is consistent with a *priori* expectation because tomato is highly perishable due to its shorter shelf life. Membership of FBO had a negative correlation with the level of postharvest losses incurred. This means that farmers who join or are members of FBO's have lower probability of experiencing postharvest losses as they link up with trader associations who buy their produce after harvesting. Babalola et al. (2010) also noted that farmers who join agricultural cooperatives would obtain some form of assistance in selling their produce and invariably have lower postharvest losses.

Cultivation of improved varieties (that is, improved *zuarungu* and *pectomech*) was associated with lower levels of losses as these varieties have certain advantageous qualities that the local varieties do not have. Such qualities as firmness, disease resistance, longer shelf life and thick skin help the fruits to withstand pressure during harvesting and maintain quality during storage. This finding is in consonance with the finding by Moneruzzaman et al. (2009) who noted that the variety of tomato cultivated goes a long way to indicate the level of postharvest losses experienced by a farmer.

Constraints faced by tomato producers

Table 5 shows that tomato producers in the study area face a number of challenges. On a five-point Likert scale, lack of storage facility was ranked as the most important and critical constraint facing tomato producers in the Offinso North district. Overall cost of tomato production

Table 5. Constraints in tomato production.

Constraint	Very high (5)	High (4)	Moderate (3)	Low (2)	Very low (1)	Mean	Rank
Lack of storage facilities	115	30	4	5	-	4.8	1st
High cost of production	78	51	15	5	1	4.3	2nd
Limited access to finance	47	77	21	5	-	4.1	3rd
Lack of market	25	79	38	8	-	3.8	4th
Unreliable transport	18	66	47	18	1	3.5	5th
Lack of technology	12	30	80	28	-	3.2	6th

Source: Field survey (2013).

was considered to be very high and therefore, ranked as the second most important constraint faced by farmers. Farmers considered limited access to finance/credit as the next important production constraint. A survey by MoFA (2011) also indicated that lack of storage facilities, high cost of production, limited access to finance, unreliable transport and lack of technology were serious constraints that tomato farmers in Ghana are faced with.

Conclusion

The study has shown that postharvest losses are very significant in tomato production in the Offinso North district. The male gender, household size, membership of FBOs and cultivation of improved varieties (*pectomech* and improved *zuarungu*) were associated with lower levels of postharvest losses. However, farm size and number of days the produce is stored before sale were found to be associated with higher levels of postharvest losses in tomato production. Largely, a number of the underlying causes of the huge losses are within the control of the tomato farmer. When these factors are managed well, there will be reduction in postharvest losses, and food availability would be increased without necessarily cultivating an additional hectare of land. Through formation of FBOs, farmers can establish small processing centres that would process tomato into purees and other alternative products when there is no ready market for the fresh fruits. The extension unit of the Ministry of Food and Agriculture should sensitise and create awareness about the improved tomato varieties available (that is, *pectomech* and improved *zuarungu*) to increase their adoption rate in order to minimise postharvest losses. Farmers should be encouraged to stager production/plan production in stages to allow for harvesting in stages which comes with reduced labour requirements and reduced postharvest losses. Periodic training in harvesting and proper handling of harvested tomato fruits should be organized for farmers. Private entrepreneurs should also be encouraged to invest in the tomato industry by building appropriate cold storage facilities at the district level to help farmers store their harvested produce before they are taken to the market. This will help reduce losses that occur at the farm level.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Full Length Research Paper

Willingness to pay for irrigation water and its determinants among rice farmers at Doho Rice Irrigation Scheme (DRIS) in Uganda

Namyenya Angella[1], Sserunkuuma Dick[2]* and Bagamba Fred[3]

Department of Agribusiness and Natural Resource Economics, School of Agricultural Sciences, Makerere University, P. O. Box 7062, Kampala Uganda.

The government of Uganda is currently rehabilitating its irrigation schemes. The largest of these is Doho Rice Irrigation Scheme (DRIS), where farmers will after rehabilitation bear the costs of its maintenance through payment of user fees. This study analyzes farmer's willingness to pay (WTP) user fees and its determinants, using data gathered from 200 rice farmers at DRIS in 2012. The contingent valuation (CV) bidding game approach and Ordinary Least Squares (OLS) methods were used to elicit WTP and analyze the determinants of WTP, respectively. The study findings show that while farmers are willing to pay Ush 20,000 (USD 8)/acre/season on average, Ush 15,000 (USD 6) acre/season is actually needed to cover maintenance costs as per the 2013/2014 work plan for DRIS. The study recommends charging Ush 15,000/acre/season, however, which not only generates sufficient revenue to cover the maintenance costs, but also lies below the average WTP, which several farmers should be willing to pay without coercion. However, because not all farmers are willing to pay Ush 15,000, it is necessary to incentivize voluntary payment and strong enforcement of penalties against non-payment among those with low WTP. The OLS regression results suggest need for additional intervention that enhances private benefits to farmers, such as improved access to credit, markets and training in soil/water management and rice growing.

Key words: Irrigation water, user fees, willingness to pay, rice, Uganda.

INTRODUCTION

Uganda has of late witnessed erratic rainfall seasons (MWE, 2007) and increasing occurrence of drought conditions which has frustrated rain-fed agriculture and rendered irrigation investment critical for increased agricultural production in Uganda (MAAIF, 2012).

Consequently, the government of Uganda (GOU) has prioritized rehabilitation of the existing irrigation schemes whose infrastructure broke down over a long period of misuse and poor maintenance (MWE, 2012a; MWE, 2009). Currently, the schemes under rehabilitation include

Doho, Mubuku and Agoro irrigation schemes in Butaleja, Kasese and Lamwo districts, respectively (MAAIF, 2012). Construction of the major irrigation schemes in Uganda started in the 1960's. Doho Rice Irrigation Scheme (DRIS) in particular was constructed between 1976 and 1985 by the GOU to promote rice production in eastern Uganda through the provision of irrigation water,improved rice seeds, farm tools, marketing and milling services. Following its completion, the GOU partitioned DRS into ten blocks covering a total area of 1,012 ha; and each block was partitioned into smaller plots (0.10 to 0.40 ha) that were leased to individual farmers on a first come, first served basis. GOU retained the role of maintaining the irrigation structures through the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) up until the early 1990s (MWE, 2012b). During this period, the irrigation and drainage channels were regularly de-silted by the GOU which enabled sustainable flow of irrigation water to the rice fields.

However, driven by budgetary constraints around 1994 and examples of successful collective action in irrigation water management in other parts of the world (Meinzen-Dick et al., 2000), the GOU withdrew its support[1] and devolved management of the irrigation scheme to Doho Rice Scheme Farmers' Association. The association adopted an earlier resolution made by farmers, district officials and local leaders, which required all farmers to pay an irrigation user fee of Ush 5,000 (USD 5.1)[2]/acre per season towards the cost of mechanized de-silting of the irrigation and drainage channels. In addition, farmers were required to contribute labor towards the collective cleaning and weeding of the channels. A committee composed of an elected Chairperson and 10 block-level executive members and counselors was set up to collect user fees; mobilize farmers for the collective cleaning of the channels; and monitor collective action on each block. A bylaw was enacted stating that those who did not comply with user-fee payment or participate in collective channel maintenance in any cropping season would have their plots of land withdrawn from them the following two seasons and rented out to willing farmers, and the money realized would go toward the cost of maintaining the scheme.

However, following the devolution of management from the GOU to the farmers' association, a collective action problem arose and hindered achievement of the desired outcome of adequate supply of irrigation water to rice plots through collective effort. This was attributed to shortage of funds to de-silt the channels caused by the failure of farmers to comply with the by-law requiring each farmer to pay the irrigation user-fee and participate in collective channel maintenance, coupled with poor

enforcement of this bylaw[3]. Literature shows that only two thirds (66%) of the farmers at DRIS fully complied with the bylaw on user-fee payment in 2001 (Sserunkuuma et al., 2009) and only about 40% of the irrigation fees are collected on average. In addition, active participation by farmers in collective channel maintenance is limited and the penalty of barring obstinate farmers from growing rice on their plots for the following two seasons is rarely enforced (Nakano and Otsuka, 2011).

The main factors emasculating compliance were found to be poor awareness of the bylaw and the associated benefits; poor enforcement of the bylaw[4]; and the negative perception by farmers of the private benefits they derived from compliance. One fifth to one quarter of the farmers surveyed in 2001 perceived the private benefits derived from the scheme not to be worth the cost incurred; and the study found a significant negative relationship between compliance with the bylaw and the perception that benefits of compliance are lower than the costs.

This negative perception was caused by the extensive silting of the channels, which significantly reduced water conveyance to some rice fields. The lack of sufficient incentives (in form of water supply) for payment of user fees partly explains why one-third of the farmers did not comply with the user-fee bylaw (Sserunkuuma et al., 2009). Failure to adequately de-silt the channels had set up a cycle of failure in which an insufficient number of farmers paid user fees in a given season, which translated into inadequate de-silting of the channels, which in turn lowered the amount of irrigation water supplied to the rice plots, limiting rice yields and farmers' ability and willingness to pay (WTP) the user fees in the following season.

To break this cycle, rehabilitation of the entire irrigation system was recommended to increase water supply to farmers and improve rice yields on their fields as well as their willingness and ability to pay the user fees. In accord with this recommendation, GOU has since October, 2011 embarked on the rehabilitation and revitalization the irrigation scheme at Doho as well as those at Mubuku and Agoro. After completion of the rehabilitation process, the responsibility of maintaining the scheme at Doho will again revert to the farmers (MWE, 2012b); and it is envisaged that a user fee will be charged per acre per season to raise funds for operating and maintaining the irrigation scheme. Poor awareness and enforcement of the user-fee and collective action bylaw at Doho and the associated poor compliance

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[1] except for payment of salaries of a few staff like irrigation engineers and agricultural extension agents

[2] The official average mid-rate for 1994 is Ush 979 to 1USD.

[3] To manage irrigation facilities effectively and allocate water resources efficiently, it is critically important to enforce the rules of water allocation and maintenance of irrigation channels and drainages (Ostrom, 1990).

[4] The administration at DRIS attributes poor bylaw enforcement to the physical characteristics of the irrigation system, with no means of blocking water supply to individual defaulters as a way of incentivizing them to pay the user fees. For similar reasons, it is not possible to levy user fees based on the volume of water received.

cited above can be attributed to the manner in which the bylaw was enacted, with limited involvement, sensitization and consultation of farmers, which led to low farmer buy-in.

Nkonya et al. (2001) observe that it is difficult to effectively enforce and educe compliance with bylaws that are not clearly understood or ratified by farmers. With the impending transfer of management responsibility to farmers after rehabilitation of DRIS and the accompanying need for farmers to contribute towards the maintenance costs, it is imperative to determine how much farmers are willing to contribute; and to use this information to guide the setting of appropriate user fees.

This study was undertaken with the objective of determining farmers' WTP user fees; and how this varies across rice farmers at DRIS. The study shows that while the provision of private incentives to farmers is important for improved management of devolved irrigation schemes, it is not a panacea but must go hand in hand with strong enforcement of penalties against free riders, and investment in provision of supporting services that enhance the private benefits to farmers. While this study shows that education attainment enhances farmers' willingness to contribute money towards maintenance of the irrigation scheme at DRIS, available literature shows that education emasculates willingness to participate when farmers are required to contribute labor.

WTP is a commonly used Contingent Valuation Method (CVM) approach for valuing goods and services that are not traded in the markets, including natural resources and resource services (Lipton et al., 1995) such as water for household use and irrigation; amenities such as national parks; and private non-market commodities such as reductions in the risk of death or days of illness avoided. It is the economic value of a good to an individual (Yang et al., 2007) or the maximum sum of money an individual is willing to part with in exchange for an increase in the quantity or quality of a natural resource good or service (Agudelo, 2001).

Akter (2007) estimated the value of irrigation water in a small scale irrigation project in the Homna sub-district in Bangladesh. He used CVM to elicit farmers' WTP for the irrigation water, using irrigation charges per decimal land area per cropping season as the payment vehicle. He found the mean WTP to be 1670 Taka (US$ 27.83) per kani (30 decimals of land) per cropping season; and a significant impact of age, education, family size, number of income sources and ownership of farmland on WTP. Basarir et al. (2009) used the Torbit and Heckman sample selection models to study the WTP of vegetable producers for high quality irrigation water in the Turhal and Suluova regions of Turkey and found a significant relationship between WTP and gender and water quality.

Whittington et al. (1990) used the bidding game format to estimate WTP for water services in Laurent, a rural community in Haiti and found it to be 5.7 gourdes (US$ 1.14) per month; and observed that developing countries

are likely to produce better quality CVM surveys compared to industrialized countries.

Casey et al. (2005) studied WTP for improved water services in Manaus, Amazonas, Brazil, using both open-ended and bidding game approaches. They found the mean WTP to be R$11 (US$ 5.61) per month; and also observed that the respondents were willing to pay more for drinking water than the current charges. Other studies have found significant relationships between WTP for water or other natural resources and education of the household head, household size, farming experience, farm size, proximity to the resource, access to markets, extension services, credit and training, peoples' attitudes and perceptions on payment (Adepoju and Omonona, 2009; Mezgebo et al., 2013; Ogunniyi et al., 2011; Wendimu and Bekele, 2011; Addis, 2010; Moffat et al., 2012; Calkins et al., 2002; Rodriguez and Southgate, 2003; Kassahun, 2009; Latinopoulos, 2001; Ulimwengu and Sanyal, 2011; Farolfi et al., 2007; Alhassan, 2012; Illukpitiya and Gopalakrishnan, 2004; Calatrava and Sayadi, 2005). These studies guided the choice of variables used in the model explaining variation in WTP user fees across the sampled households at DRIS.

METHODOLOGY

Study area, sampling procedure and data

This study was conducted at Doho Rice Irrigation Scheme (DRIS) located 34° 02'E and 0° 50'N on the right bank of river Manafa in Mazimasa and Kachonga sub-counties of Butaleja district in Eastern Uganda (Figure 1).

DRIS occupies an area of 2,500 acres (1,012 ha), sub-divided into 10 blocks of unequal size, namely; 1A, 1B, 2A, 2B, 3, 4A, 4B, 5A, 5B and 6 (Figure 2). The 10 blocks are connected by three layers of channels, namely; main, sub and tertiary channels. The main channel provides irrigation water from River Manafwa to the scheme and branches out into the sub-channels, which provide irrigation water to each of the 10 blocks. Basically, each block has one sub-channel and consists of 5 to 15 smaller zones called strips, each surrounded by a tertiary channel that provides irrigation water to plots belonging to 20 to 30 farmers by a tertiary drainage channel. The tertiary drainage channel for one strip serves as the tertiary irrigation channel for the strip next to it. After flowing through paddy fields, water is collected in the main drainage channel through the tertiary and sub-drainage channels and drained back into River Manafwa (Nakano and Otsuka, 2011).

This study involved a survey of 200 households randomly drawn from among the rice farmers at DRIS in September 2012. A stratified random sampling procedure was employed, using the 10 blocks that make up DRIS as the strata to ensure that farmers on all blocks are represented in the study sample. Using the list of households for each block, a proportionate number of households was randomly drawn based on the household population of that block relative to the total number of households at DRIS[5]. Data was gathered from the sampled farmers using a structured questionnaire administered through in-person interviews with the household head. To elicit farmers' responses on WTP for irrigation

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[5] 14 households were drawn from the smallest block and 33 households from the largest

Figure 1. Map of Uganda showing the study area; Source: www. mapsofworld.com.

water, the study used a contingent valuation (CV) approach involving the iterative bidding game (Randall et al., 1974).

The game starts by querying individuals at some initial monetary value and keeps raising (or lowering) the value until the respondent declines (accepts) to pay. The final amount of money is interpreted as the respondent's WTP. Despite criticism of the bidding game approach as being prone to starting point bias, which makes the final WTP amount at the end of the bidding game systematically related to the initial bid value, Whittington et al. (1990) argue that the bidding game produces better quality WTP data in developing countries than in industrialized countries. This is because it is well understood and accepted by respondents in developing countries, who are used and prepared to negotiating over the price of just about any item they purchase on a regular market, unlike their cohorts in the industrialized countries.

In this study, the starting bid price was set at Ush 5000/acre per season, which the farmers at DRIS were required to pay according to the existing bylaw enacted in 1994. Since the commodity to be valued (irrigation water) was familiar to the respondents, the bidding game was not framed in a probabilistic sense, but rather the respondent was asked if they were willing to pay the starting bid price of Ush 5000/acre per season to experience adequate supply of irrigation water following the de-silting of irrigation and drainage channels. If the respondent answered "yes", the bid was increased until the respondent answered no. The highest yes response value was recorded as the maximum WTP. If the respondent answered "no", the bid was reduced until the respondent answered yes, and the highest yes response value was recorded as the maximum

WTP. Farmers were not actually required to pay the bid amount they stated, which could have rendered this measure of WTP biased and subjective. This is a key limitation of this study. However, the fact that the study involved valuation of a familiar commodity for which they were already paying helped to purge some of the bias. Additional data was collected on household-level characteristics (age, gender, education, household size, years of irrigation farming), farm size, rice production and marketing in the first cropping season of 2012, access to training and extension related to rice production and irrigation water management, access to credit, and farmers' perceptions and attitudes about who should be responsible for paying the cost of maintaining the supply of irrigation water.

The theoretical model

The economic value of a non-market good to an individual can be measured by the magnitude of their WTP for the good. Formally, WTP is defined as the amount that must be taken away from an individual's income (to meet the costs of providing the non-market good) while keeping their utility constant as shown in the equation below:

$$V(y - WTP, p, q_1; Z) = V(y, p, q_0; Z)$$

Where V denotes the indirect utility function, y is the income of the
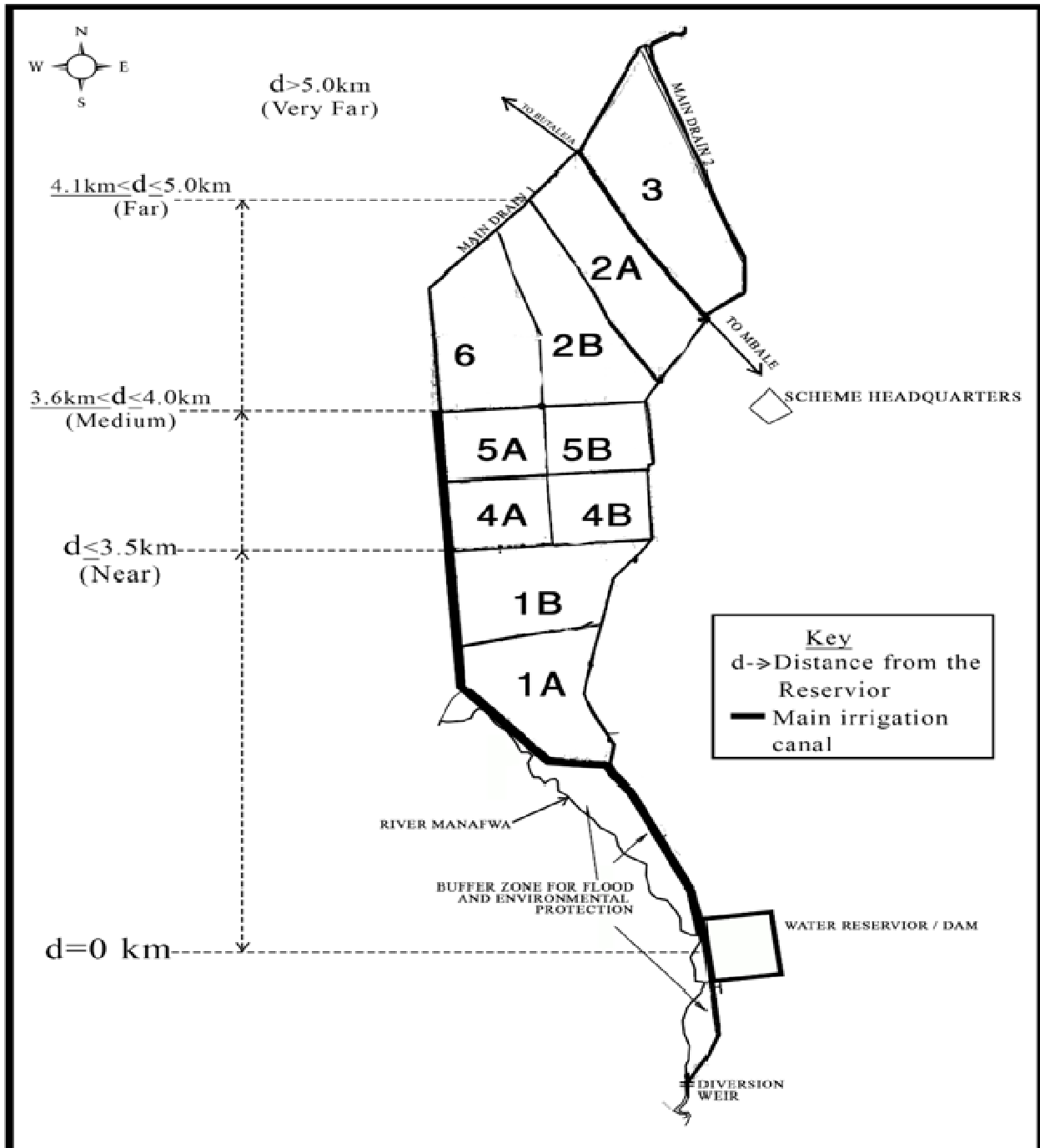
Figure 2. Map showing location of the 10 blocks with respect to water source/ reservoir.

individual, *p* is a vector of prices faced by the individual, q_0 and q_1 are the alternative levels of the non-market good under baseline and improved conditions, respectively (with $q_1 > q_0$ indicating an improvement from q_0 to q_1), and Z is a vector of individual characteristics affecting the trade-off that the individual is prepared to make between income and the non-market good. This equation implies that WTP depends on (i) the initial and final level of the good in question (q_0 and q_1); (ii) respondent income; (iii) prices

faced by the respondent; and (iv)other respondent socio-economic characteristics.

The empirical model

Determination of the factors influencing farmers' WTP for irrigation water at DRIS was achieved through estimation of a double-log

Table 1. Budget estimates for maintenance and operation of DRIS as per the 2013/2014 work plan.

Expenditure item	Estimated cost per season (Ush.)
Excavator maintenance (servicing)	3,000,000
Maintenance of canal gates (main, medium and small)	2,000,000
Maintenance of farm roads	7,500,000
Maintenance of irrigation canals	10,000,000
Maintenance of drainage canals	5,000,000
Maintenance of broken pedestrian or foot bridges	2,000,000
Servicing of other machines	5,250,000
Meetings	2,570,000
Total	37,320,000

Source: DRIS annual work plan for 2013-2014 (1 USD equals Ush 2,500).

Ordinary Least Square (OLS) regression model. The general form of the model is specified as:

$$lnY_i = \beta_0 + \beta_i lnX_i + \mu_i$$

Where; *In* is natural logarithm, Y_i is the dependent variable, X_i is a vector of explanatory variables, β_0 and β_i are the parameters to be estimated, and μ_i is the random error term. Thus, the estimated OLS model explaining variation in WTP across sampled rice farmers at DRIS is specified as:

$$\ln WTP = \beta_0 + \beta_1 \ln EDU + \beta_2 \ln EXP + \beta_3 \ln HHS + \beta_4 \ln FSIZE + \beta_5 \ln DMKT + \beta_6 TRA + \beta_7$$

$$EXT + \beta_8 CRE + \beta_9 OFFA + \beta_{10} ATT + \beta_{11} PSOURCE + u_i$$

Where; WTP= Farmers willingness to pay for irrigation water, EDU= Education of household head measured in years of schooling, EXP= Practical experience in rice farming under irrigation measured in years, HHS= Household size, FSIZE= Farm size or total area of land owned at DRIS measured in acres, DMKT= Distance in kms from the household to the nearest market where rice is sold. TRA=Participation in training related to soil and water conservation, rice growing or irrigation water management (1= Trained, 0= Otherwise), EXT=Access to extension services (1= Accessed extension, 0= Otherwise), CRE=Access to credit in the past two years (1= Accessed credit, 0= Otherwise), OFFA=Involvement in an off-farm activities by at least one household member (1=Involved in off-farm activities, 0= Otherwise), ATT=Attitude towards payment for irrigation water (1= Positive attitude, 0= Otherwise), PSOURCE = Proximity to irrigation water source [(1= Very far (>5 km); 2= Far (4.1-5 km); 3=Medium (3.6-4.0 km); 4=Near (≤ 3.5 km)], In= Natural logarithm, β_i= regression parameters, u_i = random error term.

RESULTS AND DISCUSSION

Findings from the contingent valuation survey show that rice farmers at DRIS are willing to pay an average of Ush 20,000 (USD 8) per acre or USD 20 per hectare as user fees per season. Based on the total acreage of DRIS of 2,500 acres (1,012 ha), this implies that charging Ush

20,000 per acre per season would generate Ush 50 million (USD 20,000) in total revenue per season.

However, the budget estimates for maintenance and operation costs of DRIS as per the 2013/2014 work plan (Table 1) show that only three quarters (75%) of this (Ush 37.32 million) is needed to cover the costs. This implies that charging Ush 15,000/acre per season would generate enough revenue for maintaining and operating DRIS. Before explaining the variation in WTP user fees across sampled rice farmers, their socio-economic characteristics which are hypothesized to influence WTP are hereby briefly examined. The sampled farmers are grouped into two categories based on whether or not the money they are WTP as user fees is adequate to cover the maintenance and operation costs of DRIS (Ush 15,000/acre per season). Analysis of farmers' WTP shows that 58% of the sampled farmers (N=200) are WTP at least Ush 15,000/acre per season as user fees; and these constitute the first category of farmers defined as "adequate WTP" (ADWTP).

The second category is composed of the rest of the farmers (42% of the sample) whose WTP is inadequate to cover the costs; and this is referred to as the "inadequate WTP" (INADWTP) category. Table 2 shows that a typical rice-growing household at DRIS is male-headed (94% of the sample) and of medium size (7.3 people).

However, a significantly higher proportion of households in the ADWTP category are male-headed (98.3%) than their cohorts in the INADWTP category (88.1%); and the average household size in the ADWTP category (8.1 people) is higher than in the INADWTP category (6.3 people). The average age of the head of a typical rice-growing household at DRIS is estimated at 42.2 years and does not differ between the two categories; but the education of the household head (estimated at 7.3 years of schooling for the entire sample sample) is significantly higher among households

Table 2. Selected socioeconomic characteristics of sampled rice-growing households at DRIS.

Variables	Entire sample (N=200)	ADWTP (N=116)	INADWTP (N=84)	Chi-square/ t-value
Percentage of male headed households	94	98.3 [a]	88.1 [b]	8.953
Age(years) of household head	42.2	43.3[a](1.211)	40.4[a](1.680)	1.420
Number of years of formal education of household head	7.3	8.5[a](0.283)	5.6[b](0.377)	6.270
Household size	7.3	8.1[a](0.309)	6.3[b](0.377)	3.587
Total area of land owned at DRIS	2.7	3.3[a](0.242)	2.0[b](0.162)	4.195
Practical experience (years) in rice farming under irrigation	13	15.8[a](0.855)	9.3[b](0.853)	5.163
Percentage of households trained in soil/water conservation/rice growing	58	76.7 [a]	32.1 [b]	39.75
Percentage of households accessing extension services on rice	53.5	61.2[a]	42.9[b]	6.594
Percentage of households who had access to credit in the past two years	29.5	36.2 [a]	20.2 [b]	5.974
Percentage of households with at least one member involved in off-farm activities	29.5	27.6 [a]	32.1 [a]	0.486
Distance from the household to the nearest rice market	1.5	1.5[a](0.425)	1.6[a](0.389)	-1.446
Percentage of households with a positive attitude towards payment for irrigation water	85.5	90.5 [a]	78.6 [b]	5.608
Rice output (Kgs/household) per season	683.9	792.63[a]	533.75[b]	2.721
Rice yield (Kg/Acre) per season	740.9	748.37[a]	730.58[a]	0.330
Rice Net-Income (Ushs/household) per season	1,071,800	1,254,300[a]	819,830[b]	2.704
Rice Net-Income (Ushs/Acre) per season	1,184,400	1,225,600[a]	1,127,500[a]	0.843

Numbers in parentheses are standard errors. Different superscripts (a, b) reflect statistically significant differences in variable between the farmers categories; while same superscripts signify no difference. The 3rd column labeled ADWTP presents summary statistics for households with adequate WTP (WTP ≥ Ush 15,000/acre per season); while the 4th column labeled INADWTP presents summary statistics for households with inadequate WTP (WTP < Ush 15,000/acre per season).

in the ADWTP category (8.5 years) than their cohorts in the INADWTP category (5.6 years).

Households in the ADWTP category are also endowed with bigger farmland at DRIS (3.3 acres) and longer practical experience in irrigated rice farming (15.8 years) than those in the INADWTP category (estimated at 2 acres and 9.3 years, respectively). Furthermore, significantly higher percentages of households in the ADWTP category had prior to the contingent valuation survey accessed training in rice growing and soil and water conservation (76.7%), rice-related extension services (61.2%) and credit (36.2%)

than their cohorts in the INADWTP category, for which the corresponding percentages were 32.1, 42.9 and 20.2%, respectively.

During the contingent valuation survey, respondents were asked for their opinion about compelling farmers to pay for the maintenance of the irrigation scheme at DRIS. Majority (85.5%) had a positive attitude towards payment of user fees, but the proportion of such households was significantly higher in the ADWTP (90.5%) than in the INADWTP (78.6%) category. 30% of the sampled households had at least one household member engaged in off-farm activity as their main

occupation but the proportion of such households did not differ significantly between the two categories. The distance from the home of the sampled households to the nearest market where they sell rice was estimated at 1.5 km but this also did not differ between the ADWTP (1.5 km) and INADWTP (1.6 km) categories

Recent studies conducted at DRIS show that the availability of irrigation water has a positive and significant impact on rice yield and income which in turn significantly affects household contribution of labor to the cleaning of irrigation and drainage channels (Nakano and Otsuka, 2011;

Table 3. Determinants of farmers' WTP user fees at DRIS.

Variable	Coefficient	Robust standard errors	T-Value
Constant	7.762	0.271	28.65
ln Education of household head	0.397***	0.059	6.76
ln Household size	0.083	0.092	0.90
ln Total area of land owned at DRIS	0.250***	0.059	4.22
ln Practical experience (years) in rice farming under irrigation	0.156**	0.071	2.22
ln Distance from the household to the nearest rice market	-0.444*	0.251	-1.77
Training in soil/water conservation/rice growing	0.361***	0.115	3.15
Access to extension services on rice	0.140	0.114	1.23
Access to Credit	0.214**	0.086	2.49
Involvement in Off-farm Income Activity	0.002	0.093	0.02
Positive Attitude towards payment of user fees	0.126	0.121	1.05
Proximity to Irrigation Water Source	0.076	0.059	1.27
Number of observations		200	
Adjusted R-Squared		0.51	
Prob>F		0.0000	
F(11, 188)		26.37	
Breusch-Pagan test for heteroskedasticity Prob> chi2		0.0487	
Mean VIF		1.62	

*,**,***,Significance at the 10, 5 and 1% levels, respectively.

Nakano et al., 2013). This study also gathered data on rice production and marketing by the sampled households in the first cropping season of 2012. The results show an average rice yield of 741kg/acre per season (1.83 mt/ha per season) for the entire study sample (N=200), which does not significantly differ between the ADWTP (748.4 kg/acre) and INADWTP (730.6 kg/acre) categories. This seems to suggest that the availability of irrigation water did not differ significantly across the sampled households in the first season of 2012, likely because as noted by Nakano and Otsuka (2011), rainfall and water supply at the scheme are abundant in the first cropping season and farmers occasionally suffer from flooding, although water supply is scarce in the second season. The average net income from an acre of rice (measured by gross margin) was estimated at Ushs 1,184,400 (USD 474) per season; and this as well did not significantly differ between the ADWTP (Ush 1,225,600/acre) and INADWTP (Ush 1,127,500/acre) categories.

However, the average net income per household in the first season of 2012 (estimated at Ush 1,071,800 for the entire sample) was significantly higher among households in the ADWTP category (Ush 1,254,300) than their cohorts in the INADWTP category (Ush 819,830). This is attributed to the fact that households in the ADWTP category are endowed with bigger land at DRIS (3.3 acres) than their cohorts in the INADWTP category (2 acres), which enables the former to earn higher rice income. Therefore, larger farmers earn more income from rice and as a result have better willingness and ability to

pay user fees than smaller farmers. This corroborates the findings of Nakano and Otsuka (2011); and supports the notion that private benefits conferred by plot size are the prime motivation for participation in collective irrigation water management (White and Runge, 1994), because farmers with larger plots enjoy greater income benefits from abundant water supply, hence the greater incentive to pay user fees.

The descriptive results discussed above suggest a significant relationship between socio-economic characteristics of rice-growing households at DRIS and their WTP user fees. These relationships are examined further using regression analysis; and the results are summarized in Table 3. The adjusted coefficient of determination (Adjusted R-Squared) value of 0.51 means that 51% of the variation in farmers' WTP user fees is explained by the variables included in the regression model. The regression results show statistically significant relationships between farmers' WTP user fees and formal education of the household head; farm size; practical experience in irrigated rice farming; participation in training related rice growing in general or soil and water conservation and irrigation water management in particular; and access to credit and markets. In this study, access to credit and participation in training are treated as exogenous despite being choice variables to the respondents. This is because they are pre-determined in the sense that they both happened in the past, well before the respondents were asked to respond to the bids on user fees; in the same way that education is treated as pre-determined and exogenous yet the

respondent made the choice of the level at which to end schooling.

The regression results imply that a one percent increment in education of the household head, land endowment and practical experience in irrigated rice farming increases farmers' WTP user fees by 0.4, 0.25 and 0.16% respectively; while a 1% reduction in distance to the rice market increases WTP by 0.44%. A switch from having "no access" to "access" to credit and training (in rice growing, soil and water conservation and irrigation management) is associated with a 43.5% ($e^{0.361}$) and 23.8% ($e^{0.214}$) increase, respectively in the geometric mean of farmers' WTP user fees.

These findings imply that more educated farmers have higher WTP irrigation fees, likely because higher education is associated with better understanding of the benefits of adequate supply of irrigation water in agricultural production. Education is also believed to increase farmers' ability to obtain, analyze and assimilate information that helps them to make prudent decisions related to the management of their farming enterprises.

Also, education is a good proxy for off-farm income because it enables agricultural households to pursuit alternative income opportunities outside agriculture (e.g.,salary or business), which increases their ability and WTP irrigation fees. These results are consistent with the findings Adepoju and Omonona (2009); Mezgebo et al. (2013); Ogunniyi et al. (2011); Wendimu and Bekele (2011) who found a positive relationship between formal education and WTP.

However, Nakano and Otsuka (2011) found education attainment to be negatively correlated with household contribution of labor towards the collective maintenance of DRIS, because of the higher opportunity cost of labor associated with non-farm income among more educated households. This renders more educated households less keen to contribute labor to collective action than their less educated cohorts. The implication of these findings is that the impact of education attainment on participation in irrigation water management plays out differently depending on whether the users are required to contribute labor or money to ensure the supply of irrigation water.

The positive relationship between farm size and WTP is likely because farmers with larger land endowment also cultivate larger rice plots at DRIS and earn higher income from rice when the supply of irrigation water is adequate. These findings are consistent with those of Mezgebo et al. (2013); Ulimwengu and Sanyal (2011); and Nakano and Otsuka (2011); and illustrate the prime importance of private benefits conferred by farm size in collective irrigation water management (White and Runge, 1994). Also, given that rice production is the most important income source for over 80% of the households at DRIS (Sserunkuuma et al., 2009), farm size is a good proxy for household income, which enhances ability and WTP user

fees. The positive correlation between practical experience in rice farming under irrigation and WTP is likely because farmers with longer experience are more familiar with the benefits of adequate supply of irrigation water enjoyed when DRIS was properly maintained and have also observed the decline in rice output through the years as the scheme deteriorated. This enables them to better appreciate the importance of their contribution towards improved water supply, hence the higher WTP. This result is consistent with Addis (2010); Kassahun (2009); and Latinopoulos (2001).

Access to credit and training related to rice growing in general or soil and water conservation and irrigation water management in particular are associated with higher WTP of user fees, likely because training tends to increase farmers' awareness of the dangers of unabated siltation of the irrigation channels and appreciation of their role in abating these dangers through payment of user fees, as well as appreciation of the ensuing benefits.

This finding is consistent with Calatrava and Sayadi (2005) who found that farmers who attended agricultural training courses had significantly higher WTP for water in tropical fruit production in South Eastern Spain. The positive relationship between access to credit and WTP is likely because credit enables cash constrained farmers to earn more income from agribusiness and other micro-enterprises, (Zeller, 2000), which enhances their ability and WTP user fees. The need to earn money to pay back the acquired credit also likely contributed to the higher WTP bids among farmers who accessed credit, with the hope that this will lead to increased rice output and income to enable them to pay back the credit.

This result corroborates the findings of Addis (2010) and Illukpitiya and Gopalakrishnan (2004). Distance to the rice market and WTP are negatively correlated because farmers closer to the markets incur less transaction costs and earn more from their rice compared to those further away and are, thus, willing and able to pay more to ensure adequate supply of irrigation water.

This finding is consistent with Ulimwengu and Sanyal (2011) who found a negative impact of travel distance on the WTP for agricultural services. The rest of the explanatory variables (household size, access to extension services, involvement in off-farm activities, having a positive attitude towards payment of user fees and proximity to the irrigation water source) have positive but statistically insignificant relationships with WTP user fees. This is likely because of the way these variables were captured in the contingent valuation survey, which doesn't reflect their true impact on WTP.

CONCLUSIONS AND RECOMMENDATIONS

This study analyzed farmers' WTP user fees and the determinants of WTP at DRIS, which is currently

undergoing rehabilitation by the government of Uganda (GOU) and is due to revert to farmers who are expected to manage and maintain it through payment of user fees and contribution of labor to collective action. The study was motivated by the need to determine how much farmers are willing to contribute towards the maintenance costs; and to use this information to guide the setting of appropriate user fees.

The study found that while farmers are on average WTP Ush 20,000/acre per season as user fees, Ush 15,000/acre per season is actually needed to cover maintenance and operation costs as per DRIS' work plan for 2013/2014. The higher WTP notwithstanding, the study recommends charging Ush 15,000/acre per season, which not only generates sufficient revenue to cover the costs, but also lies below the average WTP, implying that several farmers would willingly pay this amount without coercion.

However, because the WTP for some farmers (42% of the study sample) is below Ush 15,000 (for some it is as low as Ush 1,000), there is need for continued sensitization of farmers on the importance of their contribution towards the cost of supplying water to ensure farmer buy-in. This has to go hand in hand with provision of incentives for voluntary payment as well as strong enforcement of penalties against non-payment of the user fees among those with low WTP. Available literature shows a history of poor enforcement of penalties against uncooperative farmers at DRIS, leading to incessant shortfalls in the collection of user fees (only 40% of irrigation fees being collected on average) and inadequate contribution of labor towards collective maintenance of the irrigation and drainage channels.

Fujiie et al. (2005) recommends incentivizing community leaders who mobilize farmers for collective action and collect the user fees as a way of reversing the shortfalls. An incentive such as a monetary reward for chairpersons and counselors based on the number of farmers from their respective blocks who pay user fees promptly and participate in the cleaning of the channels could help to improve the performance of those leaders in collection of user fees and mobilization farmers for collective action. Another strategy for addressing the shortfalls is to switch from the current self-enforcement mechanisms to private third-party agencies to enforce compliance with the existing bylaw. The regression results show statistically significant relationships between farmers' WTP user fees and formal education of the household head; farm size; practical experience in irrigated rice farming; participation in training related rice growing in general or soil and water conservation and irrigation water management in particular; and access to credit and markets. These results imply that in addition to provision of incentives for voluntary payment and enforcement of penalties against non-payment of user fees, appropriate interventions related to these factors influencing farmers' WTP are necessary. For example,

the positive relationship between WTP and participation in training in soil and water conservation, rice growing or irrigation water management implies that intensifying training in these areas is important to increase farmer awareness of the dangers of unabated siltation of the irrigation channels and appreciation of the importance of their contribution towards the cost of de-silting to ensure adequate supply of irrigation water. Interventions that promote farmers' access to affordable credit are also recommended, based on the positive and significant relationship between having acquired credit and WTP. These may include establishment of an agricultural bank or risk-sharing guarantee schemes to motivate financial institutions with a rural branch network to provide credit to farmers at more affordable rates. In light of the findings of a positive correlation between farmers' WTP user fees and market access, there is need to invest in increasing farmers' access to rice markets to reduce transaction costs and enable farmers to receive better returns to rice production; which will in turn enhance their ability and WTP user fees.

The positive relationship between farm size and WTP implies that development of a land rental or lease market at DRIS would enable interested farmers to expand the sizes of their rice farms; which will in turn increase their income and ability to pay as well as WTP user fees.

While this study shows that education attainment enhances farmers' willingness to contribute money towards maintenance of the irrigation scheme, available literature shows that education emasculates willingness to participate in irrigation water management when farmers are required to contribute labor.

Therefore, switching from the current practice of compelling all farmers to contribute both money and labor to the alternative involving giving them the option of contributing larger amounts of either labor or money (in lieu of the other) depending on the opportunity cost of their labor in other income generating activities may help to reduce the shortfalls in user fee collection and labor contribution towards collective maintenance of the irrigation system at DRIS.

Conflicts of Interest

The authors have not declared any conflict of interest.

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Full Length Research Paper

Women's workload and their role in agricultural production in Ambo district, Ethiopia

Mohammed Endris Harun

Department of Economics, College of Business and Economics, Ambo University, P. O. Box 19, Ambo, Ethiopia.

The Government of Ethiopia is working towards mainstreaming gender in all sector programmes, including agriculture. Women, despite having key role in advancing agricultural development and food security, their contribution is undervalued and they have been neglected in the making of agricultural policies. With the aim of tackling gender issues in agricultural production this study estimated total hours spent in farm associated tasks, identified activities performed by women and examined the influence of selected socio-economic characteristics of women on their participation in agricultural production. A two-stage random sampling technique was used to select 180 respondents for this study. The research was carried out by the use of well-structured questionnaires to obtain the necessary data. The relationship between selected socio-economic characteristics of the respondents and their total hours spent on agricultural activity was determined using ordinary least square (OLS) regression. The findings reveal that, while women are found with less agricultural resources and low decision making power, they spent 26 h per week in farm activities showing high rate of involvement in agricultural production. It was also found that marital status, income and age had significant impact on women participation in agricultural production. It is recommended that women agricultural productivity should be enhanced by improving their access to agricultural resources and developing policies and technologies targeting women related agricultural activities.

Key words: Women, work load, agriculture, Ethiopia.

INTRODUCTION

Agricultural sector is the principal engine of growth of the Ethiopian economy; it employs 83% of the labour force, contributes about 90% of exports and 45% of gross domestic product (GDP), and provides about 70% of the country's raw material requirement for large-and medium-scale industries (MoARD, 2009).

Around the world, there are at least 1.6 billion women ho live in rural areas and depend on agriculture for their livelihoods – more than a quarter of the total world population. Women farmers produce more than half of all the food that is grown in the world, specifically, up to 80% in Africa and 60% in Asia (http://pdf.usaid.gov/pdf_docs/PNADA958.pdf). In most rural communities in Ethiopia, women work from dawn to dusk and, in contrast with men, have little time for leisure or socializing. Women are not only the major source of labour in the agricultural sector, they are also responsible for the vital tasks of caring for children, the sick and the

elderly as part of their household responsibilities. Despite their immense contribution to society, women's productive, domestic and community related activities seem to be undervalued, often misunderstood and are rendered invisible from official discourse and national statistics.

Women are increasingly active in virtually every economic sector. In addition to producing much of the world's food, women hold primary responsibility for gathering the water and fuel used daily by their families. Women make up an increasing proportion of the world's formal labour force and heads of households. In most societies men's role in agricultural activities is understood to be directed and clear. However, women's role in agriculture is not clearly recognized. Hence, a clear picture of women's participation in agriculture is needed. Although this is increasing that women are involved in the world agriculture until recently have been difficult to gain a clear picture of where, and under what circumstance women in particular work in the farm (Annabel, 1986).

According to the Food and Agriculture Organization of the United Nations (FAO), women in some African countries spend up to 60% of their time on agricultural activities. Women farmers contribute up to 50% of labour on farms in sub-Saharan Africa. More than 60% of employed women in sub-Saharan Africa work in agriculture. Developing policies that focus on the needs of women is not just a political priority, it is an economic imperative. As the FAO states, there is a significant global gender gap in agriculture, which translates into a costly lost opportunity to improve the quality and quantity of the world's food supply. If women had the same access to, and control over productive resources as men, they could increase yields on their farms by 20 to 30%. This could raise total agricultural output in developing countries by 2.5 to 4%, which could in turn reduce the number of hungry people in the world by 12 to 17%.

Land is not just a productive asset and a source of material wealth, but equally a source of security, status and recognition. Substantive gender equality is both relational and multi-dimensional, cutting across race, class, caste, age, educational and locational hierarchies and can only be achieved if rights are seen as socially legitimate. Sub-Saharan Africa women contribute between 60 and 80% of the labour for food production, both for household consumption and for sale (FAO, 1994). Women's access to and control over land can potentially lead to gender equality alongside addressing material deprivation (Quisumbing et al., 2004). The exclusion of women from access to and control over assets, whether land, technology or credit potentially lowers growth (Evers and Walters, 2000).

Women own only an estimated 1 to 2% of all titled land worldwide and are frequently denied the right to inherit property. There are numerous cultural, social, political, and legal factors that influence women's lack of property and inheritance rights, and specific patterns of ownership and disenfranchisement vary widely. Lack of control over both productive and non-productive resources in both rural and urban settings places women at a strong disadvantage in terms of securing a place to live, maintaining a basis for survival, and accessing economic opportunities. For instance, the widespread lack of official title to land and property among women means that, they have virtually no collateral with which to obtain loans and credit. These factors exacerbate women's generally low status and high levels of poverty when compared to men. Furthermore, women's lack of property and inheritance rights has been increasingly linked to development-related problems faced by countries across the globe, including low levels of education, hunger, and poor health.

Kotey and Tsikata (1998) have argued that discussions revolving around agricultural productivity are best explained through a land rights analysis using a social relation's approach. The "gender perspective" approach used by the World Bank to analyse growth and poverty in sub-Saharan Africa recognises that women stand at the crossroads between production and reproduction, between economic activities and the care of human beings, and therefore between economic growth and human development. Such an approach takes account of existing discriminatory, unequal and inequitable (power) relationships and practices, and lays the basis for more sustainable development based on legal and social justice. It also provides room for a broader view of social groups.

Clearly, a lack of understanding about the roles that women and men play, activities performed by each and workload of women in a sector as fundamental as agriculture will result in programs falling short of their potential and development. Gender integration is the process by which gender analysis is applied to all steps of development programs and projects. Without proper targeting policies and programs, it may not reach or impact those drivers of agricultural productivity and development. Therefore, the objective of this study was to quantify the level of women participation per each agricultural activity, to identify factors affecting level of women's participation in agricultural production and to investigate women and female-headed households' access to and control over agricultural land.

METHODOLOGY

Data and the study area

The study was conducted in Ambo woreda[1] of West Shewa Zone of Oromia regional state of Ethiopia between astronomical grids of 8°47'_9°21'N and 37°32'E which is located 114 km away from the capital of the country (CSA, 2008).The woreda has the mean annual temperature of ranging between 23 to 28°C and the mean annual rainfall of 1,300 to 1,700 mm (CSA, 2008). The low, mid and

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[1]Woreda (also spelled wereda) is an administrative division of Ethiopia (managed by a local government), equivalent to a district

Table 1. Description of variables used in OLS regression

Variable	Variable Description
Dependent Variable	
Tothr	Total hours women spent on each agricultural activities in a week.
Independent Variables	
X1	Access to irrigation(dummy)
X2	Land ownership (dummy)
X3	Distance to market
X4	Education
X5	Marital status
X6	Age
X7	Household size (actual number)
X8	Annual income
X9	Extension participation (dummy)
X10	Farming experiance(yers)

high lands cover 17, 60, and 32% of the woreda, respectively. Agriculture is the dominant economic activity engaging 92% of the labour force (CSA, 2008). Crop production is mostly dependent on rainfall and major crops produced in the area are wheat, maize, teff, barely, sorghum, and other crops. Livestock are also reared by most families. Oxen provide traction power for cultivation of agricultural lands, on the other hand livestock are kept as source of income through milk, butter, meat and egg production.

A two stage random sampling technique was used to select the sample women in the study area. The first stage was simple random sampling of 9 kebeles[2] from 24 rural kebeles found in the woreda. From the list of farm households, provided by the woreda beareu, 20 households were randomly selected from each of the 9 woredas, making a total of 180 farm households for the study.

The standard tools of household interviews, focus group interviews and community meetings were used to collect information. The involvement of rural development practitioners was adopted in order to make them more aware of the need to understand different gender roles in rural communities when planning, thus, increasing efficiency and gender responsiveness in rural development policies and programmes.

Women's workload in agricultural production

Agricultural activities women participated are identified and average total hours allocated for agricultural production is estimated.

Determinants of women's participation in agricultural production

Women participation in agriculture was measured as a continuous variable where respondents were asked to individually indicate how much hours were allotted for agricultural production. To investigate the relationship between socio-economic variables and women participation on agricultural tasks, ordinary least square (OLS) regression was employed containing 10 predictors as specified in Equation 1.
OLS is expressed as:

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[2]Kebele is the lowest administrative unit in the structure of Ethiopian government.

$$Y = \beta_0 + \beta_i X_i + e_i \;$$

(1)

Where Y is dependent variable which represent total time women spend on each agricultural activities; β_0 is the intercept; β_i is regression coefficient and e_i is error term

The demographic variables included in the empirical model are given in Table 1.

RESULTS AND DISCUSSION

Descriptive result

Age of women farmers was one of the demographic characteristic hypothesized to influence women's participation in agricultural activities. According to Table 2, the age range distribution of the respondents showed that, 42% are young (15 to 30) age groups and followed by middle age groups (31 to 50) and old age groups (>50), 32 and 26%, respectively showing women participation in agriculture in the study area are in the age of productive labour.

Education is believed to affect productivity at least in two ways. First, education increases the ability to use modern (technology) to produce more output. Second, education enhances the ability of farmers to obtain input and analyses information. Thus, education changes the types and magnitudes of inputs to be used in production. As indicated in Table 2, 60% of sample respondents were illiterates, 24% were able to read and write, 12% had elementary school education and 4% had attend secondary school. The education levels of respondents are low; this is due to family dependence on girl's labour at home.

The respondents are categorized as single, married, divorced, and widowed. The result of collected data shows that most of the respondents (64%) are married

Table 2. Socio economic characteristics of the respondents.

Variable	Range	Frequency	Percentage
Age	Young (15 to 30)	75	42
	Middle (31 to 50)	58	32
	Old (>50)	47	26
Education	Illiterate	108	60
	1 to 4 Literate	43	24
	5 to 8 Literate	21	12
	>9	8	4
Marital status	Single	4	2
	Married	115	64
	Divorced	18	10
	Widowed	43	24
Annual income	Below 1500	36	20
	1500 to 3000	33	18
	3000 to 5000	54	30
	Above 5000	57	32
Possession of land	<2hctr	54	30
	2 to 3 ha	47	26
	Above 3 ha	72	40
	Had no land	7	4
	Inheritance	54	30
Means of ownership	Leasing	15	8
	Marriage	61	34
	Sharing	50	28

and living with their husbands, while 24, 10 and 2% were widowed, divorced and single, respectively. This means the proportion of the respondents who are married, was much higher than the other categories.

In the study area, the major reason for divorce was economic problem, personal conflicts and polygamy. The economic problem implies that in most cases when a husband lack resource to sustain a family, the wife opts for separation. Most of the marital status, except married ones observed from the study had negative impact on agricultural production as well as the economic growth of farm household, especially, the marital status like divorce and widow make worse off the property family as well as the life of household. In addition, widow and divorce affects or increase women workload, because women are responsible for all assets and family or acts as head family when there is no father. Result on family annual income shows that majority (32%) of respondents belongs to income group of above 5000 Ethiopian birr followed by (30%) income group of 3000 to 5000 birr,

income group (18%) of 1500 to 3000 and (20%) were below 1500 birr annually. The results indicate that most of the respondents earn above 5000 Ethiopian birr annually from agricultural production.

According to Lindia (2005), the incomes gained from these economic activities were used for household consumptions and family support rather than re-investing it to expand their farm investments. Similarly, being rural women, most are illiterate and have no proper skill for full employment opportunity. On the other hand, information observed from the respondents of women revealed that on average the annual income and expenditure trends give priority to satisfy their household basic necessities; they tend to use fertilizer and improved seed provided by agricultural office on credit.

80% of the women farmers had between 10 to 20 years of farming experience which help them in making rational choice and decision to impact positively on the effective management and organization of their farms and families. On the other side, majority of the women group (75.0%)

were full-time farmers that had contact with their block extension agents and also belonged to different cooperative groups. Around 15% of the women engaged in off-farm activities.

The extent to which a farmer is able to perform the various agricultural tasks depends on the level of knowledge and skill possessed by the individual. It has been demonstrated in agricultural extension that many innovations are not adopted by farmers because they are based on wrong assumption about the women farmers, whose real needs are not actually met or served (Iloka, 2002).

Possession of land

Women across the developing world are disadvantaged relative to men. Under male-dominated social structure and political system, women are denied equal access to land structure and extension services (Okafor et al., 2002). The failure to consults women or to consider their specific capabilities and responsibilities can prevent new agricultural projects or technologies from adopted.

Women's access to and control over land can potentially lead to gender equality alongside addressing material deprivation. Land is not just a productive asset and a source of material wealth, but equally a source of security, status and recognition. Substantive gender equality is both relational and multi-dimensional, cutting across race, class, caste, age, educational and locational hierarchies and can only be achieved if rights are seen as socially legitimate.

Data collected on possession of land of women respondents in the study area, revealed that out of the total respondents having land the majority (40%) owned farm land above 3 ha and 26% owned 2 to 3 ha, 30% had less than 2 ha and 4% had no farm land, respectively . This indicates that 40% or the majorities had land for agricultural production. Having enough land for farm can ensure their family need and achieve food security by having enough production from a given land.

As indicated in Table 2, about 42% of respondents have their own land, while the remaining 58% of the respondents do not have their own land. In relation to means of land ownership 34% accessed land through marriage and 30% of them are through inheritance; 28 and 8% accessed ownership to land through sharing and leasing from others.

According to focus group discussion, most women in study areas or in rural areas were not collecting land either from government or from their parents. Only few women benefited from inheritance; most of them owned land through marriage. Marriage has been primary means of getting access to land under customary system. Unmarried women have little access to land because they are not allowed to inherit property in most matrilineal societies, while wives have better access to their husband lands.

Correlations among explanatory variables

According to the statistical results as the age of household tends to increase, the level of illiteracy increases. This may be because of the recent expansion of education. Consequently, as the level of education increases for household, participation of women in the agricultural production tends to decrease; this could be that education provides them other opportunities and increase the probability of getting non-agricultural jobs. Also as the level of education for household increases, the income level for them increase because education enables them to easily adopt technologies like land, labour, fertilizer, pesticides and etc. and helps them to efficiently and effectively utilize resources in agricultural production.

A correlation coefficient of marital status and land size shows, women who are married, found having, more land. This is possibly because a split leads to lower land size due to land division.

Another result shows that when the level of income for household increases, then the couple's desire to get children decreases because as the level of income of household increases, then their education access increases; consequently, households are aware of family planning and they tend to use different mechanisms like contraceptives to decrease their number of children.

The land size was positively correlated with access to credit. That means women with larger land size have an opportunity to obtain credit for the implementation of agricultural production. In other word, women who having larger land size need credit support to buy different inputs like fertilizer, pesticides and insecticide. In addition to these, results indicated that the income level of women farmer and their ages were negatively related. This means as age of women goes up their ability to participate in the sector decreases and consequently, their income goes down through time.

Women workload

As earlier discussed, women play a significant role in the agricultural labour force and in agricultural activities, although to a varying degree. They participate in all aspects of rural life-in paid employment, trade, and marketing, as well as tend to crops and animals, collect water and wood for fuel, and care for family members. Consequently, their contribution to agricultural output is undoubtedly extremely significant.

Women have dual responsibility for farm and household production. In this study, total hours spent in agricultural activities livestock raising, land clearing sowing, transplanting, weeding and harvesting, as well as

Table 3. Regression estimates of coefficients associated with agricultural technology adoption.

Variable	Coefficient	Standard error
Access to irrigation(dummy)	1.240367	0.4030926
Land ownership (dummy)	0.7295175	0.3165236
Distance to market	0.2510673	0.3029087
Education	1.448586	0.7088618
Marital status	-0.4482329**	0.3236237
Age	0.3079663***	0.342379
Household size (actual number)	0.0785357	0.3445335
Annual income	0.2689223***	0.0907089
Extension participation (dummy)	-.7803478	0.4799395
Farming experiance(yers)	-1.01143	0.4815043
Cons	-2.822129***	0.9997022
Log likelihood	-141.09847	
LR chi2	78.80	
Prob > chi2	0.0000	
Pseudo R2	0.2183	

*** and **, Significant at 1 and 5%, respectively. Source: Own survey.

in post-harvest operations such as threshing, winnowing, drying, grinding, husking, storage and marketing was estimated and found 26 h per week showing women's heavy workload that could make them less productive.

Regression results

OLS regression was employed to see the relative influence of different personal, demographic, socio-economic, and institutional variables on total hours spent by women on agricultural production. The regression result of the retained variables on women's workload and their role in agricultural productivity using OLS model as indicated in Table 3.

The result in the Table 3 shows age, marital status, and income; and was significant at 10 and 5% significant level, respectively. Moreover, the expected sign of regression coefficients for these explanatory variables were in line with the theoretical expectation.

The coefficient for the ages of respondent's variable is -0.3079663, which is significant at 10% of the probability indicating women agricultural production involvement decrease when their age increases; this happened as the age of women farmers increases, they lack energy to actively participate in agricultural productivity and they may get kids to assist them at their older ages.

The coefficient of marital status of women farmers' variable is -0.4482329, which is significant at 5% probability implying that women involvement in agricultural production is higher in divorced and widowed women than single and married ones. This shows that divorced and widowed women shall have support either from the community or government.

The coefficient for the income level of women farmers' variable is - 0.2689223, which is significant at 10% of the probability implying that women's hour spent in agricultural production decreases with increase in the income level of women farmers. This can be resulted because as their income level go up their probability of participating in non-agricultural production is high; again as income level of women increases then they have the chance to hire other workers to their production. Consequently, their chance to participate in the sector goes down.

Conclusion

Women are found engaging in activities like food preparation for family consumption, grain grinding, water fetching, fuel wood collection, washing clothes and cleaning barn in addition to their agricultural work.

In the study area, women make important contribution to agricultural economy through the labour they supply in cultivation of cash cops. Although, men perform the initial task of cutting trees and bushes on potentially cultivable plot land, land preparation and ploughing, women are responsible for all subsequent operations including removing and burning felled trees, sowing, planting the plot weeding, harvesting and preparing the crop for the storage or immediate consumption.

Women spend an average of 26.1 h per week in agricultural production. They engage in agriculture at all productive age group. But the level of participation decreases while age increases. Increased workload indicates the need for equipment to assist them in conducting these tasks.

Divorced and widowed women spend more hours on agricultural production which possibly puts them in burden. For women, marriage has been primary means of getting access to land.

Age, marital status and income were found to significantly influence level of participation in agricultural production.

The extent to which a farmer is able to perform the various agricultural tasks depends on the level of knowledge and skill possessed by the individual.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Full Length Research Paper

Impact of macroeconomic policies on poverty alleviation in Sub-Saharan African countries

Mogos Teweldemedhin

Polytechnic of Namibia, School of Natural Resources and Spatial Sciences, Department of Agriculture and Natural Resources Sciences, Namibia.

The objective of this paper is to examine the relationship between macroeconomic variables and poverty alleviation in Sub-Saharan Africa, by applying descriptive illustration and weighted least square (WLS) regression econometric analysis using the multidimensional poverty index (MPI) taken from the oxford poverty and human development initiative (OPHI) as dependent variable. Furthermore, principal component analysis (PCA) was performed to avoid multicollinearity problems and to improve the estimation power of the regression. Long-term annual gross domestic product (GDP) growth trends were analysed by dividing countries into four groupings, namely upper income, lower middle income, lower income and conflict countries. The results show that post-conflict nations experience good progress in economic growth. With the exception of the ratio of government expenditure to GDP (GEXPGDP), foreign direct investment, net inflows (% of GDP) (INFGDP), agriculture, value added (% of GDP) (AGR.GDP) and the Gini coefficient (GINICOEF) (not significant and not reported), all other variables were found to be statistically significant at the specified significance level. Furthermore, population growth (annual %) (POPGRWTH) holds greater positive magnitude, and shows that economic growth is moving at a slower pace compared to population growth, which complicates the economic development agenda on this continent. The major factors limiting growth are restrictive fiscal policy, contractionary monetary policy in most countries, and balance of payments constraints. Furthermore, it is important to improve local capabilities and inter-firm linkages, thus achieving well-managed privatisation, while it is equally important to have subsidies reaching the poor.

Key words: Sub-Saharan Africa, multidimensional poverty index (MPI), macroeconomic variables, poverty alleviation.

INTRODUCTION

Since poverty is not an easy concept to define, there is a wide range of definitions influenced by different disciplinary approaches and ideologies. The dominant Western definition since World War II has defined poverty in monetary terms, using levels of income or consumption as measurements (Grusky and Kanbur, 2006) and defining the poor by a headcount of those who fall below a given income/consumption level or 'poverty line'

(Handley et al., 2009). Subramanian (1997) subsequently devised a multidimensional definition comprising the basic needs approach (Streeton et al., 1981; Handley et al., 2009), the capabilities approach (Sen, 1999; Handley et al., 2009) and the human development approach (UNDP, 2006). The acceptance thereof is reflected in the widespread use of the human development index (HDI) of the United Nations development programme (UNDP), which is a composite measure of three dimensions of human development, namely: (i) life expectancy, (ii) educational attainment and (iii) standard of living, measured by income in terms of its purchasing power parity (UNDP, 2006). The conceptualisation of HDI is used in this paper to define poverty.

Sub-Saharan Africa (SSA) is afflicted by many forms of poverty, with HDI scores in most SSA countries having stagnated or declined since 1990, making this region the poorest in the world. Indeed, 28 of the 31 low human development countries are in SSA (UNDP, 2006). An analysis of income poverty is similarly disappointing in that since 1990, income poverty has fallen in all regions of the world except SSA, where there has been an increase in both the incidence and the absolute number of people living in income poverty. This sees some 300 million people in SSA almost half the region's population living on less than US$1 per day (UNDP, 2006).

While the rest of the world has made significant progress towards poverty alleviation, Africa in particular Sub-Saharan Africa continues to lag behind. This trend is projected to increase unless preventative measures are taken. Many factors have contributed to this trend, including the high prevalence of HIV/AIDS, civil war and the associated strife and poor governance, frequent drought and famine, and agricultural dependency on the climate and environment. Food security on the continent has worsened since 1970, and the proportion of the population this is malnourished in SSA has remained within the 33 to 35% range (Velde et al., 2004). The prevalence of malnutrition within the continent varies by region, being lowest in Northern Africa (4%) and highest in Central Africa (40%) (Mwaniki, 2009). Over 70% of the food insecure population in Africa lives in the rural areas. Ironically, smallholder farmers, the producers of over 90% of the continent's food supply, make up the majority (50%) of the food insecure population, while the remainder consists of the landless poor in rural areas (30%) and the urban poor. Food security has three aspects, namely food availability, food access, and food adequacy (Mwaniki, 2009).

To date, regardless of the intensity of development programmes, very little has changed in SSA economies in the past 10 years Although food aid, technical arrangements, and financial and other humanitarian assistance continue to flow in from the developed countries to SSA, problems of drought, famine, inflation, international debt and unemployment continue to escalate. The existing social and infrastructure facilities such as health, education, transportation and many other institutional structures are relatively weak and inadequate (Velde et al., 2004).

According to the 2010 ranking of the top 47 poorest countries worldwide, 32 of those are in SSA. Although the global headcount is between $1.25 and $2.00/day, the multidimensional poverty index (MPI) is considered below $1.50/day poverty line. Niger, Ethiopia and Mali, at 93, 90 and 88% respectively, are the top three countries on the list (Alkire and Santos, 2010).

Therefore, the objective of this paper is to test the impact of macroeconomic policies on the variables of poverty alleviation in SSA. The paper is divided into two main parts: First, the growth performance of SSA is illustrated and described, while the poverty situation is quantified with reference to the MPI, and some of the main reasons for Africa's stagnation in economic development are pointed out. Thereafter, the relationship between the MPI and different macroeconomic variables was tested.

This paper thus gives insight into the areas where research and attention by policy makers and donors are likely to prove more valuable at this point in time. This result is therefore partial rather than comprehensive; it is an agenda focusing closely on the non-macroeconomic factors constraining Africa's poor.

Problem statement and motivation of the study

Economic growth does not come risk-free. Although material progress can be measured by the growth in national output, income and spending, the rapid economic growth of developed countries is accompanied by several short-term and long-term problems (Riley and Eton, 2006), including inflation risks, inequalities and regional disparities. The idea of economic degrowth amongst rich nations is emerging as a response to the triple crisis (environmental, social and economic); it did not appear out of the blue. Sustainable degrowth may be defined as an equitable downscaling of production and consumption that increases human wellbeing and enhances ecological conditions at the local and global level, over both the short and long term (Rull, 2010).

However, according to Weeks (2009), the major causes of growth instability in SSA are: (1) Fluctuations in the terms of trade, which impact directly on aggregate demand via export and import prices, thus affecting the fiscal balance through trade taxes, and tightening or loosening the balance of payments constraint; (2) variations in weather that largely determine the performance of rain-fed agriculture in a region where irrigation is limited; and (3) Low investment confidence towards SSA (mainly due to perceptions of poor quality of governance, legal protection of private property, and institutional limits on leaders). Therefore, the study is directive from a policy perspective, as macroeconomic
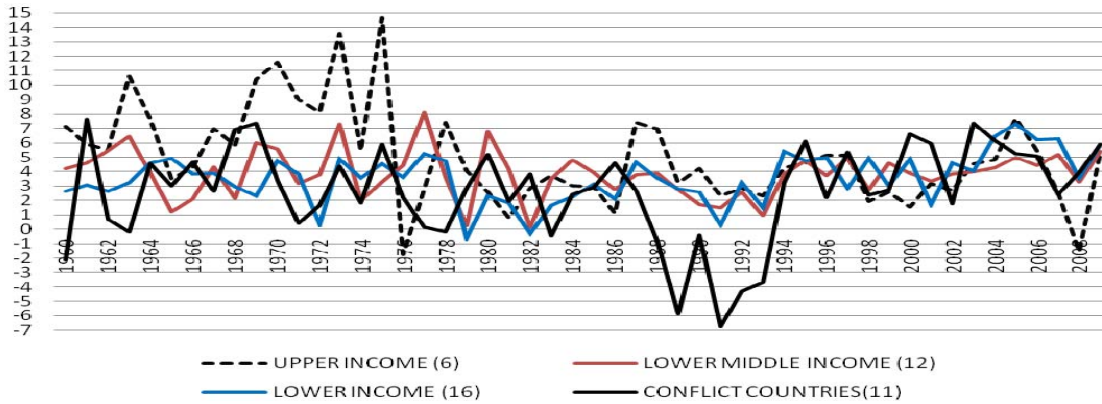
Figure 1. GDP annual percentage growth for SSA, 1960 to 2010. Source: Own representation based on World Bank dataset (2012) dataset.

policy constitutes an important element in the government's efforts to boost the underlying supply capacity of the economy. From a research perspective, the empirical results of this study would be timeous, as SSA affords the opportunity for an in-depth case study on account of significant variations in trade policy orientation and productivity performance across economies. In addition:

1. This is the time when most African nations are showing progress in governance and democracy exercises;
2. This is the time that Africa is encountering a number of challenges, such as climate change, high rates of transmitted diseases (such as HIV/AIDs), and requiring different strategies;
3. This is also the time when there is a need for sustainability to address the triple crisis (economic, social and environmental) using effective and efficient policy instruments; and
4. As mentioned above, if developed nations are willing to downscale their production and consumption to increase human wellbeing and enhance ecological conditions, this will have certain implications for Africa.

METHODOLOGY AND DATA

A descriptive illustration and weighted least square (WLS) regression econometric analysis was applied to build the influence of variables in the modelling. Descriptive statistics were used to assess differences in the basic characteristics of the macroeconomic variables that can influence or affect the MPI. Furthermore, principal component analysis (PCA) was performed to avoid multicollinearity problems and to improve the estimation power of the regression. Out of 21 variables, PCA extracted 12 variables relevant to the analysis. The econometric equation is constructed as follows:

$$MPI = \alpha_1 EXDEBTG + \alpha_2 GEXP.GDP + \alpha_3 INFL.GDP + \alpha_4 GDPGRWTH + \alpha_5 SAVGRWTH + \alpha_6 CREDP.GDP \\ + \alpha_7 MILL.GDP + \alpha_8 TRAD.GDP + \alpha_9 AGR.GDP + \alpha_{10} HBLTH.GDP + \alpha_{11} POP.GRWTH \\ + \alpha_{12} GINICOEF + \varepsilon$$

Where: MPI is as calculated for 104 developing countries by Alkire and Santos (2010) in the oxford poverty and human development initiative (OPHI). This is identified the first multidimensional poverty estimation using micro datasets (household surveys) for such a large number of countries, covering about 78% of the world's population. The MPI has the mathematical structure of one of the Alkire and Santos poverty multidimensional measures and is composed of 10 indicators, corresponding to the same three dimensions as the HDI: Education, Health, and Standard of Living. The MPI captures a set of direct deprivations that afflict a person at the same time. This tool could be used to target the poorest, to track the millennium development goals, and to design policies that directly address the interlocking deprivations experienced by the poor.

The MPI reveals the combination of deprivations that afflict a household at the same time. A household is identified as multi-dimensionally poor if, and only if, it is deprived in some combination of indicators with a weighted sum of 30% or more of the dimensions. The dimensions, indicators and deprivation criteria are contained in the Appendix. The MPI is the product of two numbers: Headcount (H), or percentage of people who are poor, and average intensity of deprivation (A), reflecting the proportion of dimensions in which households are deprived. Alkire and Santos show that this measure is very easy to calculate and interpret, is intuitive yet robust, and satisfies many desirable properties.

The independent variables sourced from the World Bank (2012) database were those relevant variables extracted by PCA, namely: External debt stocks (% of GNI) (EXDEBTG), Government expenditure ratio to GDP (GEXPGDP), Foreign direct investment, net inflows (% of GDP) (INFGDP), GDP growth (annual %) GDPGRWOTH, Gross domestic savings (% of GDP) (SAVGRWTH), Domestic credit to private sector (% of GDP) (CREDP.GDP), Military expenditure (% of GDP) (MILL.GDP), Trade (% of GDP) (TRAD.GDP), Agriculture, value added (% of GDP) (AGR.GDP), Health expenditure, total (% of GDP) (HELTH.GDP), Population growth (annual %) (POPGRWTH), Gini coefficient (GINICOEF), and Error term.

RESULTS AND DISCUSSION

Figure 1 illustrates the 1960 to 2010 growth performance for four groupings of countries in the region: conflict-affected countries (11), non-conflict lower-middle-income countries (12), upper-income countries (6), and non-conflict
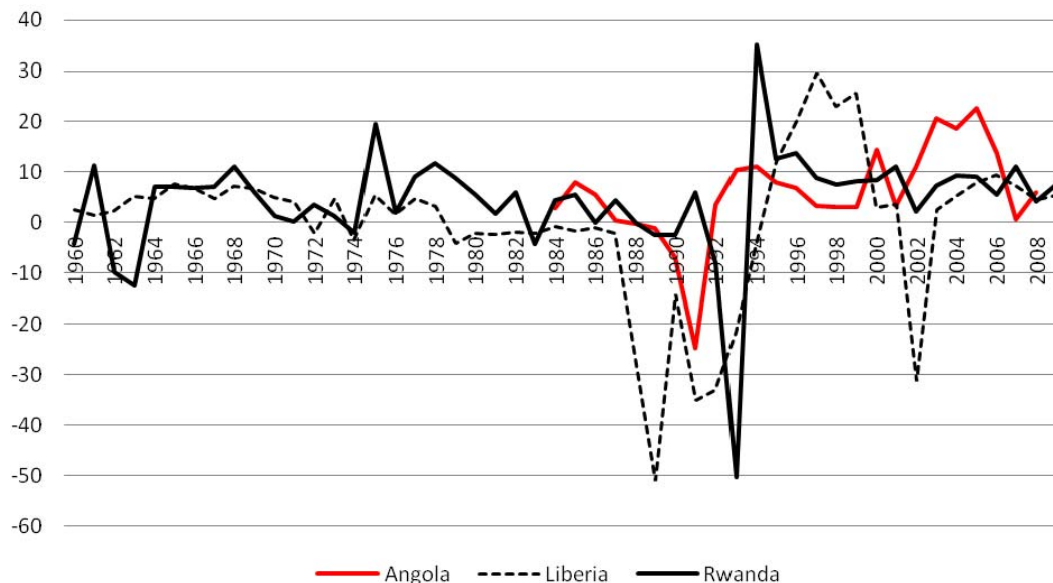
Figure 2. GDP annual percentage growth among conflict-history countries (Angola, Liberia and Rwanda), 1960 to 2010. Source: Own representation based on World Bank (2012) dataset.

low-income countries (16).

In the upper-income categories, Botswana's growth gave a misleading impression of significant improvement; however, Botswana showed exceptional growth performance of 21 to 26 % from 1970 to 1972 and again in 1987. According to a study by Maipose (2008), this was mainly due to the following reasons:

1. From 1975 to 1989, known as the second period in the history of Botswana, and characterised by the end of colonial rule, Botswana experienced the introduction of a multiparty democratic system of government under the inherited market-based economy, as well as the integration of traditional institutional structures into modern institutions, underlined by a policy stance that sought to maximise the flow of foreign capital, aid and private investment, resulting in the moderate growth of the time; and

2. The third period, covering the whole of the 1990 and the new millennium (though overlapping to some degree with the end of the 1980s), saw the start of a new policy environment, signalling the end of the state-led development strategy and a new reorientation towards private-sector-led development with the emphasis on economic diversification, export competitiveness, and privatisation options (Maipose, 2008).

The records for the low-income group of 16 countries fluctuate less than 5%, with the exception of the period 2006 to 2007, with growth of around 6% (Figure 2). This result was not a true reflection of the whole low-income grouping of SSA; rather it was the result of good economic growth in Guinea in 2006 and 2007 (22 and 18% respectively). Growth in per capita income averaged a mere 0.2% during the 1990s, rising to only 1.2% from 2000 to 2005. This lacklustre performance underscores the need for more expansionary and investment-focused macroeconomic policies. The recovery of gross domestic product (GDP) growth in conflict-affected countries, specifically after 1992, shows the annual GDP growth trend in most of those countries catching up with the rest of Africa's groupings, mainly due to certain policy changes. On the other hand, middle-income countries have been showing a drop in performance since 1994, while only modest improvements have been observed in low-income countries.

Figures 3 show the global debt as a percentage of GDP. As indicated in Figure 3, the majority of the countries' debt-to-GDP ratio is very high. The rationale behind acquiring high debt in most SSA countries is that it is believed to: (i) promote private consumption; (ii) promote public investment; (iii) increase total factor productivity (TFP), and (iv) raise sovereign long-term nominal and real interest rates. As a result, the government policy perspective is geared towards financial injections to support longer-term economic growth, but this policy becomes unsustainable and dangerous and may lead to a collapse in the economic prospective of nations and the wellbeing of societies.

The SSA international debt situation is growing ever more serious, while military expenditure is increasing simultaneously. According to WFP (2009) records, SSA remains the top food-aid receiver worldwide. Erratic climatic conditions along with other problems have placed SSA economies in the vicious cycle of economic underdevelopment (Figure 4). Worst of all, existing
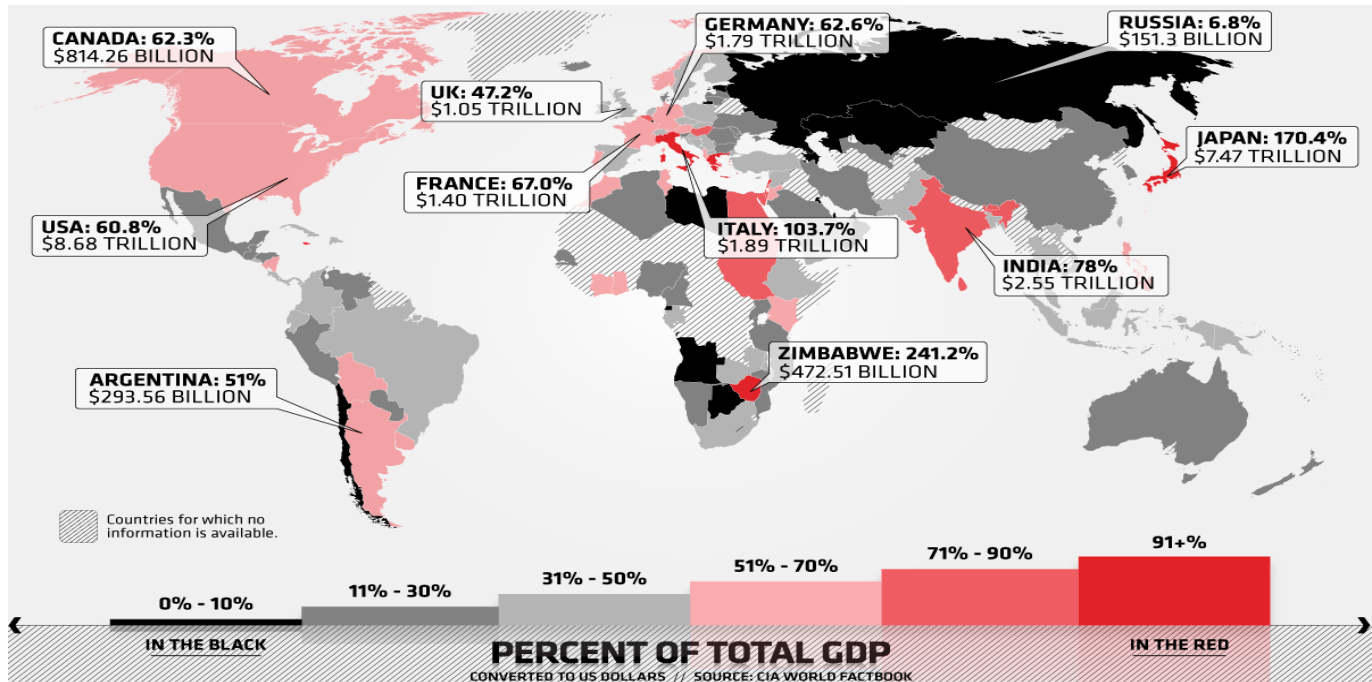
Figure 3. National debt by country, 2009. Source: CIA (2012).

ambitions of war and a lack of effective and efficient policies for development planning make SSA the front runner for a triple crisis (environmental, social and economic). The crucial questions are therefore: Why has economic development policy and cultural change been so difficult to attain in SSA? What might have gone wrong? Have the problems associated with SSA economic theory been diagnosed incorrectly, or have economic theories of development been applied incorrectly? Or are there other factors that have not yet been explored or identified that need to be addressed through other appropriate policies? And where does Africa go from here?

Some of the main reasons for Africa's stagnation in economic development can be summarised as follows:

1. Good leadership, as a prerequisite for economic growth, includes the need to create a secure environment for property, political stability, social harmony, and a respected legal code that protects the rights of owners. Additionally, SSA nations need to offer infrastructure such as roads, ports, airports, railways, electricity, water, telecommunications, and a well-educated and skilled labour force (Friedman, 2006; Sandbrook, 1985). However, the majority of African states have failed to supply the aforementioned basic services, and little has been done thus far in this regard (Mills, 2010);
2. Failure to diversify out of primary product exports led to serious policy failures in poor countries following independence. In 1950, SSA accounted for 3% of world exports, but five decades later that share had dropped to 1.5% (Mills, 2010). For example, although oil revenue in Nigeria increased by 885% over 35 years, the number of people living on less than $1 per day increased by 535%, which means an annual increment of 25% and 15%, respectively. In addition, SSA is a net importer of food, whereas Asia and Latin America have doubled or tripled their agricultural production over 30 years. Another example of policy failure is Zambia, which saw a number of sectors collapse due to poor government policy choices, such as: i) government investing in certain sectors rather than acting as a regulatory body; and ii) government later privatising those sectors while the industries were still in their infancy (Mills, 2010);
3. Notable structural factors include political and ethnic bias, excessive control of political power, economic policies that are discriminatory to the poor (Bates, 2003), and ineffective conflict resolution mechanisms with regard to disputes;
4. According to Ayittey (1998), many indebted African countries have a debt service ratio of about 40%, meaning that for every US dollar earned on exports of domestically produced goods, 40% go towards servicing the debt, while the rest goes towards covering imports, military expenditure, production improvements, education, healthcare and other expenses; and
5. African governments were pushed/forced by international monetary fund (IMF) policies to take certain actions that were not domestically feasible.

To support the above arguments from the empirical evidence, the study applied econometric equations to test
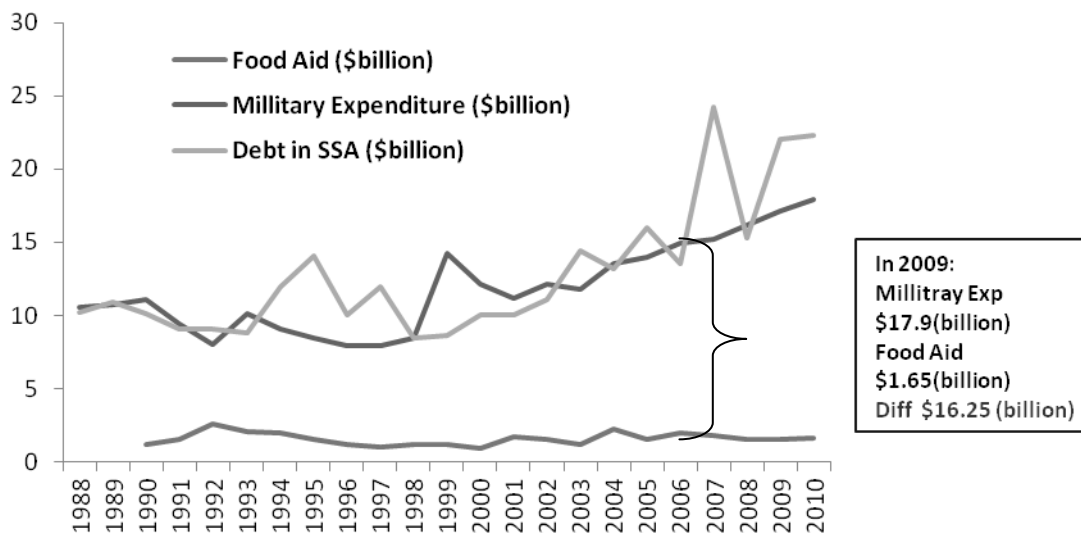
Figure 4. Comparison of debt, food aid and military expenditure in SSA, 1988 to 2010. Source: Own representation based on IMF and UNDP data.

Table 1. Macroeconomic factors influencing levels of poverty in Sub Saharan Africa: Weighted Least Square (2009).

Coefficients	B	Std Error	Beta	t	Sig "t"
EXDEBTG	0.001	0.001	0.096	0.795***	0.095
GEXPGDP	-0.001	0.002	-0.071	-0.478	0.638
INFLGDP	0.001	0.003	0.033	0.240	0.812
GDPGROWTH	0.014	0.007	0.249	1.964***	0.062
SAVGRWTH	-0.003	0.001	-0.634	-2.244**	0.035
CREDP.GDP	-0.004	0.002	-0.262	-2.175**	0.041
MILL.GDP	-0.057	0.020	0.440	2.908*	0.008
TRAD.GDP	-0.003	0.001	-0.727	-0.339*	0.003
AGR.GDP	0.002	0.002	0.211	1.110	0.279
HELTH.GDP	-0.014	0.006	-0.288	-2.250	0.0358
POPGRWTH	0.102	0.025	0.445	4.080	0.001
GINICOEF	0.138	0.169	0.097	0.816	0.423
(Error Term)	0.512	0.174		2.936	0.008
R -Square					0.800
Adjusted R Square					0.692
ANOVA					0.00
F-test					7.36
No. of Observations					34

*, ** and *** significance level at 1, 5 and 10% respectively.

the hypothesis to 34 SSA countries. After conducting the necessary statistical tests, including the relationship among the macroeconomic variables and key determinants/attributes that can contribute to MPI in the SSA region, the ordinary least square (OLS) econometrical model was applied to the cross-sectional 2009 dataset of the World Bank related to MPI. Furthermore, due to the presence of heteroscedasticity and multicollinearity, WLS was the selected estimator.

As shown in Table 1, the overall adjusted explanatory power for export determinants was estimated at 69%. The ANOVA result shows that it is significant at the 1% level, suggesting that there is a linear relationship among the variables (Table 1). With the exception of FEXPGDP, INFLGDP, AGR.GDP and GINICOEF (not significant and not reported in Table 1), all other variables were found to be statistically significant at the specified level of significance. Furthermore, all variables were found to hold the expected sign. However, POPGRWTH was determined to hold a greater positive magnitude of its
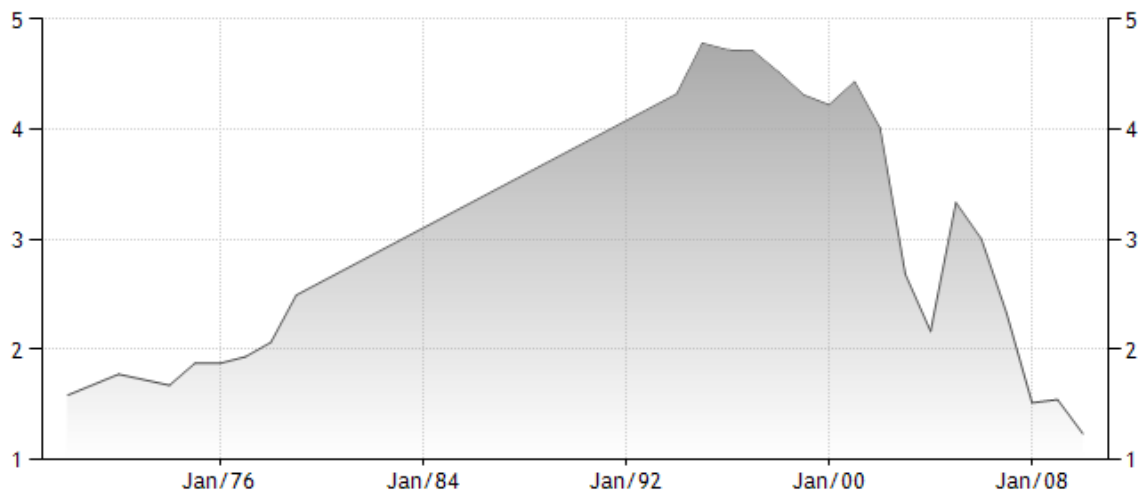
Figure 5. Total debt service (% of GNI) in SSA. Source: World Bank (2012).

estimated coefficient at 0.102, showing that population growth is the greatest challenge to economic growth in SSA.

External debt ratio to GDP (EXDGDP) was found to be significant at 10% and positive, thus implying that external debt contributed significantly to the MPI in SSA (Figure 4). The long-term debt crisis, along with a multitude of other problems, has crippled economic growth in SSA. The World Bank (2012) reported some good news, with debt servicing showing a significant improvement, amounting to 4.6% of GNI in 1996 to 1997. This is due to substantial external debt relief, which has liberated fiscal space in SSA (Figure 5). The IMF (2011) reported that deficits have been increased beyond sustainable medium-term paths; these should be revisited so that policy buffers can be restored. Whereas output remains well below potential, there is a strong case for fiscal policy to help sustain demand in the near term, subject to financing availability.

The four core components of macroeconomic policy that can drive higher GDP growth include government spending, investment spending, savings, and trade balance. This model shows that the first two variables were found not to be significant, meaning that these variables do not play a role in driving higher economic growth, whereas the second two (savings and trade balance) were found to be negatively related and significant at 5 and 1%, respectively. However, the annualised GDP growth is at a very slow pace compared to population growth, implying that SSA economic growth is not growing at the same pace as population growth to support poverty reduction strategies in SSA. According to a recent IMF (2011) report, the limited integration of many countries in the region into the global economy may have helped, but only marginally. Previous (milder) global economic slowdowns had a much more damaging impact. This time, the global downturn was much

sharper, but the dislocation was far less. The main factor distinguishing this slowdown from previous cycles has been the stronger macroeconomic position of most countries in the region.

The credit to private sectors ratio to GDP (CREDP.GDP) is negatively related to MPI and is significant at 5%, implying that there is improvement in credit access to private sectors, which can stimulate trade and investment and thereby have a positive impact on good economic growth performance. Military expenditure showed a negative and significant influence at 1% to the MPI, thus implying that if SSA can reduce military expenditure, resources could be redirected to other basic services, such as health, education and R&D, which would best support economic growth. As reported by the World Bank (2012), military expenditure as a percentage of GDP in SSA accounts for 1.57%, whereas there is zero allocated budget for R&D. Additionally, Figure 4 shows a comparison between the military expenditure (estimated at $25 billion) and food aid (estimated at $1.65 billion) in SSA in 2009. Reducing the military budget would have allowed SSA to fill the food deficit from its own resources.

Conclusions

The objective of this paper is to test the relationship between macroeconomic variables and poverty alleviation in SSA. The study applied descriptive analysis and a WLS econometric model to test the relationship between the MPI and basic macroeconomic variables, and further applied PCA to extract the relevant variables that explain the dependent variable (MPI) (Annexure Figure A1 to A5). The paper analysed some of the key trends of macroeconomic variables, and further tested the relationship between macroeconomic indicators and the MPI.

With the exception of GEXPGDP, INFLGDP, AGR.GDP and GINICOEF (not significant and not reported) all other variables was found to be statistically significant at the specified significance level. Furthermore, all variables were found to hold the expected sign. However, POPGRWTH was found to hold greater positive magnitude with an estimated coefficient of 0.102, showing that economic growth is moving at a slower pace than population growth, thus complicating the economic development agenda on the continent.

The major causes of instability in economic growth for SSA can be summarised as: (i) fluctuations in the terms of trade, which impact directly on aggregate demand via export and import prices, affecting the fiscal balance through trade taxes, and tightening or loosening the balance of payments constraint; and (ii) variations in weather, which largely determine the performance of rain-fed agriculture in a region where irrigation is limited. Both these factors are beyond the direct management of SSA governments in the short and medium term, although the effect of the latter could be reduced in the long run by structural changes in the agricultural sector.

The simplest element to specify is how to raise the economic growth rate. Setting aside exogenous factors such as weather effects, the major limitations to more rapid growth are: (1) restrictive fiscal policy; (2) contractionary monetary policy in most countries; and (3) a balance of payments constraint. Furthermore, it is important to improve local capabilities and inter-firm linkages in view of achieving well-managed privatisation, while subsidies to reach the poor are equally important.

It is highly recommended that SSA countries have effective human capital policy, improved infrastructure and good governance, thus:

1. Human capital policy, investing in education and health, focusing on quality and outreach for the poorest, e.g. by providing public goods and institutions;
2. Infrastructure, enabling the poorest to take part in growth opportunities as a result of trade liberalisation, e.g. by providing infrastructure;
3. Addressing asset and income inequality directly through redistribution via transfer and safety nets; and
4. Good governance, focusing on institutions and other factors that drive pro-poor policies and outcomes.

Lastly, it is important for SSA countries to manage debt crises properly, to reduce military expenditure, to improve conflict resolution mechanisms, to invest more in basic services and to emphasise R&D as a means to focus on export orientation capacity.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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ANNEXURE

Variables used in calculating MPI

1. Health (each indicator weighted equally at 1/6):

➢   **Child Mortality:** If any child has died in the family;
➢   **Nutrition:** If any adult or child in the family is malnourished.

2. Education (each indicator weighted equally at 1/6):

➢   **Years of Schooling:** If no household member has completed 5 years of schooling;
➢   **Child School Attendance:** If any school-aged child is out of school in years 1 to 8.

3. Standard of Living: (each of the six indicators weighted equally at 1/18):

➢   **Electricity:** If household does not have electricity;
➢   **Drinking Water:** If it does not meet MDG definitions, or is more than 30 min walk;
➢   **Sanitation:** If it does not meet MDG definitions, or the toilet is shared;
➢   **Flooring:** If the floor is dirt, sand or dung;
➢   **Cooking Fuel:** If the household cooks with wood, charcoal or dung;
➢   **Assets:** If the household does not own more than one radio, television, telephone, bicycle, motorbike or refrigerator, and does not own a car or truck.
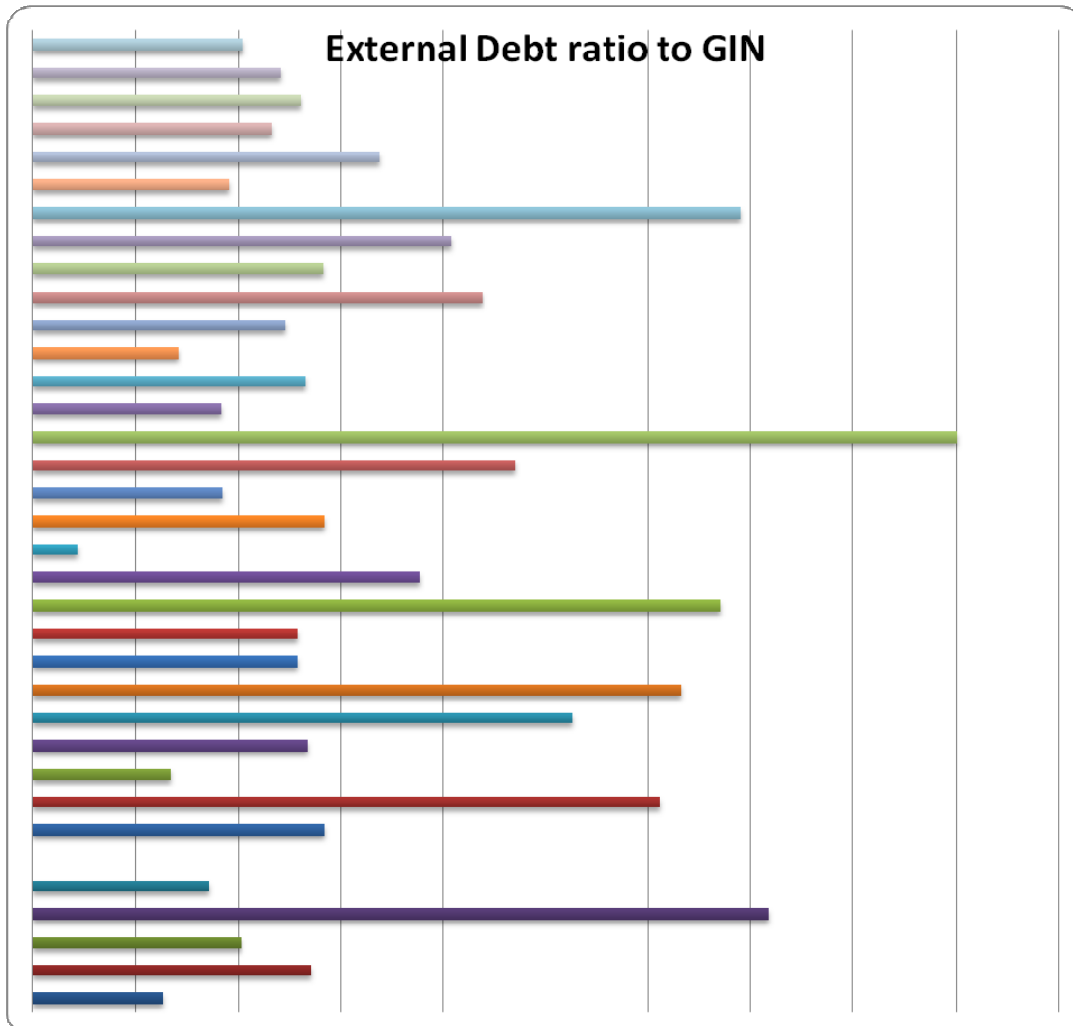

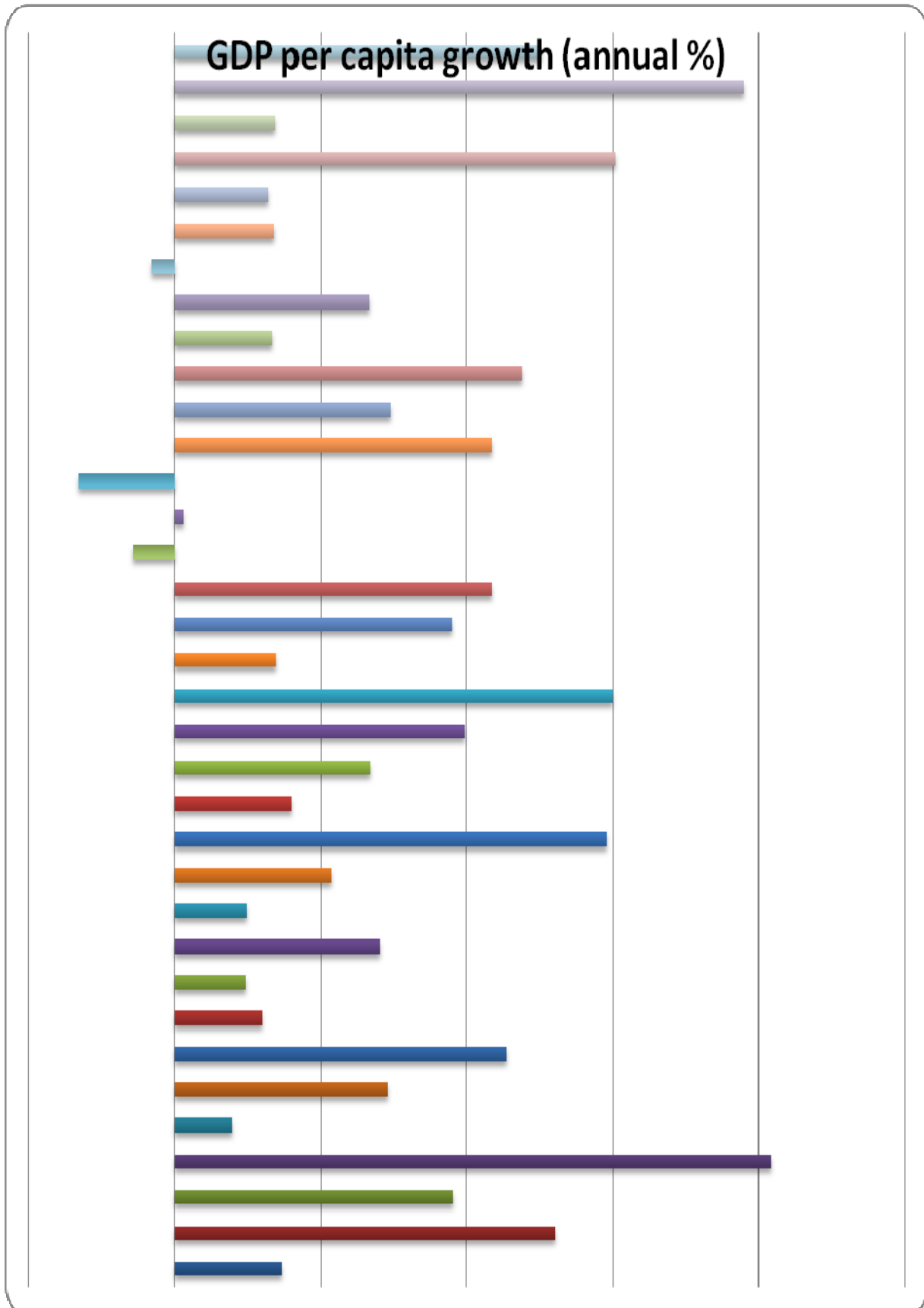**Figure A1.** External debt ratio to GNI, 2009.

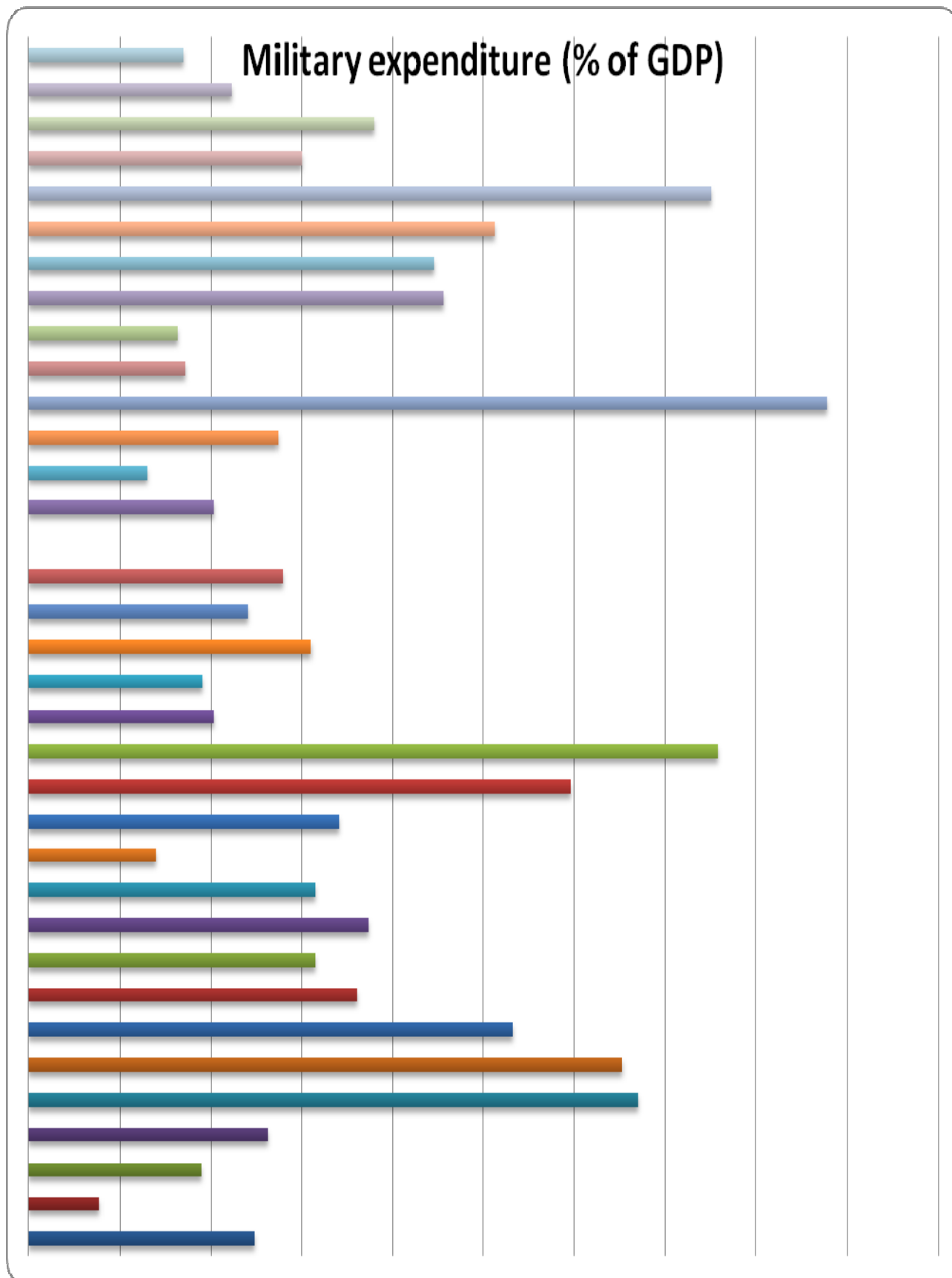**Figure A2.** GDP per capita growth (annual %), 2009.

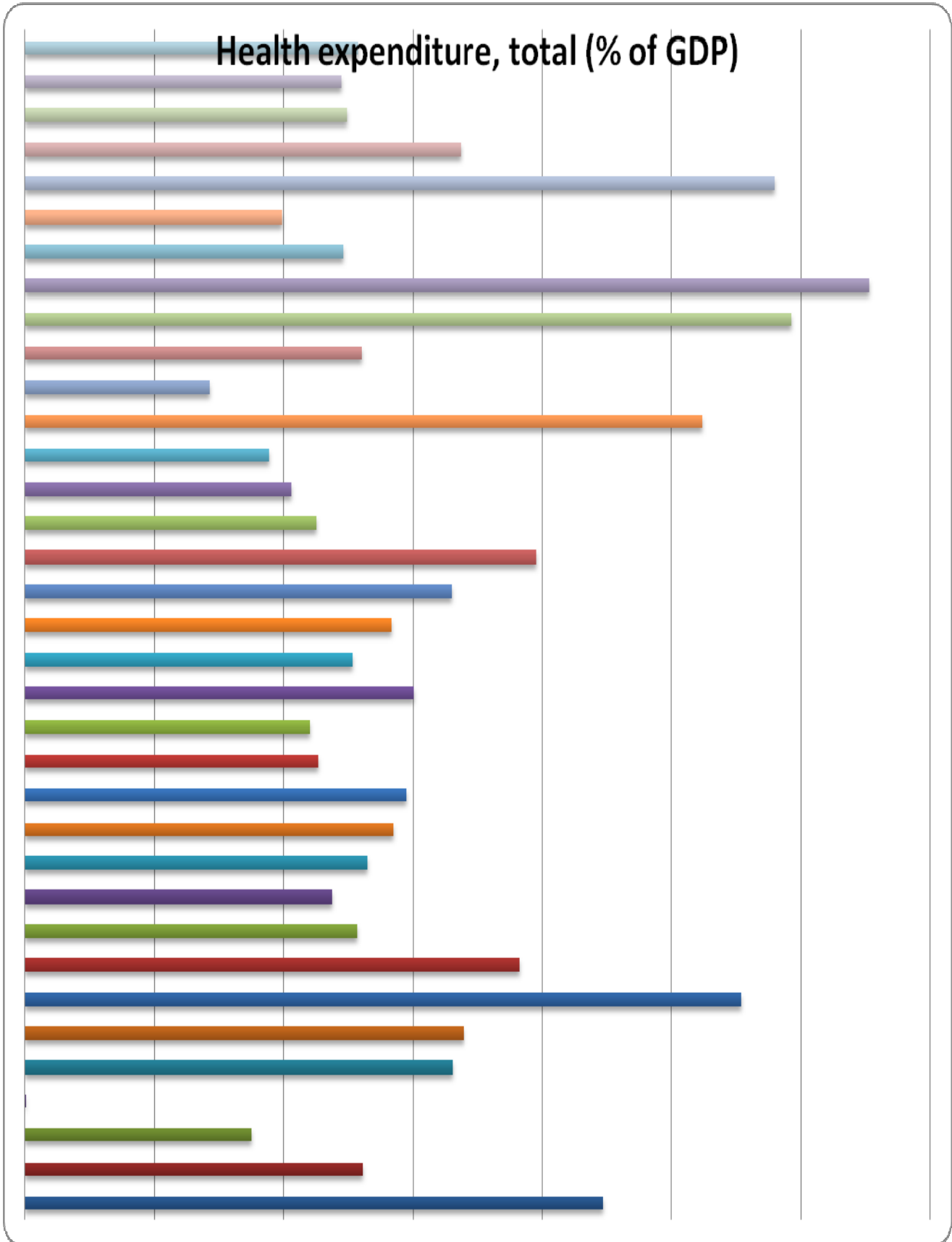**Figure A3.** Military expenditure (% of GDP), 2009.

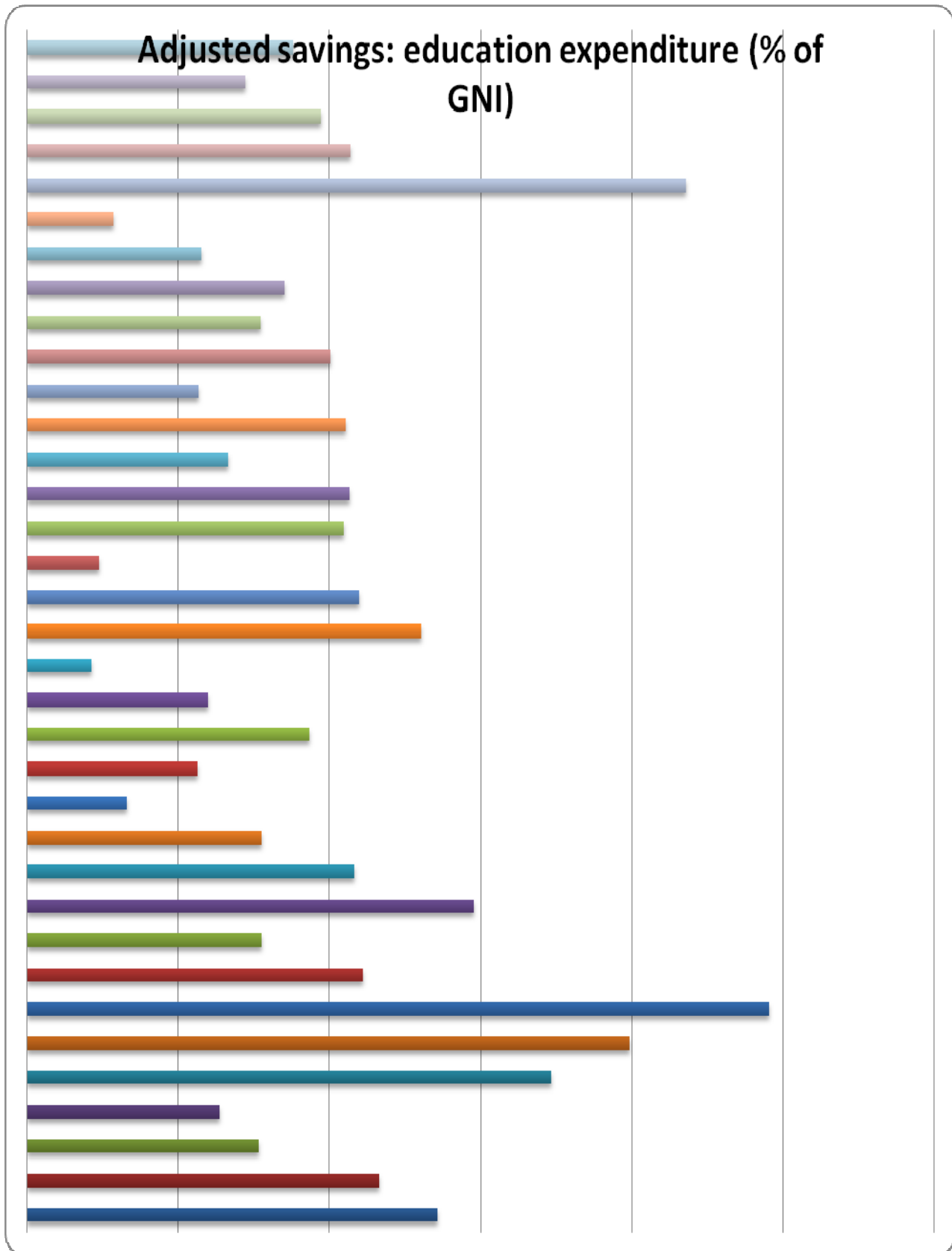**Figure A4.** Health expenditure (% of GDP), 2009.

Figure A5. Education expenditure (% of GNI), 2009.

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