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Effect of early and late water stress on the growth and storage root yield of ten sweet potato genotypes

Maia Wamala[1] and Shamsul Akanda[2]

ABSTRACT

An experiment involving ten sweet potato (*Ipomoea batatas* (L.) Lam) genotypes was conducted at the Papua New Guinea (PNG) University of Technology, Lae during the 2005 - 2006 cropping season to evaluate their drought tolerance and yield potential under water stress conditions. Water stress prolonged beyond 35 days during the vegetative and storage root development stages affected the phenological developments of all genotypes. Total storage root yield in genotypes MUIB007, MUIB011, MUIB013, MUIB057, MUIB058 and B11 were comparatively highcompared to the other genotypes indicating early storage root formation and early maturity. Genotypes MUIB 005, MUIB 015, MUIB 034 and MUIB 035 with low to very low storage root yield were late maturing. At final harvest (146 DAP) significant ($P \leq 0.05$) storage root yield reduction from as little as 0.94 % in MUIB 058 to the highest of 58.51% in MUIB 011 were observed under the stressed condition compared to the corresponding storage root yield under irrigated condition. Similarly, the marketable storage root yield at the final harvest was significantly ($P \leq 0.05$) reduced in most genotypes compared to irrigated condition. Total storage root weights at 146 DAP under irrigated and stressed trials showed highly significant ($P \leq 0.05$) differences among the genotypes. Marketable storage root weight had strong significant positive correlation with total storage root weight both under irrigated (0.0.80**) and stress trial (0.58*). Similarly, vine weight had significant ($P<0.01$) positive correlation with leaf area (0.77) in the stress trial, but was negatively correlated to drought score (-0.20) and storage root dry matter (-0.69).

Key words: Water stress, growth and development, sweet potato genotypes.

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) is a major root crop in Papua New Guinea (PNG) grown under rain-fed condition and is prone to water stress. The water stress can occur at any stage of the crop growth. The crop is very sensitive to water deficit, especially during early stages (prior to storage root formation) of crop growth affecting vine development and late stages during assimilate translocation (Indira and Kabeerathumma, 1988). Drought is often considered as the major limiting factor for sweet potato production in areas where it is grown under rain-fed conditions. Anselmo *et al*. (1998) and El Sharkawy and Cadavid (2002) reported genotypic variability among sweet potato cultivars in tolerating desiccation under severe moisture stress during vegetative and establishment stage, and in recovering from stress. Valenzuela *et al*. (2000) found that different cultivars may respond differently to limited quantities of soil water. Prolonged drought stress can significantly reduce the storage root yield and quality (El Sharkawy and Cadavid, 2002).

Rainfall is unevenly distribution in PNG. As such, it is important to find out the effect of both early water stress (i.e. stress at vegetative growth stage) and late water stress (i.e. stress at maturity stage) on sweet potato production under PNG lowlands condition so that farmers can adjust the time of planting to avoid water stress, otherwise that would adversely affect the yield and quality. The use of drought tolerant genotypes and better water management practices can

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improve the yield and quality of sweet potatoes. Selection of cultivars expressing superior characters that confer tolerance to water stress is of prime importance for the farmers of PNG. Therefore, this study was conducted to evaluate the effect of soil water stress prior to and after storage root initiation on the growth performance and yield of 10 sweet potato genotypes.

MATERIALS AND METHODS

Experimental Site

Two experiments were conducted at the Agriculture Department Farm of the PNG University of Technology (6° 41´S, 146° 98´E), Lae, PNG in 2006. The farm is situated at an elevation of 65 and is classified as having Lowland per humid climate (McAlpine *et al*., 1983).The site receives an average of 10 sunshine hours per day, minimum and maximum temperatures of 23 °C and 30 °C respectively; an average relative humidity (RH) of 77 %, and an annual rainfall of 4,700 mm.

Soil type

Soil samples collected from the site were analyzed for texture using the "Glass Jar and Triangular Method" which showed that the soil is sandy loam. The soil is shallow, fertile, well drained with clay content of 45% in the surface and the soil pH was 4.5-5.2 indicating its acidic nature. The soil of the experimental site was previously cropped with taro (*Colocasia esculenta*), peanut (*Arachis hypogeae*) and maize (*Zea mays*) and then fallowed with Johnson grass (*Rottboelia exaltata*) and kunai (*Imperata cylindrica*) for five years. During previous cropping and the land preparation before planting, farm implements, including tractor mounted disc ploughs and harrows were used, hence may have disturbed the soil structure of the area .

Experimental Design

The experiment involved two adjacent trials with different watering treatments. Each trial consisted of ten genotypes with four replications arranged in a randomized complete block design with each of the treatment plots having dimensions of 3m x 5m.

a) Irrigated Trial

This trial received 1,172 mm of rain from the time of sowing to final harvest. During the days of no rain, overhead sprinkler irrigation of 400-560 mm was supplemented for the the short fall with two irrigations per week. What is the volume of water applied?

b) Early and Late Stress

Water stress was created by covering the entire experimental area by a temporary rain-out shelter. Before the construction of the Rain-out shelter, both trials irrigated and stress trials received similar amounts of water. A temporary Rain-Out shelter measuring 22 m x 26 m and 3.5 m high was built over the experimental plot after 60 days of growing under normal adequate well watered conditions in the same manner as the irrigated trial. Stress was imposed by excluding water and rain from the plot by pulling the clear plastic tarpaulin on top of the constructed building frame over the plot. The first stress lasted for 35 days from 61 – 95 days after planting (DAP). The second stress was applied during the storage root sinking stage towards maturity from 116 – 146 DAP. Stress was relieved after the respective duration by removing the rain-out shelter.

Land Preparation and Cultural Details

The experimental sites for the two trials were fallowed with corn?? grass (*Rothboelia exaltata*) during the previous years and were ploughed and harrowed with the Massey Ferguson 4600 Tractor three weeks before planting. A compound fertilizer (12:12:17) was applied at the time of planting at 80 kg N ha^{-1}. Vine cuttings of 30 cm length for all genotypes were collected and planted on raised flat beds at 70 cm between rows and 50 cm between plants. A top dressing of 50 kg N ha^{-1}as ammonium sulphate was applied four weeks after planting. Weeds were controlled by frequent hand weeding until development of the full canopy to cover the ground.

Data Collection

Data were collected on both below (storage roots) and above ground plant parts (i.e. vines, leaves, petioles) during each harvest at 60, 95, 116 and 146 DAP. At each harvest 6 plants were randomly harvested on every adjacent row excluding the guard rows. At each sampling, plant tops were cut 2-4 cm above ground level while storage roots were dug out using the manual garden fork. Samples were weighed fresh, and then dried in oven at 70°C for at least five days to have the dry weights.

Vine Weight

Fresh vine weight and vine dry weights at each harvest from six randomly sampled plants

were recorded. Vine dry weights were taken at each sampling occasions after drying the vines for four days in the oven at 50-60ºC.

Total Storage root Weight

Harvest was done at different days after planting to observe the tuber dry matter accumulation at progressive growth stages. During each harvest at 60, 95, 116 and 146 DAP, all storage root formed were counted, washed and weighed to obtain a total storage root weight for each of the treatment plot.

Marketable Storage root Weights

Marketable storage root number and weight were taken by separating the marketable from non-marketable storage roots. Marketable storage roots are storage root sizes ranging from medium to large and weigh more than 750 g and can be sold at market for consumption.

Storage root Dry Matter

Five hundred grams of fresh storage roots from each the genotypes during the respective harvest was sliced and dried in the oven at 50-60ºC for three days to measure storage root dry matter (SRDM). SRDM was then divided by the plot area (m^2) to calculate the dry matter production per unit area.

Leaf Area (LA)

Leaf area (cm^2) was measured before, during and after stress for all the genotypes. Fifty fully developed leaves were randomly collected from each plot. LA was measured using the portable Leaf Area Meter (Model: L1 3000A, Brand Name: LI-COR

Drought Score

Effect of water stress was visually assessed on a 1-5 scale following the Drought Evaluation System devised by International Rice Research Institute (IRRI, 1975) for rice. This system, was modified for sweet potato, where 1=leaves green; 2= dry tips on some leaves; 3= dead tips on most leaves; 4= dead tips longer than 5 cm; and 5= all leaves with dead tips longer than 8 cm.

Statistical Analysis

Data collected on total fresh storage root yield, marketable storage root yield and storage root dry matter were subjected to Analysis of variance (ANOVA). Least significant differences (LSD) and Duncan Multiple Range Test (DMRT) were used to determine the treatment mean differences for the selected parameters. Data on mean leaf area and fresh vine weight were graphed against date of harvest to determine the effect of water stress. Correlations coefficients analysis by Pearson (normal) or Spearman's rank among important characters were also calculated to investigate if various growth parameters were strongly dependent on each other.

RESULTS

Total Storage root Fresh Weight

At 60 DAP harvest, just before the imposition of water stress; the genotypes differ widely in terms of storage root yield. Genotypes B11, MUIB 005, MUIB 035, MUIB 013 and MUIB 015 had comparably higher yield than the rest of the genotypes in the irrigated trial. In the stress trial (before imposition of the stress) MUIB 057, MUIB 013, MUIB 011 and MUIB 058 performed better than the rest of the clones.

At the second harvest of 95 DAP, 35 days after the imposition of water stress (61 DAP – 95 DAP), all the genotypes responded differently to water stress. Total storage root yield decreased in all the genotypes compared to the corresponding yield under the irrigated condition except for MUIB 013, MUIB 034 and MUIB 058, where they had the higher storage root yield. Under irrigated condition, MUIB 035 had the highest storage root yield of 475.5 g and the lowest being 130 g in MUIB 013. But under the stress trial, B11 had the highest yield of 285 g and the lowest of 110 g with MUIB 011. The overall mean storage root yield of the genotypes under the stress trial was 1.98% lower than the corresponding genotype mean under the irrigated condition and this difference in means was not significant.

At 116 DAP (i.e. 21 days)_ after the withdrawal of water stress by removing the rain-out shelter and re-watering, the genotypes showed high variability in terms of recovery and storage root production. Almost all the genotypes had reduced storage root yield compared to the corresponding yield under the controlled condition except for MUIB 007, MUIB 034, MUIB 057 and MUIB 058, where these genotypes had higher storage root yield than under the irrigated condition. Overall, the mean storage root yield under the stressed condition was 12.18% lower than the corresponding mean storage root yield under the irrigated condition and that difference was significant at $P \leq .05$.

At the final harvest of 146 DAP, just after the second water stress (96 - 146 DAP), almost all the genotypes were affected with reduction in storage root yield ranging from as little as 0.94% in MUIB 058 to the highest of 58.51% in MUIB 011 compared to the corresponding yield under the controlled condition. However, MUIB 007, MUIB 013 and MUIB 034 recorded higher storage root yield by 1.73%, 38.22% and 15.42%, respectively. The overall mean storage root yield under the stressed condition (early + late) was 26.53% lower than the mean under the irrigated condition and this difference was significant ($P \leq 0.01$).

Treatment mean comparisons of the total storage root weights for the ten genotypes under stress and irrigated condition at maturity (146 DAP) are shown in Table 1. Significant differences in treatment means for storage root weights were observed in both the trials. Under the stressed condition, fewer variations were observed among the genotypes in terms of total storage root weight. MUIB 034 had the highest yield of 2,679.5 g and the lowest being 1,045 g in case of MUIB 011. The difference of the means was significant at $P<0.05$. Again, the storage root weights of MUIB 034, MUIB 007, MUIB 035 and MUIB 005 did not differ significantly from MUIB 013, MUIB 057, MUIB 058, MUIB 015 and B 11.

Wider variations in terms of total storage root weights were observed under the irrigated condition (Table 1). B 11 produced the highest storage root yield of 3836.8 g and that was not significantly different from MUIB 035 and MUIB 005; but was significantly higher than MUIB 013, the lowest yielding genotype and MUIB 058, MUIB 034, MUIB 007, B 11, MUIB 057 and MUIB 015. Moreover, the mean yield differences among MUIB 057, MUIB 011, MUIB 007 and MUIB 034 were also insignificant.

Marketable Storage root Weight

It was noted that none of the genotypes produced any marketable storage roots until 116 DAP, as a result, Table 2 shows only the marketable storage root yield at 116 and 146 DAP.

At harvest 116 DAP, marketable storage root yield ranged from 234.8 g in MUIB 058 to 2033.2 g in B 11 under the irrigated condition. However, under the stressed trial, most of the genotypes had higher marketable storage root yield compared to the corresponding irrigated condition except for MUIB 013, MUIB 011 and B 11. The mean marketable storage root yield for the stress trial was 56.20% higher than the corresponding mean under the irrigated condition and this difference in means was significant ($P \leq 0.05$).

During the final harvest at 146 DAP i.e. after the impositions of second water stress at 116 DAP, most of the genotypes had reduced marketable storage root yield compared to the irrigated condition. However, MUIB 007, MUIB 034, MUIB 057 and MUIB 058 had higher yield compared to the same under irrigated condition. Marketable storage root yield ranged from the lowest of 565.4 g in MUIB 058 to the highest of 2769.2 g in B 11 in the irrigated trial, but under the stressed condition, the lowest marketable yield of 492.8 g was produced by MUIB 013 and the highest of 1585.5 g by MUIB 035.

The mean marketable yield of the genotypes under the stress trial (early + late) was reduced by 20.88% from the corresponding mean under the irrigated condition and this difference in means was significant ($P \leq 0.05$).

Vine Weight

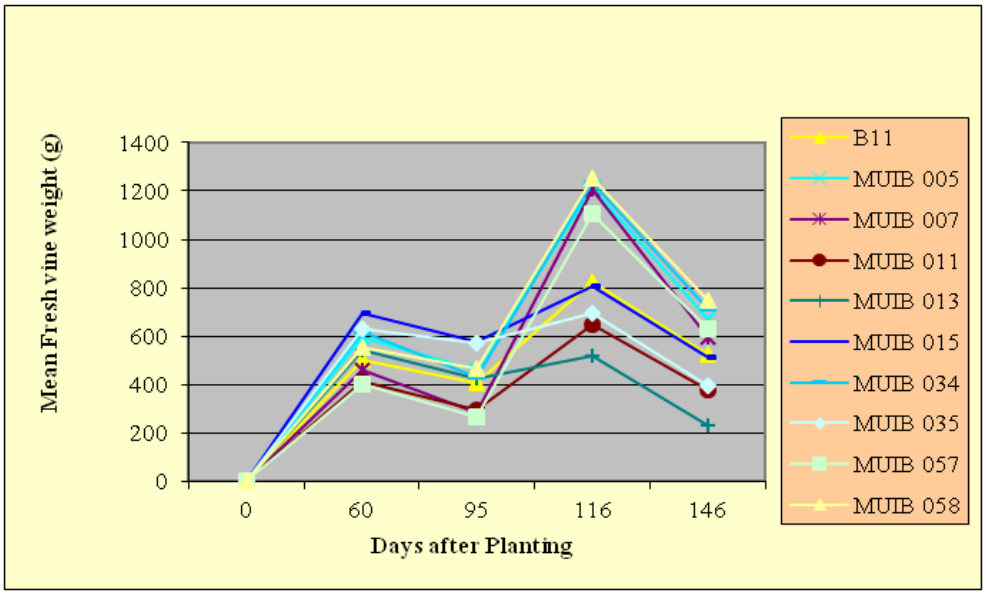
In the stress trial, the vine weights of all the genotypes increased steadily during the early growth phase (up to 60 DAP). With the imposition of water stress at 61 DAP, the vine weights of all the genotypes reduced drastically even though the genotypes differed in their responses. After 95 DAP, with the withdrawal of water stress by removing the rain-out shelter and re-watering, all the genotypes recovered and vine weights increased quite dramatically. Fresh vine weights of all the genotypes dropped sharply again with the imposition of late water stress on 116 DAP. On the contrary, vine weights for all the genotypes increased steadily under the irrigated watered condition even though differed significantly in the mean fresh vine weights.

Storage root Dry Matter (TDM)

The total dry matter for the 10 genotypes under irrigated and stressed condition is presented in Table 3. At 60 DAP before the imposition of stress, the mean TDM of the two trials did not differ significantly. MUIB 013 had the highest TDM both under the stress and controlled condition at 95, 116 and 146 DAP harvest.

The average TDM reduction under the stressed condition at 95, 116 and 146 DAP were 7.40%, 11.63% and 7.96%, respectively compared to the means under the irrigated condition and these reductions in TDM were significant at $P \leq 0.01$.

(a) Early + Late stress



(b) Irrigated Trial

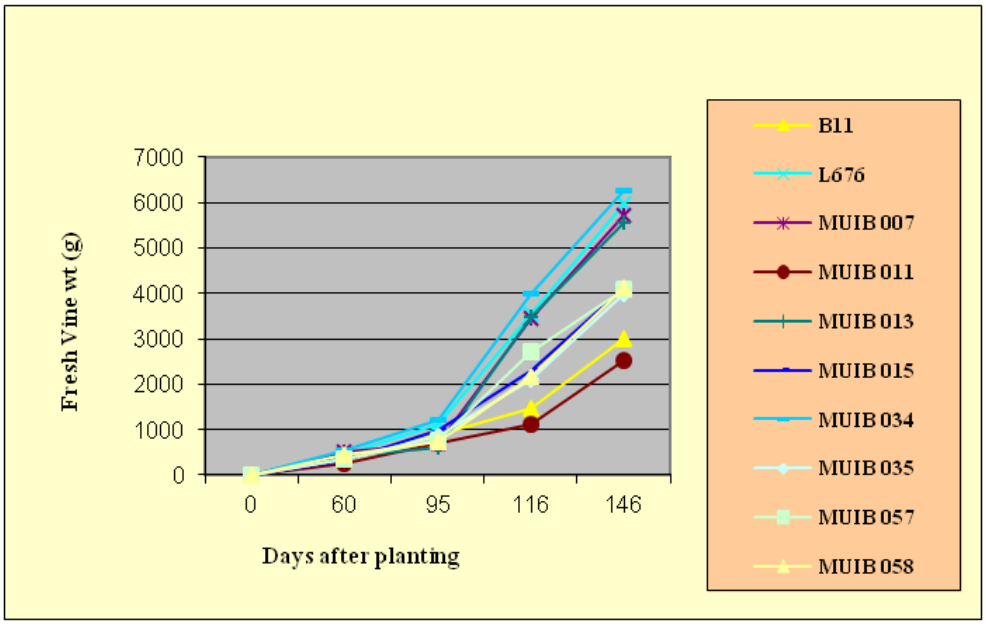
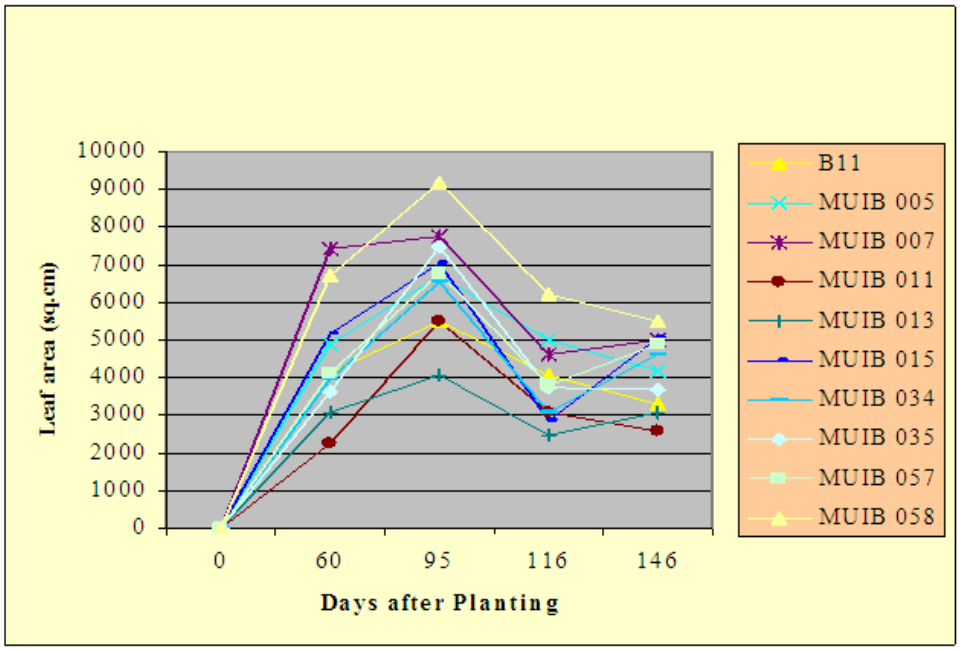


Figure 1. Mean Fresh Vine Weight (grams) in (a) Early and Late Stress and (b) Irrigated trials.

Leaf Area

In the stress trial, imposition of water stress at 61 DAP for 35 days (up to 95 DAP) did not show any impact, the LA was markedly reduced for all the genotypes from 95 to 116 DAP. The imposition of the second stress at 116 DAP did not have any LA reduction, rather leaf area increased for all the genotypes though the increase was smaller than at 0 – 95 DAP. In contrast, under the control trial, leaf area for all the genotypes increased steadily until 116 DAP and then reduced until the final harvest at 146 DAP drastically even though the individual genotypes differed in terms of leaf area.

(a) Early + Late stress



(b) Irrigated Trial

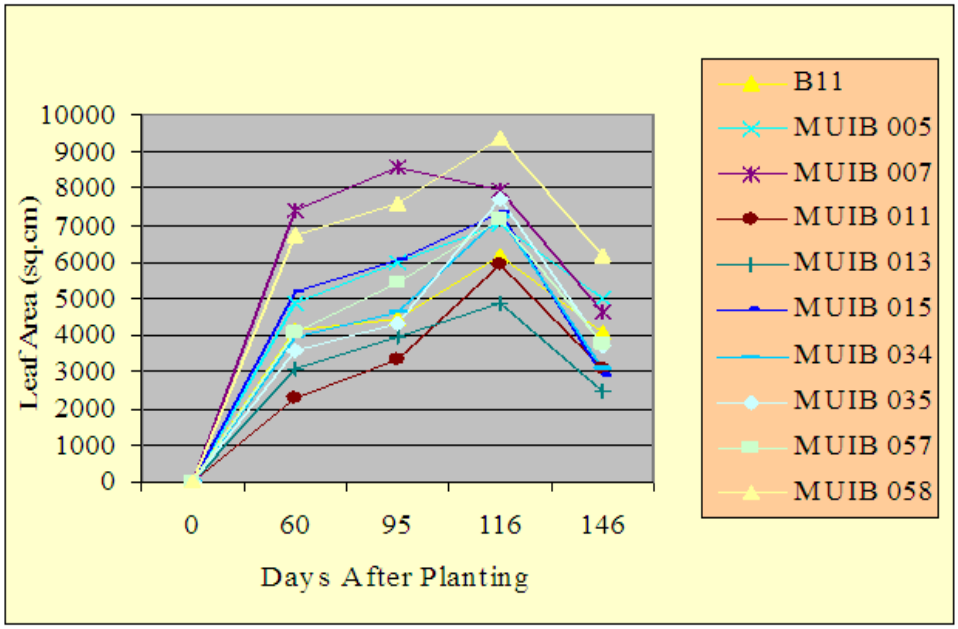


Figure 2. Mean Leaf area (cm^2) of ten genotypes from 0 – 146 DAP in (a) Early + Late Stress and (b) Irrigated Trials

Table 1: Total Storage root weight (tonnes per hectare) at 60, 95, 116 and 146 DAP under stressed and irrigated trials.

	Days after planting (DAP)							
	60		95		116		146	
Genotypes	Irrigated	Early + Late stress	Irrigated	Early + Late stress	Irrigated	Early + Late stress	Irrigated	Early + Late stress
B11	18.5	26.0	22.2	19.0	19.6	11.3	25.6**a**	11.2**ab**
MUIB 005	19.1	22.7	20.0	13.7	13.8	9.2	23.5**ab**	15.6**a**
MUIB 007	11.9	27.8	17.1	13.3	9.6	10.6	16.0**cde**	16.3**a**
MUIB 011	17.9	31.7	15.8	7.3	8.2	5.1	16.8**cde**	7.0**b**
MUIB 013	17.9	32.7	8.7	11.2	6.4	4.0	9.6**f**	13.2**ab**
MUIB 015	17.4	16.4	14.5	12.7	12.1	8.1	20.5**bc**	11.2**ab**
MUIB 034	13.2	18.9	12.6	17.4	10.1	13.1	15.5**de**	17.9**a**
MUIB 035	19.5	20.2	31.7	13.8	15.4	9.6	24.4**ab**	16.1**a**
MUIB 057	15.9	35.5	12.8	8.7	9.1	10.7	18.1**cd**	13.2**ab**
MUIB 058	10.0	31.7	10.3	15.9	6.1	8.9	12.9**ef**	12.8**ab**
Mean±SE	16.1	26.4**	16.6	13.3ns	10.3	9.0*	18.3*	13.4**

*, ** significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

Treatment mean comparisons of total storage root weight (t / ha) at 146 DAP. Means followed by the same letters in the column are not significantly different at $p \leq 0.05$ (DMRT)

Table 2: Marketable storage root yield (tonnes/hectare) for ten sweet potato genotypes at 116 and 146 days after planting under irrigated and stressed Trials

Genotypes	Days after planting			
	116		146	
	Irrigated	Early + Late stress	Irrigated	Early + Late stress
B11	13.6	10.7	18.5	10.0
MUIB 005	5.2	17.7	9.7	8.9
MUIB 007	2.4	7.2	5.8	8.1
MUIB 011	5.9	4.2	10.5	4.0
MUIB 013	3.7	2.5	5.8	3.3
MUIB 015	4.9	5.6	9.7	4.1
MUIB 034	3.8	7.2	8.6	8.8
MUIB 035	7.1	8.7	11.6	10.6
MUIB 057	4.3	10.9	7.2	8.6
MUIB 058	1.6	6.9	3.8	5.8
Means ± SE	5.2	8.2*	9.1	7.2*

*, **, significantly different at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 3.Storage root dry matter (tonnes / hectare) for ten sweet potato genotypes at60, 95, 116 146 days after planting

Genotypes	Days after planting (DAP)							
	60		95		116		146	
	Irrigated	Early + Late stress	Irrigated	Early + Late stress	Irrigated	Early + Late stress	Irrigated	Early + Late stress
B11	4.55	4.42	9.24	8.57	9.35	8.68	11.07	10.40
MUIB 005	3.91	4.09	8.89	8.22	9.46	8.12	10.10	9.43
MUIB 007	4.33	3.99	9.01	8.35	9.62	8.28	10.33	9.67
MUIB 011	4.57	4.50	8.97	8.30	9.41	8.74	11.21	9.88
MUIB 013	4.20	4.08	10.65	9.99	11.12	10.45	12.95	12.29
MUIB 015	4.23	4.25	9.17	8.50	9.63	8.29	10.21	9.54
MUIB 034	4.51	3.98	9.04	8.38	9.38	8.05	10.42	9.08
MUIB 035	3.96	3.57	8.37	7.70	9.70	8.36	10.62	9.96
MUIB 057	4.08	4.17	9.29	8.62	10.16	8.82	11.09	9.76
MUIB 058	3.99	4.21	9.19	8.53	9.65	8.31	10.91	10.25
Means±SE	4.23	4.19 ns	9.18	8.49**	9.75	8.61**	10.89	10.03**

ns = non-significant;

*, **, significantly different at $P \leq 0.05$ and $P \leq 0.01$, respectively.

Correlation coefficients among leaf area, drought score, marketable storage root weight, total storage root weight, storage root dry matter and vine weights for the two trials at the final harvest (146 DAP) are presented in Table 4. Marketable storage root weight had a strong significant ($P<0.01$) positive correlation with total storage root weight for the irrigated (0.80) and stressed conditions (0.60, $P<0.05$), respectively. Similarly, vine weight had a significant ($P<0.01$) positive correlation with leaf area (0.80) in the stress trial, but was negatively correlated to drought score (-0.1994) and storage root dry matter (-0.6852). Storage root dry matter had a significant positive correlation (0.46*) with drought score but was negatively correlated to leaf area (-0.4506), marketable storage root yield (-0.4890) and total storage root weight (-0.2357) even though none of them was significant.

Table 4. Correlation coefficients of various yield parameters measured under different soil moisture conditions at harvest

Correlations (Pearson)

	DROUGHT	Leaf area	MARKETTUBwt	TOTtub.wt	TUBER DM
LEAF	0				
	(-.2611)				
MARKTTub.wt	0	-0.2249			
	(-0.0337)	(0.1236)			
TOTTub.wt	0	0.1046	0.7984**		
	(0.1936)	(0.4400*)	(0.5791*)		
TUBERDM	0	-0.3870	-0.1561	-0.5705	
	(0.4600*)	(-0.4506)	(-0.4485)	(-0.2357)	
VINEwt	0	0.0445	-0.4890	-0.3231	-0.1111
	(-0.1944)	(0.7671**)	(0.4146)	(0.3985)	(-0.6852)

Values in the parenthesis are the correlation coefficients for the stress trial and without parenthesis are correlation coefficient for unstressed (control) trial.
*, **, correlation coefficients are significantly different at $p \leq 0.05$ and $p \leq 0.01$, respectively.
The characters use for the correlations included; MARKTTub.wt – Marketable storage root weight; TOTTub.wt – Total storage root weight; STORAGE ROOTDM – Storage root dry matter; VINEwt – vine weight.

DISCUSSION

Sweet potato is quite sensitive to water stress. As sweet potato is grown under rain-fed condition, intermittent water stress may occur at any growth stage. The effects become more severe on storage root yield when drought is prolonged (Gomes and Car 2001). Water stress decreased storage root dry matter production and this decrease may in turn reduce total storage root weight, leaf area and vine weight. Low storage root dry matter is due to prolonged water stress at early vegetative stage and late bulking stage. Gomes and Carr (2001) reported that storage root dry matter was reduced in sweet potato clones due to low radiation interception caused by leaf area index. Increased leaf death and drought score also contributed to reduced storage root dry matter. (Saraswati *et al.,* 2001)

The results from the current experiments showed interactions between watering treatments and the storage root yield at final harvest (146 DAP). The early stress (ES) that occurred during vegetative stage had significant effect on the early growth and development stage. However, stress during the sinking stage towards maturity period did not have much effect on storage root yield in some genotypes. Even some genotypes increased storage root yield during the stress at maturity. This was attributed to early storage root formation. Early stress during vegetative stage was not important in some genotypes; however, when stress was prolonged at 116 DAP, storage root yield declined drastically (Wamala and Akanda, 2010). This has shown that genotypes differ greatly in their agronomic responses in terms of growth and development, dry matter production, storage root yield, leaf area and drought score as affected by water stress (Taufatofua, 1994; Indira and Kabeerathumma, 1988).

Storage root yield declined with reduction in moisture caused by prolonged water stress in the early + late stress. It was observed that drastic storage root yield decline at 146 DAP on genotype B11 and MUIB 011 was related to damage by sweet potato weevil during the stress period. Other factor that also contributed to low storage root yield on genotype B11 was due to stealing of storage roots. Storage root yield of late maturing genotypes was lowest, mainly due to low storage root filling percentage affected by water stress (Gomes and Car, 2001). Severe water stress delayed storage root bulking of all genotypes at least 12 days. Marketable storage root number and storage root weight per plant was reduced more than other yield component in water stress treatment. (Taufatofua, 1994).Storage root yield in some genotypes was reduced during early and late stress. These findings were consistent with Saraswati *et al.* (2002).

Storage root weights of some genotypes were significantly lower in ES than under irrigated condition. Storage root dry matter 60-95 DAP was low due to insufficient availability of assimilates and source limitation to fill the storage roots. Alternatively, stress during storage root bulking and development may have restricted potential storage root size in drought tolerant lowland genotypes.

Storage root yield in both ES and ELS condition, stored assimilates available for translocation to fill the storage roots was low due low TDM at late vegetative growth stage (Wamala and Akanda, 2010). The second stress period resulted in little dry matter production between 90 –146 DAP under the stressed condition. The limited assimilates supply during storage root bulking (current and translocated assimilate) resulted in lower storage root weight and low storage root number per plant in ELS than in ES in all genotypes.

CONCLUSION

Storage root yield and dry matter production declined with the reduction in available water. Reduced dry matter production under stress was associated with decreased moisture availability and water use. Genotypic differences in storage root weight, vine weight and leaf area were shown among the genotypes in growth.

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Using livestock productivity index to assess future values of cattle rustled in Northern and Eastern Uganda

Jimmy Alani

ABSTRACT

The study explores the interactions among stability, democracy and human rights using the case of cattle rustling in northern and eastern Uganda. First, we argue that stability, democracy and human rights influence one another. Secondly, we argue that cattle rustling which occurred in Acholi, Lango, Teso, Sebei and Pallisa between 1986 and 1990 was a clear case of human rights abuse resulting from break down in democracy and subsequent political instability. Either the Karamojong, National Resistance Movement or both of them did the cattle rustling. The existing political instability and insecurity during cattle rustling period affected the two regions which in turn caused endless economic instability and abject poverty. The cattle rustling did not only deprive the victims of the nutritional resources from cattle, but also deprived them off the means of operating agricultural production. The rustling was an infringement on the rights of the affected people in terms of violation of right to life by the raiders who came to steal, kill and destroy people and property. The right to food and property was also violated during raiding and caused the greatly affected communities to rely on relief food. Among other things the study examines what government should have done to redress the violation of rights involving cattle rustling. Thus, by using livestock productivity index (LPI) and the number of cattle rustled the study examines how much government should have compensated victims in terms of the amount of cattle rustled.

Key words: Livestock productivity Index, Assessment, Future Value of Cattle Rustled, Democracy and Rights.

INTRODUCTION

Cattle rustling that occurred in eastern and northern Uganda from 1986 to 1990 caused loss of over one million herds of cattle from these two regions. Estimate given by Gersony (1997) implies that replacement of the plundered cattle from northern and Eastern Uganda might require not less than $85 million. The rustling was a gross violation of human rights. Since rights, democracy and stability are interrelated we found it worthwhile to examine interactions among them in the context of cattle rustling in eastern and Northern Uganda. Instability arises from one or a combination of four distinct notions: statis or factional conflict, corruption, the mutability of the laws, and changing global conditions. Sources of instability remain relevant because they express problem of instability in ways that are theoretically and practically useful for understanding the role that democracy plays in addressing them. The premise that instability is inherent in democracies is a deeply flawed assumption. Democracy is a solution to instability and that the success of a democracy relies on its practical ability to address the ways statis, corruption, mutable legislation, and global conditions emerge within a political society.

Democracy and human rights are clearly interdependent particularly when defined in the broader conceptualizations of democracy as substantive democracy, and human rights as civil, political, economic, social, and cultural rights. Different kinds of rights can be realized in democratic systems. Similarly, democracy can be sustained by promoting human rights. Theoretically, this relationship is evident. Interdependence of human rights and democracy could be examined through the existing political systems.

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Interdependence of stability, democracy and rights, implies that the human rights violation that happened during cattle rustling is an indication that to some extent the government of Uganda was undemocratic and the existing political system was unstable. In the context of Hohfeldian rights cattle rustling which occurred in Acholi, Lango, Teso, Sebei and Pallisa between 1986 and 1990 was a clear case of human rights abuse resulting from break down in democracy and subsequent political instability. The Hohfeldian terminology allows one to distinguish importantly different kinds of rights and so avoid needless confusion.

BACKGROUND

The Karamojong have been accused of rustling cattle in the Northern and Eastern Uganda in the 1980s. Karamojong is a term representing a group of people of Nilo-Hamatic ethnic origin living in north-east Uganda (Colonial Office Public Records Office London (CO), 1963). The Karamojong comprise of about 12 percent of the total Uganda's population (CO, 1952). The Karamojong raise cattle, camels, sheep and goats as well as cultivate millet and sorghum for subsistence. It has been claimed that although private armies armed with guns operated in 1910, their cattle raiding culture reached its climax after the Second World War. At the outbreak of the Second World War, Britain recruited a great deal from Karamojong ethnic community in recognition of its ethno-military culture and they served with distinction as soldiers for the Kings African Rifles conducted in Asia and Africa. Therefore, from 1940 onwards, the Karamojong pastoral communities reinforced their traditional raids with the skills gained during the colonial wars. Apart from providing troops for imperial policing duties, the Karamoja region remained economically deprived and having the lowest literacy and highest infant mortality compared to other regions in Uganda (Mburu, 2001).

When Uganda gained independence from Britain in 1961, the authorities of Uganda continued to exclude Karamoja from the social, economic and political changes that were taking place in the country. The Karamojong came to acquire more guns in the 1970s due to political instability existing in the country. The Karamojong acquired more guns in large quantities in the 1970s following the fall of Amin's government in Uganda by an alliance of Tanzanian People's Defense Force and Ugandans in exile. Consequently, the Karamojong took unlimited quantities of small arms and ammunitions mainly from Moroto barracks that the fleeing Amin's soldiers had abandoned intact (Mburu, 2001).

Even if the Karamojong were indeed the ones who did the cattle rustling in northern and eastern Uganda in 1980s, the NRA government is to blame for it. That is because having liberated Uganda, the NRA military allowed the Karamojong to keep some firearms for self-defense against cattle thieves from Sudan and Kenya. Therefore, the Karamojong increased their stock of guns with more than 150,000 illegal guns. Besides, the Karamojong increased their arms through illegal purchases, barter and rustling (Human Rights Watch, 1999).

By early May 1986 in Northern and Eastern Uganda, particularly in Acholiland conflict began. That was when the former Uganda National Liberation Army soldiers who had been defeated by the National Resistance Army (NRA) regrouped in Southern Sudan and decided to fight NRA (Otunu-Ogenga, 2002). The newly formed Uganda People's Democratic Army (UPA) comprised of mainly ex-UNLA soldiers attacked the NRA in Acholiland on 20th August 1986 (Acer, 2004). In June 1987, amnesty was offered to any rebel who could voluntarily give up fighting and surrender to NRA. In December 1987, between 1300 and 1800 rebels of UPDA surrendered (Behrend, 1999).

Besides, in May 1988 more than 10,000 rebels surrendered in Gulu and Kitgum, leading to signing of a peace agreement between UPDA and NRA on 3rd June 1988 (Lamwaka, 1998).

As early as March 1987, the NRA forced a large portion of the Acholi population to abandon their farms and homes and take refuge in camps or Gulu town. The NRA has also been accused of looting livestock, burning houses, supplies and agricultural fields (Odoi-Tanga, 2009). Although government argues that the cattle rustling was carried out by the Karamojong, local informants believe that the NRA was responsible. They think that NRA soldiers often disguised themselves as Karamojong cattle raiders. However, according to Behernd (1999) there is still confusion regarding the identity of cattle thieves. During the 1986 and 1988 period cattle rustling also happened in Lango located in Northern Uganda and Teso located in Eastern Uganda. Consequently, by 1988 over one million herds of cattle had been rustled from northern and eastern Uganda. To those who lost their livestock during the cattle rustling, cattle were

their main source of capital. It was out of cattle wealth that families in the eastern and northern Uganda could derive milk; get money to pay dowry, school fees and meet medical bill; or get bull-locks and oxen to plough their gardens (Odoi-Tanga, 2009:p.312-354).

EVIDENCE OF CATTLE RUSTLING IN NORTHERN AND EASTERN UGANDA

Although cattle rustling occurred in eastern and northern Uganda, records on the statistics of cattle, goats and sheep raided are hard to find to be sure over one million herds of cattle were raided from the two regions bewteen 1996 to 1990 (include the reference for this assumption). Estimate given by Gersony (1997) implies that replacement of the plundered cattle from the two regions might require not less than $85 million.

However, records of number of cattle raided from Acholi sub-region are readily available. Up to the time of cattle rustling, cattle had long been one of the main sources of wealth in Acholi. By 1985, nearly 300,000 cattle had been raided including numerous goats, and sheep. Livestock was also one of the sources of long-term savings. Cattle wealth was used in financing treatment of the sick, education and marriage dowry (Gersony, 1997).

According to Gersony (1997), in 1986 and much of 1987, farmers provided livestock to the UPDA, sometimes against promissory notes payable after the victory they expected. The UPDA used most of these livestock for food, but some might have been traded in Sudan for arms and ammunition, which were in short supply. The NRA confiscated cattle as needed to support its operations. Fear preempted, some Acholi to liquidated parts of their herds before such confiscations could happen. Karamojong cattle raiders continued to raid livestock from Kitgum, as they had done throughout history. However, form around August 1987, during the Alice Lakwena period an event unique in Acholi history happened. A large group of Karamojong cattle raiders swept through Kitgum and eastern Gulu and removed almost all the livestock in the two regions. Those who resisted the rustlers were brutally attacked.

Furthermore, Gersony (1997) reports that in areas where both Karamojong and NRA soldiers were present, some farmers reported that the latter colluded in these activities, whereas generally Karamojong raiders were seen operating on their own. It is believed that in western Gulu, at about the same time, a similar large-scale removal of livestock was conducted by NRA forces. Data provided by veterinary officers indicates that the cattle population of Gulu and Kitgum in 1985 was about 285,000. By 1997, the cattle raids depleted almost all the herd.

In 1997, ten years after the raids, the combined herd for both districts was estimated at 5,000 herd, less than 2% the earlier number. Goats, sheep and other livestock similarly were affected. More importantly, Gersony (1997) estimates the replacement cost of the plundered cattle herd alone at close to US$25 million.

To put this loss in perspective by 1997, the Gulu branch of the Cooperative Bank which was serving principally the rural clientele and was one of only two banks in Gulu, observed that in times of insecurity, savings deposits tended to increase. Yet, on average for the years 1991 through 1996, it estimated its total deposits at about US$1.5 million. In an instant, the Acholi farmers were deprived of the milk their cows provided; the additional acreage and higher yields which their oxen permitted them; their fallback form marriage dowries and education; and the savings which carried them through drought, hard times, sickness and old age retirement.

The self-respect attached to cattle ownership and the cultural functions upon which exchange of cattle had relied were disrupted. It also deprived them of livestock upon which they relied for cash and food. Probably, some of the factors that could have motivated the Acholi to launch or continue the armed anti-NRA struggle were: pride, military humiliation, sense of betrayal and alien rule, loss of government power and its economic impact. Those factors were compounded by the loss of their livestock and the defeat of the Lakwena forces at the end of 1987. Six months later, the UPDA signed a peace agreement with the NRA. However, not all the rebel forces abandoned the armed struggle perhaps because of bitterness over the cattle raids (Gersony, 1997).

Police Tracking Force in the past had restricted Karamojong raiders to sporadic incidents along the eastern Kitgum border. Its disappearance contributed to the lawless environment in which these raids occurred. The Acholi people wanted disarmament of their active insurgents. There was no reported confrontation in Acholi between the cattle raiders and the police, military or other Government authorities. That led the

local population to believe that they were tolerating the plundering, which later occurred in the same magnitude in other districts. Of course 33 Authoritative government sources acknowledged some of the NRA raids in western Gulu, which they attribute to corrupt elements in the military at that time. Efforts at restitution by the government were made for a fraction of these thefts. Government sources also accepted that the Karamojong raids were carried out with little armed Government opposition. However, the reason they gave was that in 1987 the NRA's armed forces were relatively small and not yet consolidated.

Consequently, the Acholi were forced to confront both the UPDA and Lakwena forces at the same time. This allowed the NRA few resources to spare to combat the cattle raiders and made them hesitant to risk opening another major armed front against Karamoja. Truly there was widespread belief in Acholi that the Government instigated or at least approved the raids. That could have been the source of irreconcilable and continued bitterness against the present administration (Gersony, 1997).

In 1983 cattle population in Lira District was estimated at 185,2010 and that of Gulu District was estimated at 126,375. In Kitgum the cattle population fell from 156,667 in 1986 to 7,609 in 2002. In Gulu cattle population fell from 223,524 in 1986 to 12,179 in 2002 (Uganda Bureau of Statistics, 2002).

Yet in the entire country, the cattle population rose from 3 million in 1986 to (5,749,412) six million in 2002 (Uganda Bureau of Statistics, 2002; Nampinto, Phillipps and Plumptre, 2005; Van Aker, 2004; Veterinary Departments of Gulu and Lira, 2004).

The NRM victory led to deterioration of security solution in Teso and cattle rustling became a major activity in the region. The NRM decided to disband local militias that had been in existence during Obote II regime for defending Teso against cattle rustling form neighboring Karamoja. As a result a series of raids in 1986–1987 depleted the cattle stocks in Teso. The loss was estimated at 500,000 (or 93%) of cattle that had been available as a major asset of the Iteso people (Buckley-Zistel, 2008).

Due to lack of livestock data on Apac, the cattle and human population for Lira District is used to compute the cattle population of Apac based on the ratio of their human population and the fact that the Apac and Lira are sister districts with similar cultural background (see details computations in Table 1 and Table 2).

In Table 1, G is the rate at which the LPI is increasing. It is the g that was used in computing and extrapolating the cattle statistics up to 2011 as in Table 2. Therefore, the total cattle population for the five districts was estimated at 3,144,887. The computation was based on the existing buying exchange rate figure of US$.1 to UGShs.2,498. The average weight of each herd of cattle was valued at 200 Kilograms and the price of meat was valued at US$.3.6 per Kilogram (i.e. price of meat at Gulu Municipality on 30/12/2013).

Therefore, to redress the losses met by all those who lost cattle in the five districts may require total compensation amounting to at least US$2.27 billion.

This may exclude all the other benefits missed that they should have been compensated for by Government of Uganda that should have given them maximum protection from the dangers of cattle rustling. The figure of total compensation required is by far extremely conservative (i.e. less than the actual) because all the realistic figures used in the computations are on the lower side.

Gersony (1997) made an ingenious contribution towards the value of compensation by providing a means of estimating the implied replacement cost of the plundered cattle herd altogether to be close to US$85 million. But we hereby reject Gersony's (1997) implied estimate because it is far below the realistic value of compensation worth US$838 million that should have been given to the cattle losers. That is because extremely conservative estimate of the total number of cattle rustled from Northern and Eastern Uganda by 1986 equals at least 1,163,364. In the case of Gulu and Kitgum, the minimum compensation could be US$234 million for the 337,377 estimated herd of cattle they lost by 1996, not US$25 million that Gersony (1997) computed. Similarly, the estimates are based on the fact that each herd of cattle could have yielded 200 Kilograms of meat, and that the price of meat at Gulu Municipality by 30/12/2013) was valued at US$3.6 per Kilogram.

Recall, the total amount of herds of cattle rustled in Northern and Eastern Uganda by 1996 is estimated at 1,163,364 and it equals estimates that may be derived from graph provided by (DIIS) Danish Institute For International Studies (2012). The equality between the computed amount of rustled cattle made by DIIS (2012) and the other computed in this study may imply

that the computations in the paper are reliable.

DISCUSSION ON EVIDENCE OF CATTLE RUSTLING BASED ON RIGHTS AND THEORY OF RIGHTS

According to this paper the replacement cost is by far much higher than the value Gersony (1997) estimated. Using extremely conservative calculations (i.e. making estimates on the lower side), the northern and eastern districts that lost cattle due to rustling have the right to claim for compensation amounting to at least US$2.27 billion, excluding other benefits that they could have derived from the animals. The final computation is based on projection made by using the livestock productivity index (LPI) to arrive at herds of cattle figure of 3,144,887 that could have been available by 2011 had maximum peace prevailed.

In the context of Hohfeldian rights cattle rustling which occurred in Acholi, Lango, Teso, Sebei and Pallisa between 1986 and 1990 was a clear case of human rights abuse resulting from break down in democracy and subsequent political instability. In typical legal systems, the owners of cattle had a claim against others that they had not to rustle them and others had a duty to the owner not to rustle the cattle.

Our claims and duties, like all Hohfeldian relations, have three parts: two agents and a content. Before cattle rustling, the cattle owners had a claim with respect to the cattle raiders that they had not to rustle their cattle. The owners and rustlers were the agents whereas "no raiding cattle from their owners" was the content. If the rustlers had liberty to own cattle available before raid, that could have implied the following: one, the raiders had no duty with respect to others to own the available cattle; two, they had a duty with respect to others not to own the cattle; and three they had claims with respect to others that they refrain from preventing them from owning the cattle herd in question. But if the phrase is understood in the Hohfeldian sense, it implies only two.

In the Hohfeldian terminology, one is a set of liberties distinct from two and three set of claims. In typical legal systems, the cattle owners (if they wanted) had the power to change the cattle rustlers' duty to refrain from raiding their cattle into a liberty to take away their cattle.

If the raiders were allowed by the owners to willing take away the cattle then the raiders no longer had a duty to refrain from raiding cattle. Correlative to owner's power is raider's liability. Raiders had a liability to have their duty to refrain from rustling changed into a liberty to rustle. During the cattle rustling, the cattle owners were in a helpless situation. That caused their immunity to occur because they could not change some Hohfeldian relation. The situation was as if the cattle owners allowed raiders who were strangers take them away, forcing them to have immunity to the rustlers and to see them take away their cattle. Cattle rustling was illegal i.e. had no legal effect. The correlative of that immunity was a disability.

Another way to say that cattle owners had an immunity to cattle rustlers giving themselves a liberty to raid is to say that the raiders had a disability to give themselves a liberty (i.e. no claim) to rustle. The Hohfeldian vocabulary allows one to distinguish claim-rights, immunity-rights, liberty-rights and power-rights (Wellman, 1985). The right that government compensates people who lost their animals to raiders is a claim-right. The rustlers have a no-claim to the money and government has a duty to compensate all those people who lost their cattle to raid. The victims of rustling have right to free speech about their compensation and it is an immunity-right.

They are at liberty to say cattle rustling made them poorer than before and they have immunity to having the government to extinguish this liberty. There is nothing that the government could do that would cause the losers of cattle to say, cattle rustling has brought them abject poverty.

The right to press for more compensation for cattle they lost during cattle rustling is a liberty-right (Hart, 1982). Those who lost cattle have the liberty to seek for compensation, a claim against interference with seeking for compensation. Government has a power-right to change cattle loser's duty to compensation for the cattle lost into a liberty to be compensated for the lost animals. Owners of cattle had active right to drive their cattle.

Passive rights are rights that another person do or not do something. Passive rights are subdivided into positive and negative rights. The cattle losers have a positive right that government gives them their compensation. The cattle losers' right that government does not compensate them for the cattle they lost is a negative right. We have seen that choice theories have a central problem that there seem to be rights which do not protect the right-holder's choices. Suppose that army officers were ordered by their commander to rustle cattle. The officer clearly

had a right to raid as directed. But they had no choice because they had a duty to perform the rustling. The rights of beings which cannot choose (e.g. being Acholi, Itesot or Lango) pose another problem for choice theories. If rights necessarily protect an individual's choices then individuals who cannot choose cannot have rights. For that matter several scholars have offered alternatives to the choice and interest theories.

Why would some disagree with Wellman's claim that there are three parties to every right? Consider those who lost cattle during the raid and government of Uganda.

They lost all the cattle they had. On Wellman's view, it is not possible for those who lost cattle to prevent raiders from rustling their cattle. On an interest theory, cattle owners still had the interest not to be raided. Wellman's theory has the counter-intuitive implication that those who violate the criminal law do not violate the legal rights of their victims. His view has this implication because it is like the state which has the power to file a charge of cattle rustling (Dworkin, 1984). Even under Benthamian right cattle rustling is wrong since it was immoral.

Suppose that the soldiers starved for a long time, had no food and they rustled some cattle to eat to survive, to avoid death. It seems that that their right to life was in conflict with the cattle owner's property rights.

To Feinberg it would be permissible for them to transgress on the cattle owner's property rights (Feinberg, 1980). Here the rustler's rights would be referred to an external right whereas the rights of the cattle owner's would be taken as an internal right.

On the prima facie view, cattle owners had a prima facie right that their cattle not be taken by soldiers. At the same time soldiers who might have raided had a prima facie right to take away cattle from their owners for food. Thomson prima facie view favors government in that the conflict between these rights is resolved by asserting that the soldiers' right outweighs the cattle owner's right. To Thomson, during cattle rustling the cattle owners did not have a right that their cattle be raided. No rights transgression actually occurs because it merely seemed that you were transgressing on the cattle owner's rights. Thomson example is difficult because it is not clear how any limit on owner's would not also affect rustlers' rights.

The paper argues that both the rights based theory and utility theory can provide plausible account of rights. For example once the right of a community has been found to be violated and it is at a loss, the community has to be compensated accordingly. The two analyses are proper to account for the rights and loss victims might have encountered. The right based theory helps to confirm that a right has been violated, whereas the utilitarianism enables us to assess the magnitude of the problem. If a community or groups are said to have rights, then their loss can be calculated individually and aggregated to have the victims compensated as one unit. The paper does not support the eliminative individualist notion who thinks that there are no group rights and that all claims of group rights are false. A non-eliminative individualist thinks that there are group rights, that some claims of group rights are true and that all group rights can be analyzed as sets of individual rights (Rainbolt, 2006).

CONCLUSION AND RECOMMENDATIONS

Stability, democracy and human rights are distinct, but interrelated concepts. Examining the relations among the three terms leads us to conclude that cattle rustling which occurred in Acholi, Lango, Teso, Sebei and Pallisa between 1986 and 1990 was a clear case of human rights abuse resulting from break down in democracy and subsequent political instability. The right based theory helped us to confirm that the rights of those who lost cattle to the cattle raiders were violated, whereas the utilitarianism enabled us to assess the magnitude of the problem. Utilitarianism would enable us determine the extent of the case as a first step towards finding the right way of compensating those who lost cattle during rustling. It would therefore be prudent enough for those who lost cattle during rustling to be compensated with at least US$2.27 billion as at 2011 for the cattle they lost.

As at 2014 the amount of compensation could be far greater than US$2.27 billion. The figure of the benefits missed from milk output could also be enormous and it needs to be critically researched upon, reported and published. The reason for such ventures could be for the future government of Uganda responsible for oil extraction to compensate the cattle losers as far as possible.

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.**Table 1.** Estimating the 1983 cattle population in Apac District by that of Lira District

LIRA	Human Population	APAC	Human Population	Old Districts	Cattle Population
Alebtong	163, 047	Apac	249, 656	**APAC**	**170, 906**
Amolatar	96, 189	Kole	165, 922		
Dokolo	129, 385	Oyam	268, 415		
Lira	290, 601			**LIRA**	185, 210
Otuke	62, 018				
TOTAL	741, 240	TOTAL	683, 993	RATIO	0.922769

Source of Data: Districts of Uganda by 2002 Census in The Wikipedia, The Free Encyclopedia.

Table 2. Assessing Future Cattle Population Using Livestock Productivity Index (LPI)

YEAR	LPI	G	GULU	LIRA	TESO	KITGUM	APAC
1983	46.8			**185210**			**170906**
1984	48.1	0.028748		190534			175819
1985	49.5	0.029106	**233524**	196080		**156667**	180937
1986	42.8	-0.135354	201916	169540	**500000**	135462	156446
1987	42.1	-0.016355	198613	166767	491822	133246	153888
1988	44.8	0.064133	211351	177462	523364	141792	163757
1989	50.6	0.129464	238713	200438	591121	160148	184957
1990	57.8	0.142292	272681	228958	675234	182936	211275
1991	60.1	0.039792	283531	238069	702103	190216	219683
1992	61.4	0.021631	289664	243219	717290	194330	224435
1993	64.1	0.043974	302402	253914	748832	202876	234304
1994	62.1	-0.031201	292966	245991	725467	196546	226993
1995	63.6	0.024155	300043	251933	742991	201293	232476
1996	64.7	0.017296	305232	256291	755841	204775	236497
1997	65.7	0.015456	309950	260252	767523	207940	240152
1998	68.2	0.038052	321744	270155	796729	215852	249290
1999	70.4	0.032258	332123	278870	822430	222815	257332
2000	72.4	0.028409	341558	286792	845794	229145	264643
2001	75.8	0.046961	357598	300260	885514	239906	277071
2002	84	0.108179	396283	332742	981308	265859	307044
2003	94.6	0.126190	446290	374731	1105140	299408	345790
2004	97.9	0.034884	461859	387803	1143692	309853	357852
2005	100.8	0.029622	475540	399291	1177570	319031	368453
2006	101.3	0.004960	477899	401271	1183411	320613	370280
2007	105.3	0.039487	496769	417116	1230140	333273	384902
2008	107.6	0.021842	507620	426227	1257009	340553	393309
2009	111.7	0.038104	526962	442468	1304907	353529	408295
2010	114.5	0.025067	540172	453559	1337617	362391	418530
2011	115.7	0.010480	545833	458313	1351636	366189	422917

Sources: World Bank Data (1984-2011) for LPI, Uganda Bureau of Statistics (UBOS), Lira and Gulu District Veterinary Offices, Van Acker (2004), Various Issues.

Climate change, agriculture and food security in the Pacific Islands

Eberhard H. Weber

ABSTRACT

In the past three decades climate change has become one of the most important global challenges. The Small Island Developing States in the Pacific are severely exposed to the impacts of climate change although they did not contribute meaningful to the creation of the challenge. Although food security there is lesser an issue than in many countries of Africa, Asia and the Caribbean many assessments highlight that Pacific Island Countries (PICs) can become exposed to food crisis, especially in times of natural hazards and consequent disasters. Food systems have been changing in recent decades in many Pacific Island countries creating increasing vulnerabilities. The major process in place relate to the change from subsistence agriculture to commercial agriculture. People more often depend on food from the market and supermarket rather than from own gardens with a big variety of food crops. Research in communities in the Fiji, Samoa, and the Solomon Islands that had been exposed to severe disasters however reveal that food security had not been the major challenge during the disaster and in the rehabilitation process. There is much evidence that communities with support of governments and relief organizations have been able to avert food crises relating to these disasters. It was found that in particular social capital contributed to this resilience.

Key words: Climate Change, Agriculture, Food Security, Pacific Islands.

INTRODUCTION

For long the international community hoped that it is possible to reduce greenhouse gas emissions to a level that dangerous climate change can be averted. With the failure of the Kyoto Protocol it became obvious that the mitigation strategy had failed. Further increases in average global temperatures and subsequently sea-levels seem to be unavoidable. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) highlights that small islands are particularly vulnerable to climate change. This is confirmed in the Fifth Assessment Report (IPCC, 2013) as well as in the IPCC report on disasters (IPPC, 2012).

During the last three decades global average surface temperature continuously increased. These decades had been warmer than any decade since 1850. Since 1880 the increase was 0.85 degrees centigrade on average (IPCC, 2013). Between 1901 and 2010 global mean sea level rose by 190 mm (around 1.7 mm yr^{-1}). In later decades the increase was much higher (e.g. 3.2 mm yr^{-1} between 1993 and 2010) suggesting that more recently sea level rise has accelerated (IPCC, 2013; Maharajan & Joshi, 2013).

Climate change and extreme events hit particularly rural and urban poor, who already have to live with many challenges (Archer et al., 2008; Fischer et al., 2005). They are less able to cope or adapt to additional pressures. They experience negative impacts on their livelihoods. They often live close to nature and from its resources they derive bigger parts of their livelihoods. When resources suffer, get degraded and decline in productivity poor people are often socially and economically immobile, not able to move to other ways of making a living. Spending a high percentage of their income on food they are most vulnerable to food price increases, especially when they don't have (enough) land to grown their own food.

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The same people are severely affected by natural hazards. They live in locations where they are exposed to such hazards, their housing structures are weak to withstand the forces of such hazards, and their socio-economic situation makes it difficult and lengthy to recover from the destruction of such hazards. The impacts of climate change do not only affect poor and vulnerable population severely, climate change has the potential to create new poverty and exacerbate existing inequalities. Climate change has the potential to undo the positive results of development efforts and repel people in their efforts to secure a decent standard of living.

CLIMATE CHANGE AND AGRICULTURE

Agriculture depends highly on physical factors such as soil, topography, and others. Climate parameters provide conditions that enable or restrict plant growth and influence survival (Downing, 1993). Extremes (low or high temperatures, lack of water (drought), too much water (flood, water logging) can have devastating results on plant growth (Gregory et al., 2005; Kang et al., 2009; Lobell, 2010; Schlenker, 2010; White & Hoogenboom, 2010) as well as the growth of pathogens and plant pests (Gregory et al., 2009). Most plants have a narrow scope under which their growth is optimal. Under sub-optimal conditions (below or above the optimal) decreasing yields or even plant death is happening. Humans can influence some of these conditions (e.g. through irrigation, glass houses), but technologies are costly and not everywhere available. China and India have more than one third of the globally irrigated areas. There as well as in other developing countries irrigation areas have come under great stress due to land degradation and conflicts over water distribution between and within countries (Weber, 2007; 2006; 1997; 1991; Weber & Hoffmann, 1997).

Crops are affected by a changing climate in many ways (Mendelsohn & Dinar, 2009). Some impacts have the potential to decrease productivity, while others have positive impacts (Lloyd et al., 2011). An increase in warmer days, in particular frost-free periods, prolong the vegetation period of temperate crops and help to extend production zones.

Higher temperatures and higher CO_2 concentration can support plant growth and output. Carbon dioxide is one of the most important ingredients for photosynthesis. A high carbon dioxide concentration increases water-use efficiency of some plants (Maharaj & Joshi, 2013). Whether yields increase as a result of higher temperatures and carbon dioxide concentration depends on the type of photosynthesis of a particular plant. The literature distinguishes between C_3 and C_4 photosynthesis pathways (Bunce, 2000; Ehleringer et al., 1997; 1991; Gunderson et al., 2010; Kirschbaum, 2004; Kubien & Sage, 2004; Pyankov et al., 2010; van Oosten & Besford, 1996; Zavalloni et al. 2009). C_3 crops (e.g. wheat, rice, barley, cassava and potato) respond best to increasing CO_2 while C_4 crops (e.g. maize, sugar cane, sorghum, millet and forage grasses) "are already optimized at the current CO_2 level [and] therefore have only a small response to higher CO_2 (Maharaj & Joshi, 2013, p.27). Kopp et al. (2005) and Spicer (1993) show that C_3 / C_4 photosynthesis pathways played already a crucial role in paleo climates and ecologies.

"Current research confirms that while crops would respond positively to elevated CO_2 in the absence of climate change […] the associated impacts of high temperatures, altered patterns of precipitation and possibly increased frequency of extreme events such as droughts and floods, will probably combine to depress yields and increase production risks in many world regions, widening the gap between rich and poor countries" (Fischer et al., 2005, p. 2067).

In the developing world agriculture provides livelihood to more than 70 percent of the population (Kotir, 2011; Mendelsohn & Dinar, 2009). The danger is great that additional stress on ecological fragile food production systems and socially vulnerable populations will lead to lower global food production and create great problems of hunger and starvation (Lloyd et al., 2011; Nelson et al., 2010). Many countries with challenges around food security are located in the arid and semi-arid regions of the world. Particularly countries in sub-Saharan Africa, South, North and West Africa, India and also arid locations in tropical and sub-tropical America are most vulnerable to food insecurity. Climate change will increase the danger of droughts in these regions and put additional stress to poor marginal farmers (Archer et al., 2008; CFS, 2012).

Still there are very limited studies that show, if overall net impacts on plant growth and yields will be positive or negative. Many authors assume that some regions will experience positive impacts on agriculture while others will be affected by climate change in a negative way. "Broadly, climate change may lead to increases in yield potential at mid and high-mid-latitudes, and to decreases in the tropics and subtropics" (Parry

et al., 2005, p. 2137).

Temperature, the availability of water and CO_2 concentration in the atmosphere have also impacts on pests and pathogens (Maharaj & Joshi, 2013; Newton et al., 2011; Sharma and Prabhakar, 2014). A warmer climate favours growth conditions of pathogens, insects and weeds, produce bigger pathogen numbers and more generations. This compromises the growth of crops and makes pathogens more quickly resistant to pesticides. With an increase in carbon dioxide the efficacy of pesticides is declining (Ziska & Teasdale, 2000).

An increase in the intensity (and possibly frequency) of natural hazards has high potential to affect agricultural production. IPCC (2014) expects that such extreme events exacerbate other stressors and increase people's risks. "Climate-related hazards affect poor people's lives directly through impacts on livelihoods, reductions in crop yields, or destruction of homes and indirectly through, for example, increased food prices and food insecurity" (IPCC, 2014, p. 8).

Food production comes under pressure in many parts of the world while population especially in the countries of the South continues to increase (Branca et al., 2013). Population growth and the impacts of climate change are expected to lead to increased global food prices.

THE PACIFIC ISLANDS

There are 14 Pacific Island countries and 8 territories governed by metropolitan powers at the rim of the Pacific Ocean or Europe. In mid-2013 about 10.57 million people were living in this part of the world; Papua New Guinea alone has a population of 7.4 million leaving some 3.2 million to the remaining 13 countries and eight territories (SPC, 2014, Table 1).

Table 1: Pacific Island Countries and Territories - some demographic and physical characteristics

Country	Sub-Region	Population (2013)	Population (around 1960)	increase since 1960s (%)	Land Area (km^2)[1]	Exclusive Economic Zone (km^2)[1]	Population Density (per/km^2)	Atolls / Coral Islands	Raised Islands	Volcanic Islands	Total
Cook Islands	Polynesia	15,200	18,378[f]	(15)	237	1,960,135	64	7	0	8	15
Niue		1,500	4,864[f]	(70)	259	316,629	6	0	1	0	1
Samoa		187,400	114,427[f]	60	2,934	131,812	64	0	0	2 + 8 islets	2
Tonga		103,300	56,383[a]	84	749	664,853	138	a few	>100	a few	~170
Tuvalu		10,900	5,444[h]	106	26	751,797	419	9	0	0	9
Fed. States of Micronesia	Micronesia	103,000	39,284[c]	161	701	2,992,597	147	~600	0	>10	607
Kiribati		108,800	43,336[h]	115	811	3,437,345	134	32	1	0	33
Marshall Islands		54,200	13,928[c]	295	181	1,992,232	299	34	0	0	34
Nauru		10,500	4,613[f]	121	21	308,502	500	0	1	0	1
Palau		17,800	9,344[c]	121	444	604,289	40	<300	>10	>5	340
Fiji Islands	Melanesia	859,200	345,737[a]	146	18,333	1,281,122	47	2	a few	<100	~320
Papua New Guinea		7,398,500	2,184,986[i]	215	462,840	2,396,214	16	a few	a few	>600	>600
Solomon Islands		610,800	124,076[d]	346	28,000	1,597,492	22	a few	0	>900	>990
Vanuatu		264,700	78,088[k]	222	12,281	827,891	22	0		82	82
sub-total		9,745,800	n.k.	n.k.	527,817	16,270,313					
Territory											
American Samoa	Poly	56,500	20,051[e]	233	199	404,391	284	2	0	5	7
French Polynesia	Poly	261,400	84,551[g]	221	3,521	4,767,242	74	~80	a few	~40	130
Pitcairn Islands	Poly	57	n.k.	n.k.	47	880,000	1				
Tokelau	Poly	1,200	1,870[f]	(38)	12	319,031	100	3	0	0	3
Wallis & Futuma	Poly	12,200	8,546[m]	54	142	258,269	86	0	0	2	2
Guam	Micro	174,900	67,044[e]	187	541	221,504	323	0	0	1	1
Northern Mariana Islands	Micro	55,700	8,290[c]	666	457	749,268	122	0	0	15	15
New Caledonia	Mela	259,000	86,519[c]	192	18,576	1,422,543	14	0	0	7	7
sub-total		820,957	--	--	23,495	9,022,248	--				
overall		10,566,757	--	--	551,312	25,292,561	--				

[a]1956 [b]1957 [c]1958 [d]1959 [e]1960 [f]1961 [g]1962 [h]1963 [i]1966 [k]1967 [l]1968 [m]1969

Source: for Population Data: SPC Population Data 2011 and Time Series from 1900
for Island size and island type: Pacific Islands Yearbook, 1989
[1] Land Area and EEZ for Pacific Island Countries according to www.forumsec.org

The Pacific Ocean covers more than 165 million km^2 extending to about a third of the surface of the Earth. The Pacific Island region consists of 20,000 – 30,000 islands (Ridgell 2006) located south of the Tropic of Cancer. As a rough indication the region is sub-divided into Micronesia, Melanesia and Polynesia. The islands of the first sub-division are mainly situated north of the equator and those of the second and third category are situated in the southern hemisphere (Figure 1). The entire land area of the Pacific Island countries and territories is about 551,319 km^2. With this the 22 countries and territories are a little bit smaller than Kenya (569,000 km^2). Also here Papua New Guinea, the world's second biggest island after Greenland, dominates heavily with 462,840 km^2 leaving 88,472 km^2 (16% of the land area) to the rest of the countries and territories. Today most islands in the region belong to 14 independent states that are organized in the Pacific Islands Forum Secretariat (PIFS).

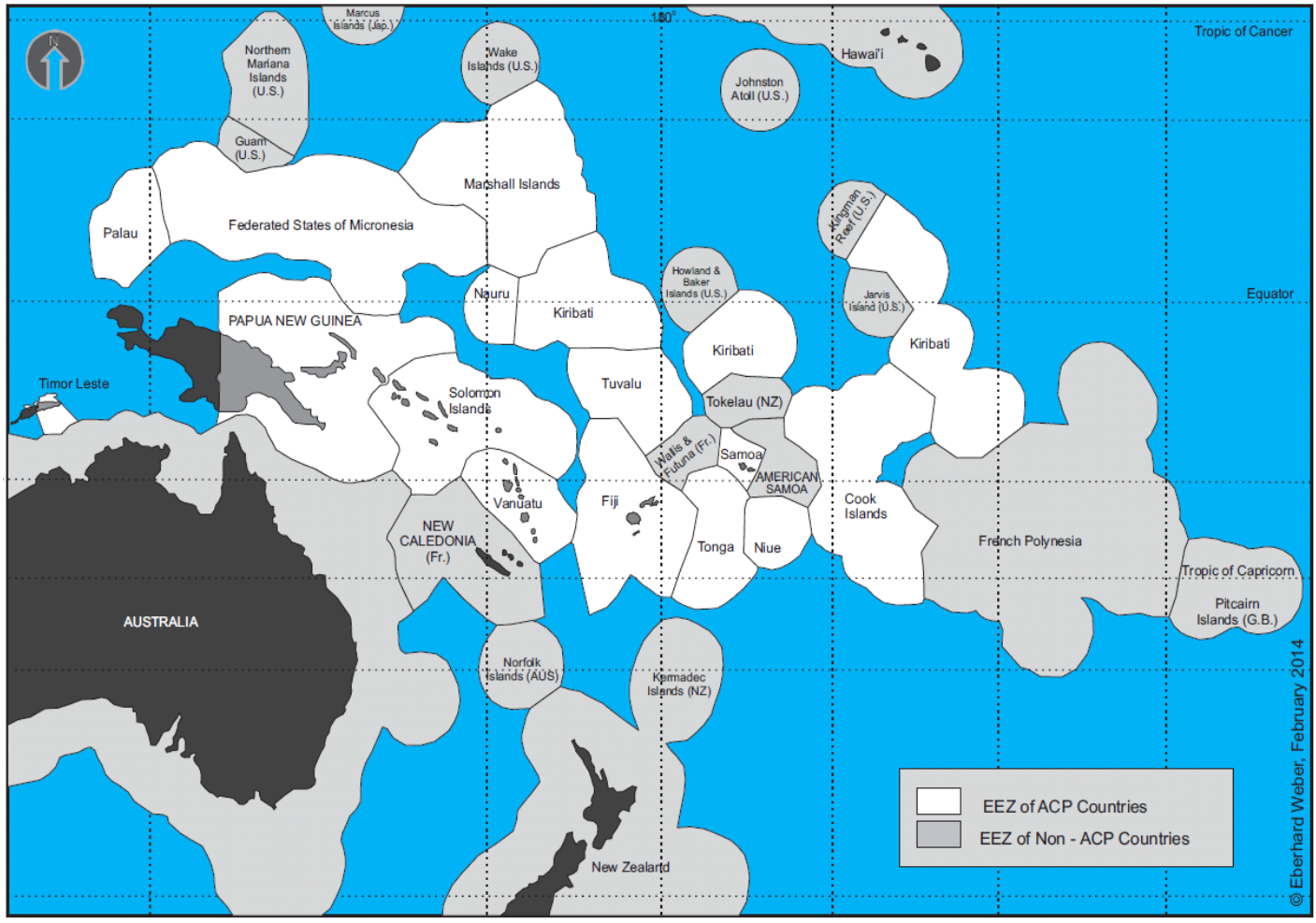

Figure 1: Pacific Island countries and territories and their Exclusive Economic Zones

Size, topography and soil types of islands are every relevant for agriculture. In Micronesia and Polynesia most of islands are tiny, low lying coral islands or atolls with very poor soils. Only a few, smaller islands are of volcanic origin, e.g. the major islands of Samoa and the Cook Islands (Table 1). In the coral islands and atolls agricultural production is often restricted to a few crops. Attempts to expand the variety of crops often results in crops of low size and quality (see also Barnett & Adger, 2003). Four of the countries in the Pacific Island region consist entirely of low lying coral islands and atolls, namely Kiribati, the Marshall Islands, Tokelau and Tuvalu. The Melanesian region on the other side is dominated by high volcanic islands that are big and usually have good soils of volcanic origin suitable for diverse subsistence agriculture. As a result of colonialism and more recently rapid urbanization commercial agriculture has been extended in the past decades in a few islands. The economic potentials of most of the Pacific Island countries

however are generally low. Subsistence agriculture and fisheries dominate. Exceptions are Fiji, which has the most diverse industrial sector and Papua New Guinea, which has some industries and well developed mining industries.

Pacific Island countries are strongly affected by regional climate systems. Considerable climate variations are caused by El Niño Southern Oscillation (ENSO) (Delcroix, 1998; Gang et al., 2014; Gouriou & Delcroix, 2002; Li & Wang, 2013; Luo & Yamagata, 2001; O'Kane et al., 2014; Pan et al., 2011; Ronghui et al., 1998; Wang & Fiedler, 2006; Xu et al., 2004), the South Pacific Convergence Zone (SPCZ) (Brown, et al., 2013; 2012; Folland, 2002; Griffiths et al., 2003; Juillet-Leclerc et al., 2006; Matthews, 2012; Vincent, 1985, Vincent et al. 2011; Widlansky et al., 2011), the Intertropical Convergence Zone (ITCZ) (Leduc et al., 2009; Leech et al., 2013; Sachs et al., 2009) and the Western North Pacific Summer Monsoon (WNPSM) (Christensen et al., 2013; Lee et al., 2011).

Great challenges to agriculture are brought by El Niño events that can bring droughts to the south-western Pacific region and increased rainfall in the central Pacific. In El Niño years also the numbers of tropical cyclones seem to increase and affect regions further to the east than usual (Diamond et al., 2012). During La Niña years the numbers of tropical cyclones increase in the western tropical Pacific (Nicholls et al., 1998; see also Lavender & Walsh, 2011).

Changes in rainfall varies considerable in the Pacific Island region. The southern Cook Islands, the Solomon Islands, and Tuvalu will see their average rainfall increase during the wet season. On the other hand countries like Vanuatu, Tonga, Samoa, Niue, and Fiji will experience "a decrease in dry season rainfall accompanied by an increase in the wet season, indicating an intensified seasonal cycle" (Diamond et al., 2012, p. 1276).

To quantify the impact on precipitation however is rather difficult and does not provide a clear picture for the future: much wetter times seems equally possible than much drier ones. Referring to Ruosteenoja et al. (2003) Barnett (2011) provides the following precipitation scenario taking the period 1961–1990 as reference: "-3.9% to +3.4% by the 2020s; -8.23% to +6.7% by the 2050s; and -14% to +14.6% by 2080s" (Barnett, 2011, p. S230).

THE STATE OF FOOD SECURITY IN THE PACIFIC ISLANDS

The Pacific Islands are not amongst the hotspots when it comes to hunger and undernutrition in the Asia-Pacific region. Other countries have bigger shares of people vulnerable to food insecurity. As population sizes in the Pacific Islands are tiny the absolute number of vulnerable population is also small. However one has to consider that undernutrition is often much hidden from the eyes of observers (UNESCAP, 2009). Currey (1980) highlights that in particular natural hazards can cause food insecurity in Pacific Island countries.

Many publications on climate change in the Pacific Islands see increasing pressures on food security. Many reports however are vague and miss to draw detailed pictures of what impacts to expect. It does not help much to assume that agriculture and food security will be affected in one way or another. To prepare for the challenges more precise knowledge is necessary. Right now one can assume that Pacific Islands are resilient enough to avoid the most drastic forms of food insecurity. Other regions where big portions of population have been living at the edge of hunger and starvation will also be most at risk in future. In Pacific Island countries impacts of climate change on agriculture have great potentials to affect people's livelihood security. With this they are more likely to become serious development challenges rather than a question of life or death.

Although the majority of people in the Pacific Islands have rather low standards of living chronical under- and malnutrition is rare and restricted to few people and few locations. This is the essence of the UNESCAP (2009) report on sustainable agriculture and food security in Asia and the Pacific. Among the Pacific Island countries the Solomon Islands has the highest proportion of undernourished people in 2003-05 (20 percent), followed by PNG (13 percent) and Vanuatu (12 percent). Table 2 shows that comparted to earlier years considerable improvements have happened in all countries. The magnitude of undernourishment in Pacific Island countries is considerably smaller than in many countries of South, South-East, and East Asia. It has been declining over the last few decades, and this downward trend seems to continue.

Table 2: Prevalence of undernourished people in selected countries in Asia and the Pacific

Country	1990-92	2000-02	2010-12	% change
Georgia	60.4	23	25	-58.6
Viet Nam	46.9	20.9	9	-80.8
Lao, PDR	44.6	38.4	27.8	-37.7
Thailand	43.8	17.4	7.3	-83.3
Solomon Islands	23.0	14.0	13.0	-43.5
Samoa	13.0	5.0	5.0	-61.5
Vanuatu	11.0	8.0	8.0	-27.3
Kiribati	9.0	7.0	8.0	-11.1
Fiji	6.0	<5	<5	>-16.7

Source: UN ESCAP (2013), p. 160

Food systems have been changing in recent decades in many Pacific Island countries increasing vulnerabilities. Major processes relate to changes from subsistence agriculture and fishing to commercial agriculture and distant water fishing fleets that come to the South Western Pacific for its rich tuna resources. People more often depend on food from the market and supermarket rather than from own gardens. As a result they are more likely affected by food price changes. Often their food choices also lead to malnutrition in form of obesity and non-communicable diseases rather than undernourishment (Pacific Institute of Public Policy, 2011, Thaman, 2003). In 2008 food prices reached alarmingly high levels putting great pressures on poor countries that are food deficit and need to import bigger shares of their food needs. In the Pacific Islands countries with the highest share of imported food are atoll countries (Thaman, 2003). According to Sharma (2006) per capita food production declined in many Pacific Island countries between 1991 and 2002 and the dependency of imported food increased. The Pacific Institute of Public Policy (2011) notes that food production in the Pacific Islands is not keeping pace with population growth. Between 1961 and 2009 per capita food production declined by 64 percent in Kiribati, 58 percent in Vanuatu and 49 percent in Tonga.

Natural hazards that affect agriculture add to the challenge. A single hazard often affects entire countries, cause damages up to 20 and more percent of the annual GDP (Weber, 2014a, b) and destroy major food sources. In 2003 Cyclone Amit caused damages to Fiji's agriculture of about FJD 66 million (Sharma, 2006).

Many Pacific Islands experienced considerable depopulation in the later decades of the 19th century (Buxton, 1926; Frater, 1947). There is little evidence that this had been related to food insecurity, famine and starvation. Wars (Cordy, 1972; McNeill, 1994; Repa; 1932; Shlomowitz, 1989; Williams, 1932; Younger, 2009), introduced diseases (Archer, 2010; Bayliss-Smith, 1974; Cassels & Singer, 2010; Cliff & Haggett, 1985; Cordy, 1972; Lessa & Myers, 1962; McNeill, 1994; Rallu, 1992; Repa, 1932; Shlomowitz, 1989; Williams, 1932), emigration (Cordy, 1972), and the Pacific Labour Trade (Valjavec, 1986; Williams, 1932) were more important for population decline than drought, natural hazards or other natural events that can lead to hunger crises and famine (McNeill, 1994).

Schmitt (1970) highlights that "famine was by and large only a minor factor in Hawaiian depopulation. Hunger caused by drought and other natural disasters was too localized and easily escaped to produce catastrophic mortality" (Schmitt, 1970, p. 115). Currey (1980) notes that Pacific island bibliographies and papers have no references on documents relating to famine and also the most important surveys on world famine do not mention Pacific Islands at all (Currey, 1980, p. 447).

CLIMATE CHANGE AND AGRICULTURE IN THE PACIFIC ISLANDS

Barnett (2011) argues that climate change will adversely affect food systems in the Pacific Island region in several ways: the ability to produce food will be compromised as well as the ability of countries to import the food that is needed. Looking more at the micro -level Barnett predicts that households will have challenges to access and utilize food.

Still there are many reasons why Pacific Island populations are better protected against food insecurity compared to people elsewhere in the developing world. Although impacts of modernization and globalization are also felt in Pacific Island countries community cohesion is still strong and land tenure systems prevent that bigger parts of the population become landless. Many have entitlements to land and fishing grounds where they can carry out subsistence production. Urban-based citizens are often closely linked to relatives that live in villages and provide produce "fresh from the farm" regularly. Systems of reciprocity are much more than symbolic: they help urban populations to complement food they buy. Especially in Polynesian countries many have relatives living overseas (e.g. New Zealand, Australian and/or the USA), who send remittances regularly or at least when urgent needs arise (e.g. after natural hazards; see below experiences from Samoa after the 2009 tsunami).

Except of the atolls Pacific Island countries often have low population densities and much unused land that can be brought under agriculture to expand food production. Such prospects however should not be taken too lightly as land use changes often conflict with environmental concerns (Arnell, 2004).

A last point to highlight is that in most Pacific Island countries people possess traditional knowledge of how to preserve food and how to minimize damages in the case of natural disasters. Such traditional practices are at danger of getting lost and there should be proactive measures put in place that assure that also future generations learn about the importance to be prepared against natural hazards. Food security in this context plays a major role (Campbell, 2006; Thaman, 1982a, b, 1979).

VULNERABILITY AND COMMUNITY RESILIENCE

Research conducted in communities of Fiji (Yila & Weber, 2013; Yila et al., 2013), the Solomon Islands (Weber et al., 2015), and Samoa (Weber et al., 2015) suggests that food insecurity not necessarily is in the centre of negative impacts of natural hazards. Resilience help people to deal with such impacts and resilience can support them also when they have to adjust to the impacts of climate change. Building on resilience detected in the three research activities it should be possible to prepare communities to the challenges that come along with climate change. In this process improvements of food and livelihood security seems to be possible as well as improvements to the overall conditions and levels of people's lives.

Two of the research activities look at impacts of tsunamis and do not directly relate to climate change. Still the studies provide insights into people's resilience to severe disasters. Two of the studies (tsunami in Samoa and flooding in Fiji) were conducted immediately after the hazard events, while the third field study was conducted with a considerable time lapse, i.e. some five years after the actual hazard (tsunami in the Solomon Islands of 2007). For the tsunami event in Samoa a second round of fieldwork has been completed in July 2014, some 4.5 years after the event. In all cases food security of people had been severely threatened, but there were mechanisms in place that prevented serious food crises. In none of the communities visited widespread lack of food had been reported immediate after the disaster events and some considerable time later.

TSUNAMI IN THE SOLOMON ISLANDS, APRIL 2007

In April 2007 the Western Province of the Solomon Island suffered from an earthquake with a magnitude of 8.1 triggering a tsunami which caused damaged throughout the Western Province. Most affected were several villages on the southern coast of Ghizo Island (Fisher et al., 2007). Members of the Micronesian population of Ghizo Island had been particularly affected.

During fieldwork five years after the tsunami the scars of the event were still visible everywhere. However people interviewed highlighted that food security was not their major challenge, neither right after the tsunami nor five years later. Although most people lost virtually all their possessions food was secure as many plantations were spread over different locations and therefore some escaped the fury of the waves. While plantations and house gardens in the coastal zone were destroyed many families had additional plantations further inland which remained unaffected. This was in particular true for the Melanesian population, while the Micronesian populations had only

few plantations away from the coast. In the first few days after the tsunami members of the Micronesian community received support and food supply from their Melanesian brothers and sisters. Later, and in those cases were also Melanesian plantations and gardens had been destroyed government agencies and relief organizations successfully helped to bridge the most serious times until a state of normality had been re-established.

In the long term the Micronesian population was able to extend their livelihood base when they started agriculture in the hilly terrain to where they had resettled. This considerably enlarged their livelihoods as they continued fishing, which had been their major source of livelihood prior to the tsunami. The vast majority of the population interviewed saw their situation some five years after the event rather positive. What food supply was concerned almost all people interviewed saw vast improvements compared to the situation before the tsunami. Members of the Micronesian community now have access to land with much better soils in the hilly terrain. Almost every family operates at least one home-garden with a great variety of crops. Some even started selling part of their produce at the fruit and vegetable market in Gizo town. Respondents were even saying that the tsunami that brought them to "their" new land was a 'blessing in disguise'. They only hope that they are not forced back to their settlements at the coast. The biggest challenge some five years after the tsunami is the question, if people are allowed to stay on the new land, which belongs to the government.

TSUNAMI IN SAMOA, SEPTEMBER 2009

End of September 2009 a strong earthquake with a magnitude of 8.1 triggered a tsunami that caused widespread damage in coastal areas of American Samoa, Samoa, and Niuatoputapu Island of northern Tonga. Like in the Solomon Islands also in Samoa government with support from local, national and international NGOs and relief organizations were tirelessly working to satisfy the most pressing needs of the people affected. Some two weeks after the disaster heavy machinery had almost completed their task of building roads to a number of new settlements inland. A few houses had already been completed, but the majority of people were still living in tents provided by relief organizations. Many relatives and friends of victims came all the way from New Zealand, the USA and Australia to help in reconstruction work. In the last quarter of 2009 Samoa received the by then highest inflows of remittances from New Zealand, worth 47 million Samoan Tala (ST) (Gibson, 2010). This amount seems to be even under-reported as many who came to support rehabilitation work also brought cash with them for construction works.

A notable difference to the situation on Ghizo Island is that in Samoa most of the families affected by the tsunami have resettled on their own land. The Polynesian land tenure system provided most families access to land at the coast as well as in the hilly terrain further inland. Conflicts over land are therefore not as frequent and sharp as it is the case on Ghizo Island.

FLOODING IN BA DISTRICT, FIJI IN 2009

Ba district is known for its severe problems of flooding. Floods in January 2009 and January 2012 (and again in March 2012) had affected the most vulnerable groups most severely, especially women and children. Farming communities sustained large economic losses due to inundation of farm land and erosion. More than 75 per cent of the households reported a considerable part of their livelihood lost to the two floods.

97 households surveyed in five villages had been severely affected by the floods in 2009 and January 2012. Many of the households (36 per cent and 24 per cent respectively) were forced to evacuate from their homes, which often were damaged. Degradation to agricultural land was also considerable and compromised livelihoods of many farmers, whose fields were situated along the banks of the Ba river and within the Upper Ba Watershed. A large proportion of sugar cane production was lost during the floods. 25 percent of households interviewed had lost land in the past five years due to flooding. Some farmers lost all their land, others suffered substantial damages. These damages did not pose biggest challenge to food security, but to livelihood security.

During and immediately after the floods mutual assistance between relatives and neighbours had been one of the most important feature preventing a food crises. The effect of social capital helped many to overcome the time, when crops were washed away, supermarkets were destroyed and transportation compromised. These aspects of social capital worked rather well and were supported by government support and the work of relief organizations. While charitable support turned out to be one-way, mutual assistance - food, short-term loans, free

housing and shelter, tools and equipment, child care assistance, exchange of labour – constitutes a major strategy people deployed to provide support to one another. Such kind of support binds individuals and social groups together helping to increase the cohesion of communities. With this mutual assistance is crucial for future events. It helps to initiate community efforts that reduces vulnerabilities and enhances resilience.

Many people interviewed highlighted that cooperation during and after the flood has created a feeling of togetherness, mutual support and trust. Differences of ethnicity and wealth became less important and the community feels stronger as the experience of the flood and the support many people received from their neighbours, family and even strangers.

CONCLUSION

There is little doubt that climate change will change conditions under which agriculture operates in Pacific Island Countries. These challenges will be foremost be associated with natural hazards and disasters arising from such hazards (Weber 2014a, b). Still there is no convincing evidence that climate change, natural hazards or other disruptions will have impacts on food security severe enough to cause a food crisis or even worse. At this point of time nothing indicates that Pacific Island countries are prone to famine. It seems that also in the foreseeable future this is rather unlikely to change. Food insecurity does not top the list of urgent development challenges in the Pacific Islands.

While this is very good news it does not mean that climate change impacts on agriculture and food security are non-existing or negligible. Still disasters and also impacts arising from climate change have great potentials to negatively affect people's livelihoods. Climate changed and its impacts have the potential to destroy people's long time effort to improve, to enable a decent standard of living. Challenges do not only come from climate and other forms of environmental change. Challenges come from the declining position Pacific Island countries play in the world economy, their smallness and inability to benefit from economies of scale. On the positive site however their cohesiveness, the importance of social capital, which often translates also into financial capital in form of remittances from outside the region make Pacific Islanders resilient to various impacts. Of course there are enormous differences between Pacific Island countries, and more research on individual countries and their risks profiles need to be conducted. Much concern surely deserve atoll countries; not only as they are in particular exposed to the threats of sea-level rise, but because they have rather poor populations (e.g. Kiribati) with often low educational standards and are weak in social capital structures outside their countries.

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Socio-economic characteristics of poor farming households in Ondo State, Nigeria

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ABSTRACT

This paper examined the socio- economic characteristics of rural farming households in Ondo State, Nigeria. Two hundred and forty farmers were randomly selected from three (3) local government areas in Ondo State, Nigeria. The study made use of primary data, collected through the aid of interview and structured questionnaire .The analytical tools used were descriptive statistics and Gini – Coefficient. The socio-economic characteristics of the respondents revealed that 27.9% of the farmers were within the age group of 25-29years, 69.65% were male, 69.2% were married, and 30.8% had secondary School education. About 79.6% of respondents engaged in farming, 25.4% were members of Credit and Thrift Cooperative, 37.1% had 3-6 children, 47.5% uses family and hired labour, 5.0% of respondents had 6 hectares of farm size.17.9% had above N 60,000 annually from farm activities and 32.9% had average distance of 1km to primary health care. The result of the Gini Coefficient by sources of income shows that total contribution is 1 out of which farming accounted for 0.62070 while non- farming activities contributed as follows; petty trading 0.004773, Government work 0.00471, artisan 0.00016, small scale business 0.00096 and inter-group 0.36874. This clearly shows that farming contributes more to inequitable distribution of income. This could be explained by the fact that majority of the respondents are farmers and they derive their income mostly from subsistence farming. The rural populace should be empowered in order to contribute to the wealth of the economy through involvement in viable businesses in order to improve their savings culture.

Key words: Social, economic, farming, households, Nigeria

INTRODUCTION

Poverty is a state of not having or not been able to get the necessities of life. According to Maxwell (1989), in real life, it can be assumed that all who are poor are vulnerable because they are susceptible to large fluctuations.

The perceived linkage between income inequality and poverty motivated Datt and Ravallion (1992) to propose a method that decomposed poverty change into income redistribution, income growth, and residual components, otherwise known as the black box. However, Shorrocks (1999) applied the Shapley (1953) theory to poverty decomposition. This was able to take care of the problematic residual component in the Datt and Ravallion (1992) method. The relevance of poverty to economic development efforts can be judged by the spread of researchers that have kept close focus at it in the last few decades.

It has been argued that poverty can be caused by inequality. (UNU/WIDER, 2000; Babatunde, 2008). When economic growth increases, poverty rate decreases but as income inequality increases, incidence of poverty also increases. The recent minimum wage policy of the Federal Government of Nigeria has not been able to solve the problem of poverty level in our country. Unfortunately, most discussions on income have failed to recognize that to achieve poverty reduction, income growth has to be equitably distributed (Babatunde, 2008). Evidence from previous studies point to the increasing level of

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income inequality in developing countries over the last two decades (Addison and Cornia, 2001; Kanbur and Lustig, 1999).

One major factor that should have helped in this area which is Agriculture has not really been of much assistance. Whereas Agriculture-led growth played an important role in reducing poverty and transforming economies of many Asian and Latin American countries, the same has not yet occurred in Africa (Babatunde and Quaim, 2009).

Given the general belief that poverty is more widespread and prevalent in rural than urban areas (IFAD, 2001), and that inequality is higher in rural than urban Nigeria (Oyekale *et al*. 2006), it becomes appropriate to conduct an in-depth analysis of rural poverty level, with the aim of identifying the income sources that contribute more to overall poverty level and suggesting ways of reducing it.

Poverty is a state of not having or not been able to get the necessities of life. Physiological needs is the most essential need of man especially food crops supply. In Nigeria, poverty, hunger and malnutrition are the three main obstacles to national development and growth. According to Maxwell (1989), in real life, it can be assumed that all who are poor are also vulnerable because they are susceptible to large fluctuations in real income over relatively short periods, coupled with the absence of off selling mechanisms to stabilize purchasing power of nutritional intake. The average annual income of a rural peasant farmer is four thousand naira (N4, 000.00) as at 1994 (NARP, 1995). Going by the 1990 World Bank definition, the poor are those with an income below $370 (N37, 000) and the extremely poor are those with an income less than $275 (N27, 500.00).

From the above discussion, it could be seen that the essential need of human existence which is food has not been fully met all over the world since majority of people are still living below the average annual income. Also, in Nigeria, as a result of farming activities in Nigeria which is subsistence in nature, farmers has only been able to meet their immediate need with the little sold out to public hence, there is high poverty level of food consumption. It is a common knowledge that food production has not been able to keep pace with our population growth and those substantial food imports have to be made to supplement local production. There is a wise saying among the Yoruba's that" if the question of food is removed from poverty, the poverty problem is virtually solved".

The poverty level of an average Nigeria has made them opt for things that can fill their stomach and not things that can satisfy them or things that they are desirous to eat i.e. an average Nigerian eat to fill and not to satisfy hence, malnutrition has risen.

It is observed that core poor were in agriculture and all basically reside in the rural areas. Household heads engaged in agriculture and allied activities had the highest poverty level for all years except 1996 (FOS, 1999). It is therefore not far-fetched to say that poverty in Nigeria is related to agriculture and the rural areas. Hence, reducing poverty is the most persistent challenge in Nigeria today.

Many international development organizations use an absolute concept of poverty which has been defined in terms of the minimal requirements necessary to afford, minimal standards of food, clothing, healthcare and shelter. Hauser and Pilgram (1999) further reported that in Benin Republic lack of money is the overriding symbol of poverty, and the degree of satisfaction of other basic needs such as food, health, clothing and shelter. Unemployment, Childlessness and lack of means of transport are also considered as signs of poverty.

The Nigerian poverty situation exhibits geographical (locational) and occupational differentials in its incidence, depth and severity (Aigbokhan, 2000, FOS 2000). The poverty situation in Nigeria, as measured in quantitative terms with data from FOS reveals the poverty incidence. Hence, the number of persons in poverty in the rural areas is larger than in the urban areas.

Meltor and Mensah (1986) in their preface to International Agricultural Research and Human nutrition, concluded that the alleviation of poverty and related ills such as insufficient food intake and malnutrition is one of the most important tasks facing mankind. According to World Bank (1999), poverty is hunger, lack of shelter, being sick and not being able to go to school, powerlessness, not having a job etc. Sanya (1991) and Schubert (1994) also see poverty as either absolute or relative or both. Absolute poverty is that which could be applied at all times in all societies such as the level of income necessary for bare subsistence, while relative poverty relates to the living standards of the poor to the standards that prevail elsewhere in the society in which they live.

Obadan (1997) also identified the following as the main causes of poverty in sub Saharan

Africa; inadequate access to employment opportunities, inadequate physical assets such as land and capital and minimal access by the poor to credit; inadequate access to markets where the poor can sell goods and services.

Poverty is defined as the absence of means to maintain and enjoy basic needs of life (Afonja and Ogwumike, 1995).The magnitude and dimensions of poverty in a country depends on two related factors. First is the average level of income and second is the degree of inequality in distribution of that income. The greater the average income level, the greater the incidence of poverty. Also the more unequal the distribution of a given level of income per capital, the greater the incidence of poverty.

In Africa, poverty remains a scourge that undermines development in contemporary African societies in that, it is deep-rooted and pervasive. Perhaps, nowhere else in the African continent is the scourge more prevalent than in Sub-Saharan African Countries like Nigeria where about one-sixth of the people are chronically poor (World Bank, 1996; Chartered Financial Analysts CFA, 2005). To reverse this trend, many developing countries from the early 1980s initiated and implemented the International Monetary Fund (IMF) and World Bank Structural Adjustment Programme (SAP). These programmes have been reported to have stimulated growth in most of these developing countries. However, in some other countries, there has been little or no change in terms of growth and poverty reduction.

As at August 8, 2012 Nigeria Per Capita income was estimated at $1,600. Nigeria's cumulative revenues from oil (after deducting the payments to the foreign oil companies) have amounted to about US$350 billion at 1995 prices (Salai-Martin and Subramanian, 2003). Worse still, the problems of poverty in Nigeria are multi-faceted, among which are widespread outbreak of Acquire Immune Deficiency (AIDS) , lack of access to good health facilities, high infant mortality rate, lack of essential infrastructure, unemployment and underemployment, corruption, etc.

Poverty rate is characterized by lack of purchasing power, exposure to risks (natural, environmental, gender-related life events etc.) insufficient access to social and economic services and limited opportunities for income generation.

The incidence of poverty in Nigeria appears moderated prior to democratic transition in 1999. As a proportion of the population, 27.2% of Nigerians were living below poverty line in 1980. The poverty incidence did not cross the 50% mark until 1996 when it surged to 65% as a result of the near collapse of the Nigerian economic system. This was a time when economic growth in Nigeria reached its lowest at 2.5% in 1995 and 4.3% in 1996. The high incidence of poverty in the 5-years period of 1995-1999 could be as a result of political instability that characterized that period.

Democratic rule in 1999 is a period of high economic growth built on improved flow of capital into the economy as a result of renewed confidence in democratic rule which encourage liberalization of the economy for increased private sector participation and financial market efficiency. Real GDP growth surged from an average of 2.54% in the period of 1995-1999 to11.9% for the period of 2000-2004. (112million Nigerians are also relatively poor, and 99.5million people lives on less than one dollar per day).

The NBS measures four types of poverty incidence: The food poverty measure, which defines proportion of population living on less than 3000 calories of food per day; the absolute poverty measure, which defines those living below or those that can afford a defined minimal standard of food, clothing, healthcare and shelter; the relative poverty measure, which defines those living below the living standards of majority in a given society. Household with expenditure greater than two thirds of the total household per capital expenditure are non-poor whereas those below it are poor while those with less than one third of total household Per Capital expenditure are core-poor and those with greater than one third of total expenditure but less than two third of the total expenditure are moderate poor. From the Dollar per day measure, which defines those living below US$1 per day based on the World Bank's Purchasing Power Parity (PPP) index. In 2010, it was estimated that 66million Nigerians or 40.63% of the population did not have access to 3000 calories of food per day.

About 99million or 60.5% of Nigerians are absolutely poor living below humanly acceptable level of food intake, had no decent clothing and no access to standard healthcare and shelter.

Poverty in Nigeria is associated with high unemployment, poor governance, corruption, lack of accountability, gross violation of human right etc. Poverty has a gender dimension as women are over-represented among the poor due

to the subordinate status of women, traditional and social cultural practice discrimination and lack of access to productive assets and financial services. The problem has however been traced to high population growth rate and rural-urban migration that has made the quality of life in urban slums worse while urban services and infrastructure are more stretched hence, it becomes appropriate to conduct an in-depth analysis of poverty with the aim of identifying the income sources that contribute more to overall poverty and suggesting ways of reducing poverty generally.

High level of poverty exist around the world mostly in developing countries. This is due to increase in unemployment rate which however has brought increase in crime rate and insecurity. Different policies must be put in place to either reduce poverty or eliminate poverty completely. It is necessary to go beyond the general information that poverty is more pervasive in agriculture and allied activities and establish the poverty profiles for workers in various sub-sectors of agriculture. This will enable policy makers to appropriately determine the type and mixture of policy interventions suitable for reducing or eliminating poverty.

Poverty and Income inequality can be detrimental to economic growth and development of a country. Addison and Cornia (2001), Adams (1999), Adams (1995) and Aboyade (1983) have proven in their various studies that income inequality is closely related to poverty. Thus, a careful study of poverty incidence through the study of sources of income and accessibility to social services and productive assets in the selected areas and determining the socio-economic characteristics of the rural farmers in the study area. Hence, this study is focused on evaluation of poverty levels among small holder farmers in Ondo State, Nigeria.

Several studies in Nigeria have decomposed poverty by economic sector, income source and family characteristics. Most of these studies were conducted at the Local Government level and the studies are useful because they help to identify the structure of poverty within a given society. This paper evaluated the socio-economic characteristics of poor farming households in Ondo state, Nigeria. The knowledge of poverty among farmers in the state will help policy makers to formulate policies that will ensure reduction in the level of poverty in the state.

The general objective of this paper is to examine the socio-economic characteristics of small holder farmers in selected Local Governments of Ondo State;

The specific objectives of this study are to:

a) Identify various sources of income among small holder farmers in the study area;
b) Examine the distribution of income among small holder farmers in the study area;

RESEARCH METHODOLOGY

This study area is Ondo State. Ondo State was created in 1996 out of the old Ondo State (which consisted of the now Ondo and Ekiti States) as one of the 36 states of the Federation of Nigeria. Ondo State is made up of 18 (eighteen) local Government Areas, it is located in the South Western zone of Nigeria with its headquarters in Akure.

The State lies between longitude 4'30' and 6'East of the Greenwich Meridian M, 5'45'and 8'15' North of the equator. This means that the state lies entirely in the tropics. Ondo State is bounded in the North by Ekiti/Kogi States; in the East by Edo State; in the West by Oyo and Ogun States, and in the South by the Atlantic Ocean. It has a total land area of 14,788,723 square Kilometres (km) and a population of 3,441,024 comprising 1,761,263 males and 1,679,761 females (NPC, 2006).The tropical climate of the State is broadly of two seasons: rainy season (April-October) and dry season (November-March). Temperature throughout the year ranges between 21^0c to 29^0c and humility is relatively high. The annual rainfall varies from 2,000mm in the southern areas to 1,150mm in the northern areas.

The State enjoys luxuriant vegetation with high forest zone (rain forest) in the south and sub-savannah forest in the northern fringe. Ondo State economy is basically agrarian with large scale production of cocoa, palm produce and rubber. Other crops like plantain maize, yam and cassava are produced in large quantities. Sixty-five percent of the state labour force is in the agricultural sub-sector.

The state is also blessed with very rich forest resources. The state is equally blessed with extensive deposits of crude oil, bitumen, glass sand, kaolin, granites and limestone. (Ondo State Ministry of Information, 2012).

Multi-stage sampling technique was used. In the first stage, three Local Government Areas noted for high incidence of poverty were pur-

posively selected: Akure North, Ifedore and Idanre Local Government Areas. In the second stage, two (2) communities from each of the selected Local Government Areas were randomly selected. At the third and final stage, forty (40) respondents were randomly selected from each of the communities making a total of two hundred and forty (240) respondents.

Both primary and secondary data were used for this study. Primary data were collected through direct personal interview and structured questionnaire, pre-tested and administered randomly on the respondents. Simple random sampling was used for the selection of the respondents. It began by purposively selecting three (3) Local Government Areas, (Ifedore, Akure North and Idanre).

Information were collected on socio-economic characteristics of the respondents such as age, household size, farming experience, farm size, education, marital status and sex etc. In addition, information were collected on farm operations especially, inputs, output, as well as the costs and returns to their production. Secondary data were collected through journals, publication, textbooks and the internet.

Descriptive Statistics such as mean, median, mode, standard deviation, percentage, frequency distribution and pie chart were used to examine the socio-economic characteristics of the respondents.

RESULTS AND DISCUSSIONS

Socio-economic characteristics of the respondents in the study area

Age

Table 2 shows that about 3.8 % of the respondents were less than 25years of age, 13.8 % were between age range of 25 – 29 years, 27. 9 % from 30-39 years, 16. 7 % from 40-49 years, 23.8% from 50-59 years while 14.2% were between 60 years of age and above. The mean age of the respondents was 43.64 years. This shows that majority of the respondents were between the middle age hence, there is possibility of improvement in production i.e. the more active farmers are, the more their productivity.

Sex

Table 3 shows that about 69.6% of the respondents were male while only 30.4% of the respondents were female, an indication that farming was male dominated. The dominance of the male over their female counterparts may be attributed to the fact that farming is energy consuming and requires much strength. Therefore, they are likely to generate more income for the family that can help in reducing poverty.

Marital Status

Table 4 revealed that about 69.2% of the respondents were married and 12.5% respondents were single: 4.6% of the respondents were separated 10.0% were widowed while 3.8% were divorced. The implication of this is that majority of respondents are "responsible" and can take marketing decisions with their spouses. The married are more productive and it also determines the degree of "responsibility" of an individual to his family and society at large. The availability of goods will reduce level of poverty.

Educational Background

Educations liberate from ignorance and also have positive influence on farmers' productivity for there is a positive correlation between education and adoption of technology.

Table 5 shows that about 18.3% of the respondents had no formal education, 27.1% completed primary school education while 30.8% had secondary school education, 2.5% had Arabic/koranic education, 0.8% had nomadic education, 5.0% had vocational training 3.3% had post-secondary education while 12.1% had university education. The high percentage of respondents with tertiary education may be due to high unemployment rate in the formal sectors of the economy making the educated populace to seek employment in other sectors (non-formal).

Occupation

Table 6 shows that 79.6% of the farmers interviewed engaged in farming, 9.6% engaged in petty trading, 3.8% are into medium Scale business, 5.0% are Government workers, and 2.1% are artisans. The implication of this is that majority of the farmers are into subsistence farming with low productivity and in turn high incidence of poverty.

Sources of finance

Table 7 shows that 12.9% are financed by Credit and Thrift Cooperative society, 7.5% from produce marketing cooperative, 12.5% from consumer cooperative, 2.1% from Fadama III cooperative group, 7.5% finance from multipurpose cooperative. The implication of this is that some farmers take advantage of membership of societies in the areas of seeking and obtaining credit

and information while others took advantage of other sources of income for self-financing in order to reduce their poverty level.

Household size

Family size determines dependency ratio as well as family labour available for use. Table 8 shows that about 12.5% of respondents had 2 children, 37.1% had 3-6 children, 27.6% had 7-10 children 17.8% had 11-15 children while 1.3% had 18 children. The implication of this is that majority of the respondents had small and manageable family size. The small family size will made the farmers involve activities of outside labourers which will however increase amount spent on farming activities and may also increase poverty level of farmers as a result of low income from farming.

Farm size

Table 9 shows that about 4.2% of the respondents had less than 1 hectare of land, 39.6% had about 1-2.9ha of land about 38.3 had 3-4.9 hectares 12.9% had about 4–5.9hectares of land while 5.0% had 6hectares and above. This shows that majority of the farmers were small farm land owner. The implication of this is that production from farming activities will be low, hence increase in poverty level of farmers.

Sources of land (Ownership of farm land)

Table 10 shows that majority of the respondents (42.9%) acquired their farm land through lease, 28.3% through inheritance, 23.8% through purchase, 4.2% through communal (jointly owned) while 0.8% acquired theirs through other means. Some farm owners might spell out conditions on the usage of the land. The implication of this is that production may be lower compared to farmers who owns the farm land or acquired it from family inheritance and the lower the production the higher the poverty level of farmers.

Labour Utilization (Sources of labour)

Table 11 shows that19.2% uses family labour, 31.3% uses hired labour, 47.5% uses family and hired labour, 19.2% uses family labour. The implication of this is that the cost of production will be high since farmer's involved hired labour in production hence, low savings. The low savings of farmers will affect the standard of living of farmers and this might also increase poverty level.

Annual Income from Farm Activities

Table 12 shows the income of the farmers in the study area. The result revealed that 10% had less than N10, 000 annually, 9.2% had N10, 000- N20, 000, 12.1% had N20, 001- N 30,000, 18.8% had N30, 001- N 40,000, 16.3% had N40,001 - N 50,000, 15.8% had N 50,001- N 60,000 while 17.9% had above N 60,000. The implication of this is that most of the farmers' income are not enough to meet the needs of the farmers. This also call for government intervention in order to get more income from farming activities through training and retraining of farmers which will help in reducing poverty level.

Distance to Primary Healthcare

Table 13 shows that 32.9% of the respondents had an average distance of 1km(one kilometer) to primary health care, 28.3% had an average distance of 2km(two kilometers) to primary healthcare, 9.6% had an average distance of 3km(three kilometers) to primary healthcare.

Also, 5.8% had an average distance of 4km (four kilometers) to primary healthcare, 20.8% had an average distance of 5km (five kilometer) to primary healthcare, 0.8% had an average distance of 6km (six kilometers) to primary healthcare and 1.7% had an average distance of 7km (seven kilometers) to primary healthcare. More than half of the respondents (61.2%) trekked between 1-2 kilometres to the nearest health centres. Hence, availability of health center to the farmers is great importance as an indication of good and sound health for improved standard of living and reduction of poverty among farmers.

Sources of income among small holder farmers in the study area

The study revealed that, these are two major sources of income for the respondents namely:

- Income from farming activities.
- Income from non-farming activities

Income from Farming Activities

It was observed that cash crops like Cocoa, Coffee, Oil palm, Rubber, Kola nut and Cashew etc. and food crops like cassava, yam, coco yam, maize, cow pea/bean etc., were grown by the farmers and contributed 62.5% of their total income within a year.

Income from non-farming activities

Non farming activities contributed the

remaining 37.5% income of these farmers. The activities involved in this group include, petty trading, medium scale businesses, civil service and artisan.

Distribution of income among small holder farmers in the selected area

Table 14, shows that 10% of the respondents had annual income of less than1 N 120,000 from farming activities, 9.2% had annual income of N 120,012- N 240,000 from farming activities, 12.1% had annual income of N240,012- N 360,000 from farming activities, 18.8% had annual income of N 360,012- N480,000 from farming activities, 16.3% had annual income of N 480,012- N 600,000 from farming activities, 15.8% had annual income of N 600,012- N 720,000 from farming activities while 17.9% had above N 720,000 annually from farming activities. An indication that farmers can depend on their activities to meet their daily need to reducing poverty level.

Analysis of income inequality among small holder farmers

In order to analyze income inequality among farmers, Gini coefficient was used. Gini coefficient (Gini Index or Gini Ratio) is a measure of equality of distribution of income within a population. The Gini coefficient ranges between 0 and 1. When the value is zero it means perfect equitable distribution and 1 indicates that there is perfect inequitable distribution of income. The total income of the respondents is taken to be the sum of farm income and non-farm income.

The value of Gini coefficient obtained is 0.32401. This value suggests that there is some measure of inequality in the distribution of total income of the respondents. However, since the value is less than 0.5 (the midway between 0 and 1), the inequality is not all that pronounced. This may be explained by the fact that farmers in the study area are generally poor.

Decomposition of respondents by sources of income

Table 15 shows the variables that contributed to income inequality among the farmers. The Gini coefficient was decomposed based on the sources of income, education, age, marital status and sex. Also, intra-group and inter-group comparison was carried out. The results of the decomposition are presented in Table 15. The last column of Table 15 shows the relative contribution of each source of income to poverty. The total contribution is 1 out of which farming accounted for 0.62070, petty trading (0.00473), small scale business (0.00096), government work (0.00471), and artisan (0.00016) and inter-group (0.36874). This clearly shows that farming contributes more to inequitable distribution of income and also to poverty level. This could be explained by the fact that majority of the respondents are farmers and they derive their income mostly from subsistence farming.

CONCLUSION AND RECOMMENDATION

The study established a high level of poverty among small holder farmers in Ondo State. Majority of the respondents do not have proper access to institutionalized credit as a result of prohibiting factors such as collaterals and the terms and conditions attached to institutionalized credit. Some of the farmers had no access to health care facilities, water, electricity and good roads. All these have contributed immensely to poverty among small holder farmers.

The paper recommended among others that:

a) The rural populace should be empowered in order to contribute to the wealth of the economy through involvement in viable business in order to improve their savings culture.
b) Credit facilities on easier terms and conditions should be granted in order to reduce the poverty level of the farmers. This is because majority of the farmers got finances for farming activities through self-financing.
c) Diversification of economic activities should be encouraged. This is because farmers that diversified activities had more savings, and more tendencies of reducing poverty.
d) The bureaucracy and collateral requirements of obtaining credit from banks should be relaxed so as to increase farmers' access to loan from commercial banks.

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Table 1: Poverty incidence by location – Rural/Urban (in %)

	Urban			Rural		
Year	Non Poor	Moderately poor	Core Poor	Non Poor	Moderately Poor	Core Poor
1980	82.8	14.2	3.0	71.7	21.8	6.5
1985	62.2	30.3	7.5	48.6	36.6	14.8
1992	62.5	26.8	10.7	54.0	30.2	15.8
1996	41.8	33.0	25.2	30.2	38.2	31.6

Source: FOS Poverty profile for Nigeria 1980 – 1996.

Table 2: Distribution of respondents by age

Age in years	Frequency	Percentage
<25	9	3.8
25-29	33	13.8
30-39	67	27.9
40-49	40	16.7
50-59	57	23.8
60 and above	34	14.2
Total	240	100

Source: Field Survey, 2012

Table 3: Distribution of respondents by sex

Sex	Frequency	Percentage
Male	167	69.6
Female	73	30.4
Total	240	100

Source: Field Survey, 2012

Table 4: Distribution of respondents by marital status

Marital Status	Frequency	Percentage
Single	30	12.5
Married	166	69.2
Separated	11	4.6
Widowed	24	10.0
Divorced	9	3.8
Total	240	100

Source: Field Survey, 2012

Table 5: Distribution of respondents by educational background

Education	Frequency	Percentage
No formal Education	44	18.3
Primary School education	65	27.1
Secondary School education	74	30.8
Arabic/koranic education	6	2.5
Nomadic education	2	8
Vocational training	12	5.0
Post-secondary education	8	3.3
University education	29	12.1
Total	240	100.0

Source: Field Survey, 2012

Table 6: Distribution of respondents by occupation

Occupation	Frequency	Percentage
Farming	131	79.6
Petty trading	23	9.6
Medium Scale business	9	3.8
Civil service	12	5.0
Artisan	5	2.1
Total	240	100.0

Source: Field Survey, 2012

Table 7: Distribution of respondents by finance

Sources of Finance	Frequency	Percentage
Credit and Thrift Cooperative Society	31	12.9
Produce marketing Cooperative Society	18	7.5
Consumer Cooperative Society	30	12.5
Fadama 111 Cooperative group	5	2.1
Multipurpose Cooperative Society	18	7.5
Others (SEAP,LAPO,ESUSU,Self)	138	57.5
Total	240	100

Source: Field Survey, 2012

Table 8: Distribution of respondents by household size

Household size	Frequency	Percent
<3	30	12.5
3-6	89	37.1
7-10	66	27.6
11-14	43	17.8
15-18	3	1.3
No response	9	3.7
Total	240	100.0

Source: Field Survey, 2012

Table 9: Distribution of respondents by farm size

Farm size	Frequency	Percentage
Less than 1ha	10	4.2
1-2.9ha	95	39.6
3-4.9ha	92	38.3
4-5.9ha	31	12.9
6ha and above	12	5.0
Total	240	100

Source: Field Survey, 2012 (Mean farm size 3.28)

Table 10: Distribution of respondents by their main sources of farm land

Sources of farm land	Frequency	Percentage
Inheritance	66	28.3
Purchase	57	23.8
Lease	103	42.9
Communal (jointly owned)	10	4.2
Others	2.0	0.8
Total	240	100

Source: Field Survey, 2012

Table 11: Distribution of respondents by the types of labour utilized

Labour used	Frequency	Percentage
Family labour	46	19.2
Hired labour	75	31.3
Family & Hired labour	114	47.5
Others(friends, societal group)	5	2.1
Total	240	100

Source: Field Survey, 2012

Table 12: Distribution of respondents by annual income from farming activities

Annual income from farming activities.	Frequency	Percentage
Less than N10,000	24	10.0
N 10,000- N 20,000	22	9.2
N 20,001 - N 30,000	29	12.1
N 30,001- N 40,000	45	18.8
N 40,001- N 50,000	39	16.3
N 50,001- N 60,000	38	15.8
Above N 60,000	43	17.9

Source: Field Survey, 2012

Table 13: Average distance to primary health care (km)

Average distances to primary health care (km)	Frequency	Percentage
1	79	32.9
2	68	28.3
3	23	9.6
4	14	5.8
5	50	20.8
6	2	0.8
7	4	1.7
Total	240	100

Source: Field Survey, 2012

Table 14: Income distribution among small holder farmers

Income Range	Frequency	Percentage
Less than N 120,000	24	10.0
N120,012- N 240,000	22	9.2
N 240,012 – N 360,000	29	12.1
N 360,012 – N 480,000	45	18.8
N 480,012 – N 600,000	39	16.3
N 600,012- N 720,000	38	15.8
Above N 720,000	43	17.9
Total	240	100

Source: Field Survey, 2012

Table 15: Decomposition of Gini Coefficient by sources of income

Group (Source of Income)	Estimated Gini	(Proportion)	(Mean of group)/Mean	Absolute Contribution	Relative Contribution
Farming	0.31797	0.63335	0.99890	0.20117	0.62070
Petty trading	0.22247	0.00918	0.75090	0.00153	0.00473
Small Scale Business	0.19380	0.00141	1.14051	0.00031	0.00096
Civil Service	0.45549	0.00250	1.34076	0.00153	0.00471
Artisan	0.10513	0.00043	1.11717	0.00005	0.00016
Inter-Group	0.11951	---	---	0.11951	0.36874

Source: Field Survey, 2012

Figure 1: Relative contribution of sources of income to inequality

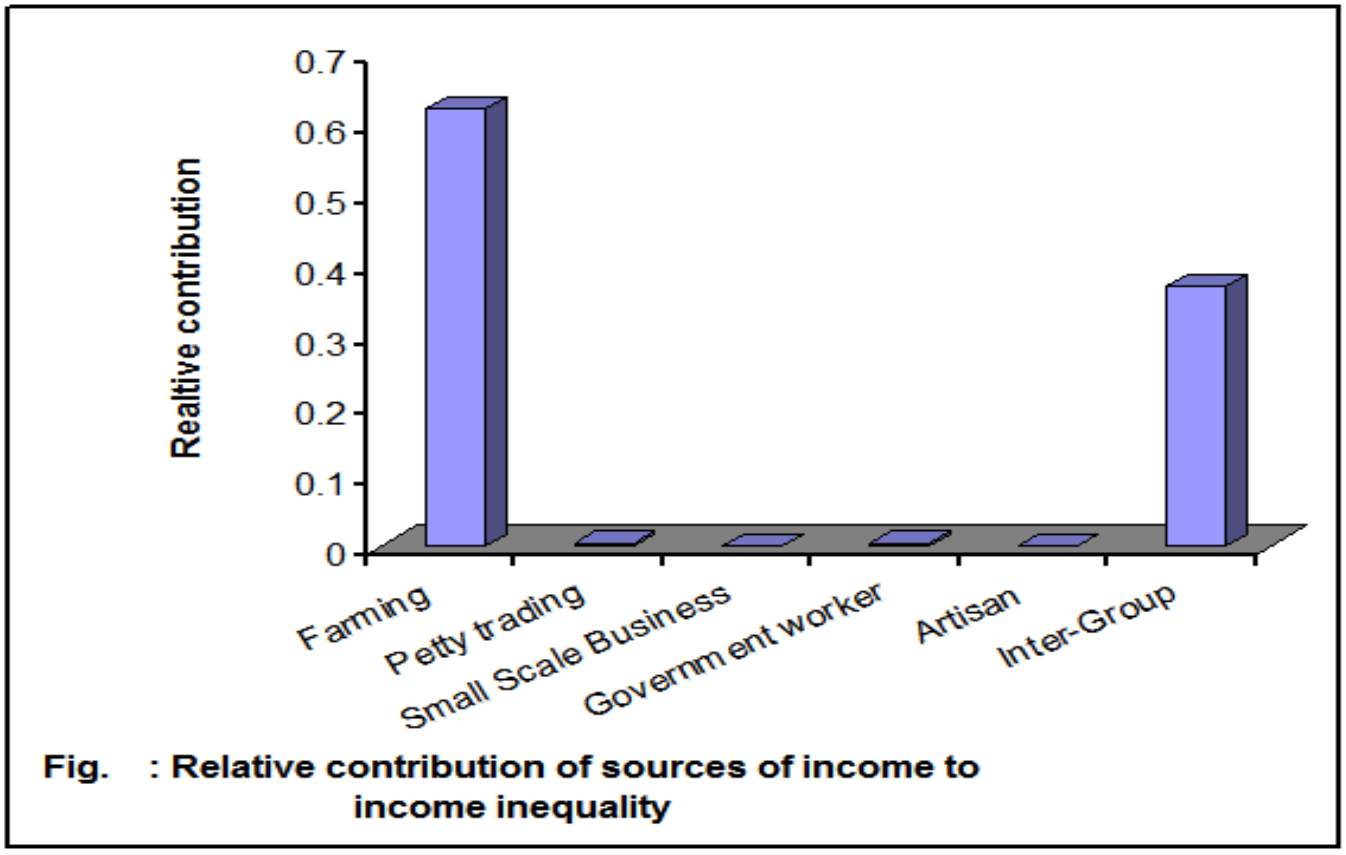

Fig. : Relative contribution of sources of income to income inequality

Valuing the canarium trees in Malaita Province of the Solomon Islands

Ramona S. Sulifoa[1] and Sonny Lameta[2]

ABSTRACT

The canarium tree has been a source of food, income and it has cultural significance for the Malaitan communities. The introduction of cocoa as a cash crop and copra processing has resulted in a reduction in canarium nut processing. This study attempts to value the provisioning services lost from the canarium nut as a result of the introduction of the cash crop using the market price and production function approach methods. The cultural ecosystem services value of the canarium tree was difficult to quantify and has been defined qualitatively. The results from this study showed that there has been a shift in the males' priorities from traditional crop processing to cash crops. This shift is due to the fact that canarium nut processing is labor intensive compared to cocoa and copra processing. Due to this shift, the cultural values associated with the canarium nut are being lost and with it the social cohesion and food security associated with the nut. The opportunity still remains for the canarium nut to be processed through the local women by optimizing the available labor. A reduction in labour used for copra processing can instead be used for processing of the canarium nuts and cocoa which would yield higher returns. If the government were to subsidize some of the labor costs associated with canarium production, it might encourage the males of the community to divide their labor between the three enterprises which would improve income diversification and ensure food security for the communities.

Key words: Canarium nut, Ecosystem services, Food security.

INTRODUCTION

Canarium nut has the potential to be commercialized (Carlos and Dawes, 2000), but it is constrained by an inconsistent supply (Pelomo et al., 2003; Sulifoa, 2012). Meanwhile, the Malaitan communities are accruing more revenue through cash crops such as cocoa and copra (Pacific Islands Trade and Invest, 2012, McGregor et al., 2013).

"Every day she cracked some of the nuts with a rock, stopping every now and then to chase the flies off her sores. Every day she ate the sweet, white, oily kernels. The others watched her, wondering what would happen. She'd volunteered because she had nothing to lose. No one had wanted an ugly girl like her for a wife so she had no children and now she was old. There were many trees bearing this type of nut around her village and in the tribal forests in Malaita, but no one ate them because everyone thought they were poisonous. To everyone's amazement the old woman didn't die. In fact after months of eating this nut locally known as *"ngali"* she looked healthier. Her sores were gone and her skin was becoming smoother. The people realized that the nut was edible and so began the nutritional, cultural and economic journey of the canarium nut in Malaita Province."

- Retold by Lilia, Malaita Province to Ramona Sulifoa -

The story depicts how the canarium nut became important to the local communities in Malaita Province, Solomon Islands. The canarium season was important as the local communities would camp and work together for a month to harvest and process the nuts which would be stored for feasts (Pelomo et al*.,* 1993). Each

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gender group was allocated a role so that harvesting and processing the nut was done efficiently. The communities would chant during processing to keep the momentum going (Pelomo et al., 1993). Processing of the nut was part of their survival techniques in addressing food security in the traditional system. The nut was an important food source, and it was used in the bartering system for traditional shell money, which is a significant part of the bride price in the Malaitan culture. With the introduction of the cash economy into the Solomon Islands around 1923 (Tedder, 1966) the communities began selling the canarium nuts in the local village or main markets as a source of revenue.

Communities are replacing the potential economic value of the canarium nut with the more lucrative cash crops, and they are losing an important source of food, and community togetherness associated with the canarium tree. In essence, they are losing the cultural value associated with the tree.

This study investigates the influence of the cash crops on the Malaitan societies and how this has contributed to the loss of the cultural ecosystems and provisioning services provided by the canarium nut. Using the market price and production function approaches for valuing the canarium tree ecosystem services, the results from this study will shed light on policies to aid the communities, especially convincing males to partition their time in the harvesting and processing of the canarium. This will help the local communities in terms of food security, and it will also assist the communities in rethinking their relationship with the canarium to enable the survival of knowledge associated with the tree to be passed onto future generations. It is also important as future valuing work can be done on the canarium tree.

METHODOLOGY

Location of the study and research design

The study was carried out on Big Malaita of the Solomon Islands. The people from this area are mainly Melanesians and rely on semi subsistence agriculture for their livelihood. This Province was selected because it had large areas monocropped with canarium nut, and these communities were active in supplying the majority of the nuts sold during the commercialization trials carried out in the Solomon Islands. Additionally, the nut is important in the diets of the local people as well as in the bartering and commercial systems.

Method of data collection

This study used the stratified sampling method. From the 20 wards in Malaita accessible by road, eight wards (Baegu/Fataleka, Foondo/Gwaiau, Keaimela/Radefasu, Malu'u, Mandalua/Folot, Sububenu/Buruaniasi, Waneagu/Silaviasina, Fauabu were randomly selected. A total of 100 households were interviewed from these wards using a structured questionnaire. The study also involved direct observations on the collection, consumption and marketing of the canarium nuts.

Secondary data on cocoa and copra production was collected from Dan Vadnjal and Moses Pelomo's (2014) cocoa chain analysis and David Young and Moses Pelomo's (2014) copra chain analysis.

Data analysis

Several approaches were used to analyze the data collected to enable economic and quantitative comparisons to be made with the cash crops as well as the canarium trees. The geographical information as well as statistical differences in the information collected were analyzed using the Genstat Statistical Software. The market prices as well as the production function approach were used to determine and make comparisons in the profits earned between the three enterprises and to identify an optimum division of labor between the three enterprises.

Market price approach

The market price approach is one method which can be used to value ecosystem services. It is mainly used for those services in which a market price can be obtained as the goods are sold in the market (TEEB, 2010). The main challenges with this method is that imperfect market structures may distort the market price influencing the final value for the ecosystem service in question.

Profits and costs associated with the production of each enterprise (cash crops and canarium nuts) was determined using the market price approach method. The survey carried out identified the market prices that people were willing to pay for the canarium nut. The main costs of production include labor and capital associated with the enterprises, because land is owned by tribes and clans, the communities do not have to pay for its use (Bunt, 1996). Profit takes into account the labor and capital costs associated with the enterprises.

Since the research only collected data related to canarium nut marketing, the information related to cocoa and copra processing and sales was determined through literature review. The findings from the analysis carried out by Dan Vadnjal and Moses Pelomo (2014) for a cocoa chain analysis and the analysis by David Young and Moses Pelomo (2014) on the coconut chain analysis in the Solomon Islands were used to provide estimates for marketing costs for both copra and cocoa production in Malaita.

This analysis uses the authors' shadow price of S$30.00 per labor person for labor costs associated with the production of the cash crops as well as labor costs associated with the canarium nut. This is to ensure that there is consistency in terms of determining the end costs for all products to allow for comparisons to be made. Directly determining the casual labor costs associated with labor services in the villages is difficult as labor can be exchanged for goods, a situation similar throughout the Solomon Islands.

The calculations used by Dan Vadnjal and Moses Pelomo (2014) and David Young and Moses Pelomo (2014) indicate that labor costs for cocoa production were calculated based on 150 person days, whereas for copra production, the labor costs have been calculated based on 37 person days. Similarly for processing the canarium nuts, the labor costs have been calculated based on discussions with communities In contrast to past practice, almost exclusively women now harvest the canarium nuts; these estimations allowed for comparisons to be made between the three enterprises.

Production function based approach

The production function approach is one valuation method which can be used to measure ecosystem services (TEEB, 2010). It is mainly used for valuing provisioning and regulating ecosystem services (UNEP, 2010) and in some cases, it has been used for valuing cultural services such as recreation values (TEEB, 2010). Production function looks at the input – output relationships between the ecosystem being valued and the output which in most cases is the marketed product (UNEP, 2010; TEEB 2010). The method is heavily dependent on market data being available in order to make the estimations. Furthermore, it is important that the correct function is derived for the purposes of the study.

Generally, the input – output relationship can be mathematically written as:

$$Y = \boldsymbol{f}(X_1, X_2 \ldots . X_n)$$

Where Y is the output being determined and X_1, $X_2 \ldots . X_n$ are the inputs.

For the purposes of this study, the production function was only used to look at the relationship between the factors of production such as Land, Labour and Capital associated with the profits for the three crops compared. Since market data were available for the factors of production for canarium, cocoa and copra, the study used the production function to identify the best option for maximizing profits taking into account that labour is a scarce resource. It is important to note that capital is minimum at the village level as cocoa and coconut seeds are saved. In some cases, the seeds are given to the communities for free by the government through their outreach programmes. No fertilizers are used in the production of any of the crops compared.

For the purposes of this study, (Y) will be our profits and the inputs (X) into the function will be land, labour and capital. Furthermore, since labour will be one of the units in the function which is one of the scarce resources, it is important to note that labour will be a function of the processing methods, as well as the distances travelled to harvesting site and marketing of the three individual crops. This can be expressed as:

Labour = $\boldsymbol{f}$ (Harvesting, Processing stages, Distance travelled). Solver in excel was used to identify the maximum profit output taking into account labour as being a scarce resource. The cultural ecosystem services provided by the canarium nut cannot be directly valued in this study using the production function. However, the hope is that through the use of this method, an idea of how to share the scarce labour available between the three crops studied for profit maximization can be recommended and that in the end, the cultural values associated with the canarium nut are conserved.

The cultural ecosystem services provided by the canarium nut cannot be given a monetary value, and has been defined qualitatively. It is anticipated that the study, will shed an idea of how to share the scarce labour available between the three crops for profit maximization which will in turn bring to light the cultural values associated with the canarium nut.

ciated with the canarium nut.

RESULTS

Geographical representation of respondents

The geographical representation of the communities surveyed can be found in Tables 1, 2, 3 and 4.

Canarium nut and the provisioning ecosystem services

Provisioning services are those products derived from our ecosystem such as food, genetic resources and energy (MA, 2005; TEEB, 2005). The canarium nut is a source of food for the local communities. Yen, (1996) notes that the oil is high in minerals as well as some vitamins and it is a good source of protein (Evans, 1999b). The canarium is not only mixed with starch crops such as taro, but it is also mixed with slippery cabbage (*Abelmoschus manihot*) (Chaplin, 1988).

Canarium nut and the cultural ecosystem services

The cultural values of the canarium to the communities, can be identified through the values associated with knowledge systems, educational, as well as social relations and cultural heritage values. It is important to note that in least developed countries such as the Solomon Islands, the cultural services of the canarium are closely linked with the provisioning services which are needed to support the overall wellbeing of the communities (Goto, 1996).

In defining these values, it was important to look at how they processed and stored the nuts using the traditional way. These traditional processing methods required knowledge and skills in order to ensure that it is carried out successfully. Furthermore, the link between the canarium nut and its use in the bartering system was identified. The bartering of the nuts with shell money was important as shell money is part of the traditional economy of the communities.

Canarium nut harvesting

The canarium season varied between edible species, but generally the season for the main edible species *Canarium indicum* preferred by the Malaitans occurs around May to October with the peak harvesting time occurring around July or August (Sulifoa, 2012). Around this time, the communities would camp at the harvest sites for one month and work together to harvest and process the canarium nut. It is not clear when this communal practice and more research to identify this change could be looked into as currently no research addresses the changes in the practices.

Four methods were used by the communities for harvesting the canarium nut. The most popular method was by climbing the tree and using a hooked bamboo to twist off the canarium bunches (86 percent). The second method was by picking up the ripened fruits which had fallen to the ground (46 percent). The least popular methods were by climbing the trees and cutting the branches with a bush knife (26 percent), snapping the branches off (five percent), throwing the nuts with rocks (one percent) and climbing by using a rope (one percent).

Significant differences existed between the number of nuts harvested using the two common methods (using the bamboo and picking the nuts off the ground). Harvesting the nuts using the bamboo with a median of 15,040 nuts with mesocarp (485.16 kg) was significantly ($P = 0.002$) better than using the hand picking method which gave a median amount of 5,302 nuts with mesocarp (171.03 kg).

Canarium nut processing

Five main methods were still used by the communities for processing the canarium nut.

Method one: This is the most commonly used one for processing the canarium nuts. The mesocarp, shell and testa are removed. The kernels are placed in bamboos and the top of the bamboo is closed with canarium leaves. The bamboo is placed over a hot fire to remove the oil and the juices from the canarium nuts. The bamboos are then placed over the fireplace to be further dried. This method had a mean shelf life of five months.

Method two: The mesocarp is left to decompose in baskets for several days before being cleaned and the nuts in shell (NIS) are washed and dried in the sun for about a week. The nuts are then cracked, the testa removed and the kernels roasted over hot stones. The kernels are then left to cool down before being packed in either plastic buckets or in plastic bags.

Method three: The canarium nut is cracked, the mesocarp, shell and testa are removed and the kernels are eaten immediately. Around 25 percent of the respondents used this method during the canarium season.

Method four: The nuts are left in baskets to decompose, once the NIS have been cleaned, they are placed in baskets over the fire place to

be stored.

There were significant differences detected between the different processing methods at ($P \leq 0.05$). The results showed that most people used the first method of processing (73 percent). It is important to take note of the fact that the above methods are used by different community members during the canarium season.

Pelomo et al., 1993 noted that there were songs associated with the processing of the canarium nut. This was mainly to keep the momentum of processing and packing the canarium as it was tedious work. When the communities were asked whether the practice of communities camping together to harvest the canarium still occurred, all respondents indicated that this was no longer done but that whoever was willing to go and harvest was welcome to do so.

Cultural importance of the canarium nut

When asked on the cultural importance of the canarium nut, the respondents noted feasts (95 percent) were the most important aspects of the nut to their culture. They also responded that it was important in the bartering system (52 percent).

The importance of the canarium to the local feasts is interesting to note in that the Malaitans make *"kata"* (canarium mixed with taro to make a pudding). If this pudding was not present in a celebration then the occasion was second-rate (Pelomo et al., 1996; M. Pelomo 2009, pers. comm., March). It identified the status of a person because the work associated with preparing the canarium nut for this feast cost time and red shell money in payment for the labour to prepare the feast.

Canarium nut in the bartering system

Respondents were asked about the items they used to barter with the canarium nut. The results indicated that 22 percent of the respondents would barter up to 20 one meter "*pinali"* (a pinali is a length of bamboo filled with canariam kernels in testa) for an eight foot length of red shell money. Around 33 percent of the respondents bartered the canarium for fish. The amount of *"pinali"* exchanged for fish varied from three to five depending on the size of the fish. In some households, they exchanged the *"pinali"* for sweet potato and taro.

Bride price in the Malaitan culture

Bride price is a custom that is explicit to the Malaitan people and it is paid by the family of the groom to the bride's family in an arranged or unarranged marriage (Buchanan-Aruwafu et al., 2003). In essence the bride price creates ties between families and it is seen as compensation to the bride's family for the loss of their daughter (Fugui, undated). Buchanan-Aruwafu et al., (2003) stated that the bride price can be as high as ten or more *"tafuli'ae"* (red shell money).

Shell money has increasing market value in the Solomon Islands. Research carried out by Peio, (2006) had the value of the shell money at S$650, and lately the price has increased to S$1,000 for an eight foot length (Scott, 2014). With the average market price of one *"pinali"* being S$11.89 at the time of this study, one red shell money was being exchanged for less than the actual market price value. An eight foot length red shell money which would be sold in the town markets for an average price of S$1,000 would only be worth S$237.80 if it were exchanged for 20 *"pinali"*. More research needs to be carried out in this area to better understand the difference in the exchange value of *"pinali"* for red shell money compared to its exchange value in the modern economy using the local Solomon Dollar.

The economic value of the canarium nut

The value obtained from the canarium revenue was compared with the value obtained by communities for their cocoa and copra production. This section describes the number of fruiting trees per hectare for the canarium in each household and the number that they are currently harvesting. It looks at the sale price of the canarium per kg and it provides three main scenarios to show the economic value of the canarium.

Number of fruiting trees and amount harvested

From the survey, the mean number of fruiting trees currently growing and available for harvesting was 110 trees per household per hectare. However only ten percent of the trees were harvested per hectare during the canarium season. From the ten percent of the trees harvested, the communities sold around 45 kg of canarium nuts with mesocarp.

Respondents who sold the canarium nuts and place of sale

The nuts were sold directly in villages/ roadsides (91 percent) and few of the respondents went to the Auki market (7 percent), to middlemen (1 percent) or to restaurants to sell

the canarium nuts (1 percent). Table 5 shows the different packaging methods as well as the average price which the canarium nuts were sold for per kg of kernels.

Comparing the current cost of production, revenue and profits derived from canarium to cocoa and copra

The calculations for the revenue, costs and profits made for each of the crop (canarium, cocoa and coconuts) are carried out on an annual basis per household and per hectare. The list of processing activities for each enterprise is seen in Table 6.

The average amount of canarium nuts harvested and sold per year per hectare per household was 45 kg (kernels in mesocarp). The nuts were sold for an average price of S$14.45 per kg. There is minimum capital costs associated at the rural level in the marketing of canarium. These costs mainly include the packaging methods used in the sales of the canarium. Most of the costs associated with canarium processing are labour. These costs include harvesting, cracking, baking and packaging of the canarium nut as well as the distance travelled to collect and to sell the canarium nuts. It is assumed that cost of labour is approximately 70 person days per annum to harvest 45 kg of canarium nuts (refer to Table 7).

Current profits for canarium, cocoa and copra

The average amount of wet cocoa bean harvested by a household is 2,244 kg/ha/year. This is the estimated amount on a per hectare level per household. One kg of wet cocoa beans sells for S$3.00 per kg (Vadnjal and Pelomo, 2014). There are no capital costs associated with cocoa production as communities in the villages usually sell the wet beans to the cocoa processors and do not need to dry or package them. The main costs involved would be labour which was estimated at 37 person days/ha per annum (Vadnjal and Pelomo, 2014).

On average, a household can produce up to 1,000 kg of copra on an annual basis. This amount is assumed to be harvested from a hectare based on calculations by (Young and Pelomo, 2014). Capital costs associated with copra production include the packaging materials used for copra. The main costs incurred were through labour which was estimated by Young and Pelomo (2014) at 150 person days per annum (refer to Table 8).

Comparing the potential profits which could be derived from canarium to the profits currently derived from cocoa and copra

From the research, it was estimated that the Malaitan communities has the potential to harvest 100% of the available canarium trees on one hectare. There is approximately 110 trees which are on one hectare of land and the communities can harvest up to 340,340 nuts or 1,158.35 kg canarium nuts with their mesocarp from all the available trees per hectare.

If an average family of seven members worked together to harvest the canarium nuts, the labour costs would be approximately S$12,900. Taking into consideration that only 39 percent of the nuts harvested were sold for cash, and that packaging costs would also increase, the estimated revenue potential of canarium is calculated at S$3,708/ha per household per annum. This is the income lost to the communities every canarium season (refer to Table 9).

Profit maximization with scarce labour

The best way to achieve a clear picture of sharing the scarce labour between the three crops, is to calculate for profit maximization. The results for profit maximization shows that the communities need to produce less copra as this gives them little return compared to canarium and cocoa. By producing 215.25 kg less of copra, more energy can be focused towards the production of the other two crops. This will give the best possible profits and will utilize the labour available (refer to Table 10).

DISCUSSION

The canarium nut has been a source of food for the communities in the past (Pelomo et al., 2003, Sulifoa, 2012) and the harvesting and processing skills involved were carried out by the communities as a team effort. There were songs and proper division of labour amongst the community members so that the work of harvesting and processing can be done efficiently (Sulifoa, 2012). All these efforts were needed so that the communities would be food secure.

The canarium nut was also used in the bartering system in the form of *"pinali"*, it was traded for red shell money. This shell money was used for bride price as well as for other traditional practices. The cultural knowledge and skills associated with the nut in the past showed that this was a part of their survival mechanism as the canarium nut provided food for these communities. With significant differences in the traditional processing methods used for the

canarium nut, it meant that communities were able to store the nuts for times when there was food shortage. Furthermore, their ability to barter it for fish or other staple crops ensured that they had a diverse diet. With communities no longer practicing the traditional harvesting of the canarium as a community effort, the economic potential of the canarium nut is also underutilized.

The introduction of cash crops into the communities around the 1920s, caused a shift in crop priorities for the males. The males have prioritized cash crops such as cocoa and coconut (in the form of copra) and have disregarded the processing of the canarium nuts (Sulifoa and Lameta, 2011). In turn, the females have taken on the responsibility of harvesting and processing the canarium nut. Due to the reason that there are cultural barriers which prohibits females to climb the trees and the fact that women are not as efficient at cracking and packing the canarium nuts, their productive capabilities have been reduced and the full potential of the canarium trees underutilized.

The research shows that one household can harvest an equivalent of approximately 340 thousand nuts (+/- 1 tonne) with their mesocarp per hectare per year. However, the communities are currently only harvesting 45 kg of canarium nuts with their mesocarp. There is a deficit not only in the amount of nuts harvested, but also in the amount of canarium nuts which could be consumed or sold by the communities.

Using the market price approach the monetary values for the canarium trees were estimated. The results show that with the decline in harvesting, the communities were making a loss with the sales of the canarium (Table 7 and Table 8). However, if they were to utilize the canarium nuts available to them, they would be gaining more profit compared to the other two crops (Table 9).

Research carried out by Sulifoa (2012) shows that the markets for canarium currently exist and the consumers on the capital of Honiara were willing to pay a premium price of S$50.00 per kg of dried canarium kernels, but communities were unwilling to meet the demand. Perhaps the real reason behind this lack of response is the amount of time and effort which needs to be invested in the processing of the canarium nut. In Table 6, the different steps taken to process the canarium nut in comparison to cocoa and copra is shown. In short, more work is involved and more people are needed to ensure that the canarium nuts are harvested and processed to its potential. Furthermore, the distance travelled to harvest the cash crops is closer compared to the distances required to harvest and process the canarium nuts (Sulifoa, 2012).

The study shows that to utilize the current labour available to the communities, a reduction in the amount of copra produced will enable them to utilize the potential amount of canarium nuts which can be processed and maintain the amount of cocoa currently processed (Table 10). Understanding how to utilize the scarce labour resource is important for diversification and decisions aimed at increasing crop diversity. Diversifying agriculture production helps to improve self-sufficiency, reduce the risks associated with natural disasters and price fluctuations (Increased food security and food self-sufficiency strategy, 2012).

This brings the study to realize that the potential of the canarium can only be fully explored if policies were put in place to attract the males to assist the women in processing the canarium nut. Creating an enabling environment can be done in the form of supporting business ventures for the local women. With the assistance from the Solomon Islands Government and donor agencies capital costs for a canarium business start-up could be explored. Attracting males could be a challenge and perhaps the introduction of subsidies for labor payment may be needed. The aim is to keep the cultural values associated with the canarium nut alive, which will support the food security and overall well-being of the communities.

CONCLUSION

The canarium tree has been part of the Malaitan culture and has contributed to their food security and traditional way of life. The cultural skills and knowledge associated with the canarium are becoming extinct as males in the community have focused their attention on cash crops such as cocoa and copra production.

This study gives an idea of the potential profits currently lost due to a reduction in the amount of canarium nuts harvested. It shows the potential profits which could be made from canarium nuts if they were harvested to their full potential. Labour seems to be the main scarce resource in this case, and that the best allocation of labour would be through a reduction in the amount of copra produced. This would aid in utilizing the potential number of canarium nuts

which could be harvested and processed.

Creating an enabling environment for the women to process the canarium through entrepreneurial incentives and labor subsidies may be key to meeting the demand and provide local employment. This will help conserve the skills and knowledge associated with canarium nut harvesting and processing which is important for food security and the general well-being of the communities.

This study gives some idea on the potential value of the canarium nuts which would help inform polices to encourage crop diversification. The cultural ecosystem services provided by the canarium needs to be further studied.

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Table 1: Sex of respondents

Sex of respondent	Percentage
Male	79.0
Female	21.0

Table 2: Age group of respondents

Age	Percentage
Less than 20 years old	2.0
20 years - 29 years old	9.0
30 years - 39 years	26.0
40 years - 49 years	24.0
Greater than 50 years old	39.0

Table 3: Education level of respondents

Education level	Percentage
Primary	43.0
Secondary	18.0
Vocational	2.0
University	5.0
Theology	3.0
No formal education	29.0

Table 4: Household size of respondents

Household size	Percentage
1-5 members	32.0
6-10 members	63.0
11-15 members	4.0
16-20 members	1.0

Table 5: Packaging method used for canarium and price per packaging method

Packaging method	Percentage	Mean Price per packaging method (S$)	Mean price (S$) per kg of canarium kernels
Parcels of raw KIT (40 KIT per parcel)	13.0	1.33	2.66/kg (raw kernels in testa)
Bamboos (300 kernels/1m bamboo)	77.0	11.89	3.17/kg (dried kernels)
KIT in heap (40 KIT per heap)	9.0	1.00	2.00/kg (raw kernels in testa)
Buckets (13 kg KIT per bucket)	1.0	650.00	50.00/kg (dried kernels)
Average price for canarium per kg			**S$14.45/kg**

Table 6: List of processing activities associated with canarium, cocoa and copra production

Activities associated with Canarium production	Activities associated with Copra production	Activities associated with Cocoa production
Harvesting	Nut collection/harvesting	Harvesting
Carrying of the canarium nuts	Cutting	Tree maintenance
Depulping	Drying	
Cracking	Sorting	
Shell removal	Ramming	
Testa removal	Firewood cutting	
Storing of the nuts	Transportation of firewood	
Packing of the canarium nuts	Drier maintenance	
Transportation of canarium nuts to village for processing	Transportation to village	
Transportation of the canarium nuts to markets for selling		

Table 7: Comparison of costs of production for canarium, cocoa and copra

Factors of Production	Canarium production (S$/ha/annum)	Cocoa production (wet beans) (S$/ha/annum)	Copra production (S$/ha/annum)
Labour	2,100.00	4,500.00	1,110.00
Capital	10.00	0.00	150.00
Total cost of production*	2,110.00	4,500.00	1,260.00

Table 8: Comparison of the profits earned from canarium to the cash crops (cocoa and copra production

Revenue earned	Canarium production (S$/ha/annum)	Cocoa production (S$/ha/annum)	Copra production (S$/ ha/annum)
Gross revenue	650.25	6,732.00	1,600.00
Cost of production	2,110.00	4,150.00	1,260.00
Net profit*	(1,459.75)	2,582.00	340.00

* The net profit is displayed as the average amount per household per hectare per annum for the respective crop.

Table 9: Potential revenue from canarium production compared to cocoa and copra production if 100 percent of the trees were harvested

Revenue earned	Canarium production (S$/ha/annum)	Cocoa production (S$/ha/annum)	Copra production (S$/ha/annum)
Gross revenue	16,738.00	6,732.00	1,600.00
Cost of production	13,030.00	4,150.00	1,260.00
Net profit *	3,708.00	2,582.00	340.00

*The net profit is displayed as the average amount per household per hectare per annum for the respective crops.

Table 10: Profit maximization between the three crops taking into account the scarce labour available

Revenue earned	Canarium	Cocoa	Copra
Kgs produced/ha/annum/	1158	2245	784.75
household	430	150	37
Labour person days/ha/annum			
Capital $/ha/annum	50	0	150
Land $/ha/annum	0	0	0
Unit Price S$/kg	12.45		1.60
		3.00	
Maximum Profit			
Total Labour used		**S$6,554.17**	
		617	

Farmers' awareness of climate change in Iwajowa Local Government Area of Oyo state, Nigeria

Oladayo O. Okunlola

ABSTRACT

Climate change poses a great threat to farming in many ways. However, a good knowledge of this phenomenon will assist farmers in mitigating its effects. The study was aimed at determining the awareness of climate change amongst crop farmers in Iwajowa Local Government Area (LGA) of Oyo state, Nigeria. Multistage sampling technique was adopted for this study. In stage one, Iwajowa LGA was divided into five quarters. Second stage had four villages purposely selected from each quarter. In the Third stage, five crop farmers were randomly selected from each village making a total of 100 respondents in all. Contact administration of the questionnaires was adopted and all data collected were processed and analyzed using frequency count and percentage. The results obtained show that majority of the respondents were between the age bracket 40 to 59 years (65%) and had no formal education (43%). Also, 86% of the respondents were food crop farmers and had not been visited by extension agents (84.0%). Regarding climate change awareness, majority (87%) of respondents was aware of the phenomenon and 53.6% got their information from the media. Concerning the perceived causes of climate change, majority (66.67%) of the respondents perceived it was caused by natural processes destined by God. The perception of the respondents as to the effects of climate change on their farming activities showed that majority (33.89%) perceived climate change has been causing reduction in their farm income.

Key words: Climate change, farmers' awareness, Iwajowa LGA

INTRODUCTION

The ability of farmers to adapt to climate change depends greatly on their knowledge of the causes and effects of this phenomenon. African farmers are known to have a low capacity to adapt to changes that accompany climate change (IPCC, 2007), but they have, survived and coped in various ways over time (Hassan and Nhemachena, 2008). The impact of climate change on farmers is enormous as it affects the production, and distribution of both crop and livestock. Climate change also affects pest outbreaks, weed distribution, water supplies, changes the nutritional content of forage due to elevated CO_2, and other factors which in turn influence production (USDA, 2009).

Previous studies by different authors showed that many farmers in Nigeria claimed they had heard about climate change at one time or the other, however, their awareness of the adverse impacts of the weather phenomenon was poor. For example, Nzeadibe *et al.* (2011) stated that majority of the respondents in their report claimed they were aware of climate change in the Niger Delta region of Nigeria . However, the authors pointed out that up to 60% of farmers in the region knew little or nothing about the adverse effects of climate change.

Another study by Adetayo and Owolade (2013) in selected rural communities of Oyo state, Nigeria corroborated the above report as the authors indicated that 87.5 % of the respondents have heard about climate change although their understanding of the possible effects of the phenomenon was poor. However, the observation of Adebayo *et al.* (2012) that 96.47% of the

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farmers in Adamawa state of Northern Nigeria had awareness of climate change and a larger percentage of them claimed it has affected their farming activities negatively in recent years is contrary to the present findings.

In a study by Idrisa *et al.* (2012) in Borno state, Nigeria, it was revealed that 82.22% of the respondents were aware of climate change and got their information from extension agents, friends and neighbours and media. Also, the authors reported that the respondents perceived climate change was caused by deforestation, bush burning and overgrazing by livestock. Farauta *et al.* (2012) observed majority of respondents in Northern Nigeria had knowledge of the changing climate through experience and information received from different quarters. The authors also reported that incidence of climate change in the study area is on the increase and characterized by higher temperature, low rainfall, desertification and low crop yield. Another study by Codjoe *et al.* (2013) indicated that farmers in cocoa growing areas of rural Ghana were aware of climate change although they had divergent views on the causes. To some of the respondents, climate change was caused by God and a sign of end time while others adduced the following reasons for the phenomenon: mechanization and urbanization, deforestation, sinful nature of man, manipulation by "Whites" (developed countries) and ozone layer depletion. In another survey of 8000 farmers by Hassan and Nhemachena (2008) across 11 countries in Africa, it was reported that half of the farmers surveyed perceived long – term temperatures were warming and precipitation declining while one – third believed there had been significant changes in the timing of rains and one – sixth of the respondents thought droughts were more frequent.

This study was aimed at determining the following:

1. The awareness level of crop farmers in Iwajowa LGA of Nigeria of climate change;
2. The level of understanding of climate change as regards the causes and effects by the farmers in the study area.

Parameters measured included the following: farmers' bio data, farm characteristics, awareness of climate change and perceived causes and effects of climate change.

MATERIALS AND METHODS

Description of the study area

This study was carried-out in Iwajowa Local Government Area (LGA) of Oyo state, Nigeria. The LGA covers an area of about 2,529 sq km, and has a population of 102,980 (Federal Republic of Nigeria, 2009). It is located on latitude $7^0 45"$ N of the equator and longitude $3^0 45"$ E of the Greenwich meridian. The area has two seasons: dry from November to March and rainy from April to October.

Data collection and analysis

Data were collected with the use of structured questionnaires. Multistage sampling technique was adopted for this study. In stage one, Iwajowa LGA was divided into five quarters. Second stage had four villages (mostly farming communities) purposely selected from each quarter. In the Third stage, five respondents were randomly selected from each village making a total of 100 respondents from all the five quarters. All questionnaires were recovered as contact administration of the questionnaires was adopted. Parameters measured included the following: farmers' bio data (sex, age, educational status, farming experience), farm characteristics (farm type, farm size, access to extension), awareness of climate change (knowledge of climate change, source of awareness) and perceived causes and effects of climate change. All data collected were processed and analyzed using frequency count and simple percentage.

RESULTS

The bio data of the respondents is shown in Table 1. Majority (67%) of the respondents was male, between the age groups 40 to 59 years (65%), had no formal education (43%) and with 20 – 29 years of farming experience (45%).

Data on the farm characteristics (Table 2) show that majority of the respondents (86%) were food crop farmers and operated 6 – 10ha of land (37%). Majority of the farmers were not receiving any visits by extension agents.

The awareness of climate change by the respondents is shown in Table 3. Majority (87%) of the respondents were aware of the changing climate. Of that figure, 53.6% got their information about climate change from the media (radio and television), 18.4% from friends and neighbours, and 15.2% through extension agents, while 12.8% got the information from Non Governmental Organizations (NGOs).

Data on the perception of the respondents

on the causes and effects of climate change show that majority (66.67%) of the respondents perceived climate change as being caused by natural processes destined by God. Other respondents perceived that industrial activities, emissions by vehicle and domestic activities were the causes of climate change. Also from the table, the perception of the respondents on the effects of climate change on their farming activities shows that majority (33.89%) of them perceived climate change caused reduction in their farm income. This was followed by reduced crop yield, spoilage of farm produce, and wilting of crops.

DISCUSSION

The results of bio-data of the respondents is an encouraging situation as aging populations are less able to engage in modern agricultural practices as they are less able to source and synthesize information relative to younger farmers. The lack of education has negative implications for the level of awareness of the farmers on climate change and also for the development of adaptive strategies to mitigate the negative effects of the weather phenomenon. Education plays an important role in creating awareness in farming communities because educated people are better equipped to source information. Idrisa *et al.* (2012) asserted that a minimum threshold in terms of educational qualification is necessary for understanding the scientific and technical nature of modern agriculture. Education also helps farmers understand where to access farm inputs as well as how to use them. It has been observed that education affected agricultural productivity by increasing the ability of farmers to produce more output from given resources and by enhancing the capacity of farmers to obtain and analyze information (Asfaw and Admassie, 2004; Bamire *et al.,* 2002). Education could also influence the ability of farmers to adjust quickly to farming disequilibria (Idrisa *et al.,* 2012).

Small-scale farmers, as observed by Oyekale (2009), operate at subsistent level thereby making them vulnerable and less able to cope with the consequences of climate change. Also majority of the farmers surveyed were not visited by extension agents. This underscores the importance of interpersonal communication in creating awareness. The extension agents are the main source of technical information to farmers. Rogers and Shoemaker (1983) stated that extension agents are not able to work closely with all farmers in a farming community, rather, they work with few farmers (the contact farmers or the opinion leaders) who become the agents to spread the information in their own communities.

Concerning the awareness of climate change in the study area, this report corroborated the findings of many other authors (Ezeadibe *et al.,* 2011; Adebayo *et al.,* 2012; Idrisa *et al.,* 2012; Farauta *et al.,* 2012; Adetayo and Owolade, 2013 and Codjoe *et al.,* 2013) that the respondents in their study areas were aware of climate change although their levels of understanding of the weather phenomenon varied from one another. The report also shows that majority of the respondents got their information on climate change from the media (radio and television). This shows the importance of the media, especially the radio in information dissemination because of its wide coverage relative to other sources of information.

This report also reflects the level of ignorance the respondents were plagued with on the perceived causes of climate change. It could be because majority of them did not have formal education thereby comforting themselves with traditional believes that had no scientific basis. This result was supported by report of Codjoe *et al.* (2013) who stated that rural cocoa farmers in Ghana adduced the cause of climate change to God and a sign of end time. Regarding the effects of climate change causing reduction in their farm incomes, other factors (reduced crop yield, spoilage of farm produce, wilting of crops and unpredictable nature of the rainfall patterns in recent times) were stated by the respondents as the effects of the adverse weather condition because all of them were contributory to this.

CONCLUSION

The results of the findings showed that the majority of the farmers in the study area were aware of climate change although they had a shallow knowledge of the causes of the weather condition which may be attributed to their low level of formal education. Also, the respondents submitted that climate change had affected their farming activities in recent years. The effects mentioned included reduced crop yield, spoilage of farm produce, wilting of crops and unpredictable nature of the rainfall patterns in recent times.

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Table 1: Bio data of respondents

Item	Criterion	No.	%
Sex	Male	67	67
	Female	33	33
Age (years)	20 – 39	30	30
	40 – 59	65	65
	60 above	05	05
Formal Educational status	None	43	43
	Primary	27	27
	Secondary	23	23
	Tertiary	07	07
Farming Experience (years)	< 10	16	16
	10 – 19	14	14
	20 – 29	45	45
	– 39	25	25

Table 2: Farm characteristics

Item	Criterion	No.	%
Farm type	Food crops	86	86
	Cash crops	08	08
	Food and cash crops	06	06
Farm size (ha)	< 5	24	24
	6 – 10	37	37
	11 – 15	20	20
	16 – 20	15	15
	20	04	04
Access to Extension services	Yes	16	16
	No	84	84

Table 3: Awareness of climate change

Item	Criterion	No	%
knowledge of climate change	Yes	87	87.0
	No	13	13.0
Source of awareness	Friends and neighbors	23	18.4
	Media (radio and television)	67	53.6
	Extension agents	19	15.2
	NGOs and input sales agencies	16	12.8

Table 4: Perceived causes and effects of climate change

Item	Criterion	No	%
Causes	Industrial activities	22	17.05
	Domestic activities	08	6.20
	Emission by vehicles	13	10.08
	Natural process destined by God	86	66.67
Effects	Wilting of crops	12	6.67
	Unpredictable rainfall pattern	25	13.89
	Reduced crop yield	47	26.11
	Spoilage of farm produce	35	19.44
	Reduction in farm income	61	33.89

Poverty profile of farm households in Cross River State Nigeria

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ABSTRACT

There is endemic poverty in Nigeria particularly in the rural areas where majority of the poor smallholder farmers whose main source of income are derived from agricultural activities reside. This study examined the extent of poverty among farm households in Nigeria. The study was conducted in Cross River State, one of the thirty-six states in Nigeria. Both primary and secondary data were used for the study. A multi-stage random sampling technique was employed to select 260 rural farmers who were administered with questionnaires for the study, while simple frequencies and percentages as well as Foster, Greer and Thorbecke index were used for data analysis. The findings revealed that majority of the respondents are male (83.0%), aged 41-60 years (52.0%) attained primary education (42.0%), belonged to several social organizations (92.0%); had household sizes of 1-5 (67.0%), owned farm land (83.0%) with an annual income of between N 41,000 - 60,000 (63.0%). Based on a poverty line of N 37, 232.31, the result showed the incidence, depth and severity of poverty among the respondents to be 30.78%, 3.03%, and 3.84% respectively. The implication of these results is that, on average, to lift a poor person out of poverty in the state will require the sum of N 112, 813.90. It was recommended that poverty alleviation in the state requires proper targeting and focusing on the rural areas with high incidence and severity before others.

Key words: Farm households, Nigeria, poverty, rural areas, smallholder farmers

INTRODUCTION

Sub-Saharan Africa has abundant agricultural resources. But in all corners of the region, millions of people remain hungry and malnourished—the result of glaringly uneven local food production and distribution and chronically deficient diets, especially among the poorest (Africa Human Development Report (AHDR), 2012). Available statistic showed that as much as 1.4 billion people, out of the 6.5 billion people around the world in 2005 lived on less than US$1.25 a day and are thus classified as extremely poor with over 850 million people going to bed without sufficient food (Human Development Report Nigeria, (HDRN), (2008); United Nations Development Programme (UNDP), (2008). The situation in Sub-Saharan Africa (SSA) has been the most deplorable; not only is the incidence of extreme poverty much higher, the region was reported to have recorded about 100 million more extremely poor people in 2005 than in 1990 unlike the experience in other regions where both the incidence of extreme poverty and the actual number of the extremely poor fell between 1990 and 2005 (Millennium Development Goals Report (MDGR), (2009). In essence, one can conclude that SSA contributed more to the extreme poverty in the World more than any region (Idowu, Awoyemi, Omonona and Fausi, 2011). According to Amalu (1998), Africa's poverty is captured in a single statistic: the total Gross National Product (GNP) of the 45 countries of Sub -Saharan Africa in 1985 was slightly less than the total GNP of Spain, a nation of about 40 million people. This implied that Africa need to work harder to reduce the level of poverty in the continent as we take a closer look at the poverty profile for Nigeria in Table 1 and Table 2.

With reference to Table1 and 2, Nigeria's statistical agency, the National Bureau of Statistics (NBS), has been conducting poverty surveys

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since 1980, the more nationally representative ones being those conducted in 1980, 1985/86, 1992/93 and 1996/97 as well as the living standard survey conducted in 2003/2004 (Human Development Report Nigeria, 2008). The total poverty head count in Nigeria rose from 27.2 per cent in 1980 to 65.6 per cent in 1996, an annual average increase of 8.83 per cent over the 16-year period. However, between 1996 and 2004, the head count declined by an annual average of 2.1 per cent to 54.4 per cent. Over the same period, the percentage of the core poor rose from 6.2 to 29.3 per. cent, and declined to 22.0 per cent in 2004. The fact that over 50 per cent of total population is officially poor should be of great concern to policy makers (HDRN, 2008). Considering the challenge of poverty in Nigeria first by looking at the geographical dimension, the urban poor rose from 17.2 per cent in 1980 to 58.2 percent in 1996, but declined to 43.2 per cent in 2004. From 1980-2004, the core poor in urban areas rose from 3.0 per cent in 1980 to 25.2 per cent in 1996 and declined. The corresponding the figures in the rural areas were 6.5 per cent, has 31.6 per cent and 27.1 per cent (Table 1) whereas the decline in core poor was 38 per cent in the urban areas, it was only 14 per cent in the rural areas, which is lower than national average of 25 per cent. Also rural areas accounted for 65 per cent of national poverty incidence (HDRN, 2008). By implication, it appears that being resident in the rural areas and in the Northern geopolitical zones increases the likelihood of being poor. Taking a cursory look at the human development statistics in Nigeria could give another better picture of the situation as shown in Table 3.

Table 3 showed some selected human development benchmarks across the six (6) States in South-South geo-political zone in terms human development index (HDI), human poverty measure (HPM), gender development index (GDI); gender empowerment measure (GEM) and inequality measure (IM). Beginning with human poverty index data, poverty is most pronounced in Bayelsa State (32.5) and Cross River State (31.9) listed in order of intensity while other states have better HPI. Cross River State ranked second in this order indicating the endemic nature of poverty in the state. Similarly, Cross River State places fifth position in the human development index score with Rivers State topmost and Edo state the least. With regard to gender development index, Rivers, Akwa Ibom, Bayelsa, and Delta states all ranked high while Cross River State ranked fifth though followed by the least Edo state. Just like gender development index, Cross River and Edo states ranked fifth each in gender empowerment measure whereas Rivers state scored the highest (0.367) followed by Delta state (0.316), Akwa Ibom (0.310) and Bayelsa state (0.219). The whole scenario shows a clear picture of what the state of poverty and human development is in Cross River State, hence the need for this research on non-farm employment diversification and poverty in the state).

There is a high incidence of poverty in Nigeria and this has been largely traced to the adverse macroeconomic performance of the economy especially as dictated by the effects of negative external shocks and the adjustment reforms that were initiated in response to the shocks; succeeding governments have not been able to adequately cope with this deep-rooted problem (Olaniyan, 2000); he further stated that, studies on poverty in Nigeria have not been given priority until recently. According to IFAD (2007), stressed Nigeria has a population of 150 million, the largest in Africa and a fast-growing economy. Therefore, in spite of Nigeria's plentiful agricultural resources and oil wealth, poverty is widespread in the country and has increased since the late 1990s. Over 70 per cent of Nigerians are now classified as poor, and 35 per cent of them live in absolute poverty. The rural areas of the country are the worst hit by poverty where up to 80 percent of the population lives below the poverty line and social services and infrastructure are limited. About 90 per cent of Nigeria's food is produced by small-scale farmers who cultivate small plots of land and depend on rainfall rather than irrigation systems (IFAD, 2007). In other words, there is much dependence on agriculture for food and income by the poor rural population.

In spite of the importance of agriculture to the Nigerian economy and that of Cross River State in particular for poverty reduction, the sector has performed below its potential for generations neglected by government policies and held back by low farm productivity, hence, the knowledge gap this study intend to fill by examining the poverty profile of farm households in Cross River State Nigeria. Specifically, it described the socioeconomic characteristics of the farmers and determines the extent of poverty among the farming households in the state.

MATERIALS AND METHODS

This study was conducted in Cross River

State one of the 36 states in Nigeria. The State comprises of eighteen (18) Local Government Areas, namely: Abi, Akamkpa, Akpabuyo, Bakassi, Bekwarra, Biase, Boki, Calabar Municipal, Calabar South, Etung, Obanliku, Obubra, Obudu, Odukpani, Ogoja, Ikom, Yala, and Yakurr. The state is also multi-ethnic with diverse cultural groups and languages. Cross River State is situated within the tropics sharing common boundaries with Cameroon Republic in the East, Benue State in the North, Enugu and Abia States in the West and Akwa-Ibom State in the South. The State has a population of about 2.6 million (1.8 by 1991 Census with an annual growth rate of 3.0 percent). Cross River State cover an area of 23,074.425 sq.km and lies between latitudes 5°32' and 4°27' North and longitudes 7°50' and 9°28' EastThere is an Obudu plateau in the State with an altitude of 1,575.76 metres above sea level which enjoys a temperate climate like other temperate regions of the world (CRS Government Dairy, 1996).

Cross River State has a typical tropical humid climate characterized by distinct wet and dry seasons known as the rainy and dry seasons. The state is also noted with a two-peak wet season having a short dry spell of 2-3 weeks, referred to as "August break". The annual rainfall distribution varies greatly throughout the state. It is lowest in the Northern zone (less than 1700 mm) and highest in the forest of coastal zone (above 3000 mm). A mean annual maximum temperature of 26^{oc} is recorded for the State with a relative humidity of about 70-80 percent (CRADP, 1992; and Abang *et al.,* 1994). Large hectares of land are yearly being brought under cultivation, thereby allowing for only isolated patches of natural vegetation (CRADP, 1992). Cross River State holds about a third of Nigeria's total forest area. A total of 22.4 percent of the total land area of the state is thickly forested. Animal breeding pastures are extensive on the grassland of Obudu Plateau and Gabu in Yala Local Government Area.

Both primary and secondary data were used for this study. Primary data was collected through the use of questionnaire. The instrument with 20 items was tested for reliability using the Cronbach's Alpha test statistic analysed through the use of SPSS package. The coefficient of reliability (consistency) was 0.816, suggesting that the items had relatively high internal consistency. Cronbach (1951) determines the internal consistency or the average correlation of items in a survey instrument to gauge its reliability. The coefficient usually ranges from 0-1. A multi-stage random sampling technique was employed to select samples for the study. The first stage involved the purposive selection of three agricultural blocks from each of the three agricultural zones in State making a total of nine (9) blocks. The blocks selected were among the populated blocks with high agricultural activities. The second stage was a random selection of five (5) cells each from the nine (9) selected agricultural blocks resulting in a total of forty-five (45) cells. The third stage was the random selection of six (6) farmers each from the selected 45 cells to make a total of two hundred and seventy (270) farmers as sample size (respondents) as shown in Table 5. However, out of a total of 270 questionnaires administered, only 260 were retrieved and used for the analysis resulting in questionnaire return rate of 96.3%. Data obtained were analyzed using simple frequencies and percentages as well as the Foster, Greer and Thorbecke (FGT) index, for poverty analysis (Foster *et al*., 1984)

$P^{\propto}$ (y, Z) =…(1)

Where Z = poverty line

Y = Income of the household i (i = 1, 2,… q)

q = No of household below the poverty line (poor)

n = total number of sampled households

α= parameters of the FGT index (P).

α > 0 and it can take three values of 0,1 and 2. These values give different implications.

If α =0 then, measures the headcount or incidence of poverty

Poq=…(2)

If α = 1, then, FGT measures the depth of poverty

P1…(3)

If α =2, then FGT measures the severity of poverty

P2=…(4)

RESULTS

The result of Table 4 revealed that 25.0% of the respondents were aged between 20 and 40 years, 52.0 % were aged between 41 and 60 years while 23.0 % were aged between 61 years and above. In terms of sex, 83.0% of the respondents were male while 17.0% were female. The educational status of the respondents shows that 21.0% of the respondents had no formal education, 42.0% attained primary

education; 29.0% attained secondary education while 8.0% attained tertiary education. Membership of social organization revealed that 92.0% of the respondents are members of social organizations and 8.0% of respondents do not belong to any social organizations. The household size of respondents indicate that household size of 1-5 recorded 67.0%, household size of 6 -10 was 25.0% while household size of 11 and above was 8.0%. Land ownership result showed that majority of the respondents in the study area owned their farm lands accounting for 83.0%, rented land 13.0% and leased land only 4.0%. The annual income earned by respondents shows that 27.0% earned annual income of between 20-40 thousand Naira, majority (63.0%) of the respondents in the study area earned annual income of between 41-60 thousand naira while 10.0% of the respondents earned annual income of 61 thousand Naira and above. The state poverty incidence was 30.78%, the poverty depth was 0.0303 (3.03%) and the severity of poverty was 3.84%.

DISCUSSION

In other words, the age structure presented indicates that a large proportion of the respondents belonged to the age bracket of 41-60 years which is their active age confirming results of earlier studies by Angba, (2000) and HDRN, (2008) that Nigerian farmers are over 50 years. Sex result implies that majority of the respondents were males while females only accounted for small proportion. Although women make up the greater percentage of people involved in agriculture in Nigeria (HDRN, 2008), this result could be explained by the fact that the majority of households in Nigeria are headed by males. Another reason could be that more female-headed households have limited resources and are likely to be cash-and credit-constrained, lack extension services thereby affecting their ability to produce (Ndifon, Patrick and Idiku, 2012). Higher attendance of primary education can be attributed to previous government regimes which promoted free (Universal) Primary education in the country. It can therefore be concluded that the majority of the respondents from the study area did not attain higher levels of education such as tertiary education. Education also helps illiterate farmers to increase their agricultural output by changing their attitude towards the adoption of modern agricultural techniques and inputs as well as an increase in income generation thereby confirming results earlier studies such as (Knight *et.al.,* 2003; World Bank, 2008) that education raises income as it enables individuals to obtain and process information. As pointed out by Ekong (2003), there is a positive correlation between Nigerian farmers' level of participation (membership of social organizations) and adoption of agricultural innovations as several studies showed that Nigerian farmers belong to a number of formal and informal organizations. This result therefore agreed with the recommendations that extension agencies should train their officers to be proactive in helping farmers to develop skills in social organization and club development (Akpabio, Okon, Angba and Akpabio, 2007).

Household size of 1-5 accounted for the highest percentage while the mean household size in the study area was 5.0. Family or household size is more linked to family labor supply as almost all farming activities in West Africa are not mechanized (Edriss and Simtowe, 2003). This result confirmed the study that the average household size has a bearing on availability of labor and efficiency, especially considering that most smallholder farmers depend on family labor (Wang *et al.,* 1996). Land ownership results indicate that the typical land tenure practice in the area is the customary style of inheritance. However, Idiku and Angba (2010) found that food production in Nigeria throughout the year is becoming a necessity due to the large expanse of land available for agricultural production. The result of this study confirms earlier research that land tenure system greatly influences the organization and efficiency of agricultural production and particularly, customary (inheritance) land tenure is the predominant system among smallholder farmers in West Africa (Kachule, 1994). The mean household income in the study area was N60, 502.50K. The result shows that only very few respondents earned income above the mean income. This low income earning capacity might be attributed to several factors including lack of access to credit, education, and other production input, as well as farm experience as noted by Dorosh, *et al,* (1998).

Table 5 showed the poverty status of respondents across the agricultural zones and the State. The highest poverty incidence of 37.16% was recorded in Ogoja agricultural zone followed by Calabar agricultural zone with 22.68% while Ikom agricultural zone had the least poverty incidence of 19.52%. On the other hand, the entire state poverty incidence was 30.78%. Among the three agricultural zones, Ogoja zone was more rural than the other two and also very

far from the administrative headquarters, lacking several institutions and infrastructure; therefore it was likely to have had the highest poverty incidence. These result shows that poverty levels at each of the agricultural zone were quite different from one another and also went further to conformed to results of studies that poverty in Nigeria is more concentrated in the rural areas . In order to understand further these poverty measures, it became necessary to analyze the data in terms of absolute number of poor persons in each category (zone) and the relative contribution of each zone to the overall poverty incidence in Cross River State. Therefore, with regards to absolute numbers, the relative contribution of respondents in each zone to the total state poverty incidence indicated that respondents in Ogoja agricultural zone contributed 12.69% (33 poor persons), Ikom agricultural zone contributed 6.5% (17 poor persons) and Calabar agricultural zone contributed 7.3% (19 poor persons). These results clearly showed that the challenge of tackling poverty in the State lies squarely in Ogoja agricultural zone. The poverty depth for Cross River State was 0.0303 (3.03%); disaggregating by agricultural zones indicate that Ogoja zone has the highest poverty depth of 3.08% followed by Calabar zone with a poverty depth of 2.03% while Ikom zone has the least poverty depth of 1.46%. In other words, Cross River State will require the sum of N112, 813.90 (which is the poverty depth value of 3.03 multiplied by the poverty line value of N37, 232.31). Therefore, on average, to lift a poor person out of poverty in Ogoja, Ikom and Calabar agricultural zones will require the sum of N114, 675.50, N54, 359.17 and N75, 581.59 respectively. The results so far indicate that tackling poverty challenge will require more resources in Ogoja than the other two zones. Severity of poverty in the study area, Ogoja agricultural zone again recorded the highest value of poverty severity with 4.29%, Ikom zone 1.97% and Calabar zone 3.47%. The severity of poverty at the State level was 3.84%. In other words, apart from the headcount measure (incidence), poverty depth and severity measures underscored the need for other measures of poverty.

CONCLUSION

Poverty was widespread in the study area, thus, in cases where poverty incidence was high, it becomes difficult to target intervention at the poor simultaneously, rather, with the poverty depth and severity measures, targeting intervention at the poor become a matter of those whose poverty depth and severity are higher before others. In conclusion, poverty in Nigeria and Cross River State to be specific is a rural phenomenon.

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Table1. Population and poverty (1980-2004)

Year	Estimated population (Million)	Population in poverty (Million)	Poverty level (%)
1980	65	17.7	28.1
1985	75	34.7	46.3
1992	91.5	39.7	42.7
1996	102.3	67.1	65.6
2004	126	68.7	54.7

Source: NBS, 2006

Table2. Incidence of poverty by sector and zones in Nigeria 1980-2004

S/N	Sector/Zones		1980	1985	1992	1996	2004
1	National	Total poor	28.1	46.3	42.7	65.6	54.4
		Core poor	6.2	12.1	13.9	29.3	22.0
2	Urban	Total poor	17.2	37.8	37.5	58.2	43.2
		Core poor	3.0	7.5	10.7	25.2	15.7
3	Rural	Total poor	28.3	51.4	66.0	69.3	63.3
		Core poor	6.5	14.8	15.8	31.6	27.1
4	South-South	Total poor	13.2	45.7	40.8	58.2	35.1
		Core poor	3.3	9.3	13.0	23.4	17.0
5	South East	Total poor	12.9	30.4	41.0	53.5	26.7
		Core poor	2.4	9.0	15.7	18.2	7.8
6	South West	Total poor	13.4	38.6	43.1	60.9	43.0
		Core poor	2.1	9.0	15.7	27.5	18.9
7	North Central	Total poor	32.2	38.6	46.6	64.7	67.0
		Core poor	5.7	9.0	14.8	28.0	29.8
8	North East	Total poor	35.6	5.8	54.0	70.1	71.2
		Core poor	11.8	16.4	18.5	34.4	27.9
9	North West	Total poor	37.7	52.1	36.5	77.2	71.2
		Core poor	8.3	14.2	9.0	37.3	26.8
10	Population in poverty (Million)		17.7	34.7	39.2	67.1	68.7

Source: NBS, 2005, Poverty profile for Nigeria

Table 3. Human development statistics by States in South-South Nigeria

S/No.	States	Human development index (HDI)	Human poverty index (HPI)	Gender development index (GDI)	Gender empowerment measures(GEM)	Inequality measure (IM)
1.	Akwa Ibom	0.616	27.1	0.622	0.310	0.34
2.	Bayelsa	0.593	32.5	0.600	0.219	0.40
3.	Cross River	0.539	31.9	0.544	0.148	0.40
4.	Delta	0.592	23.6	0.591	0.316	0.40
5.	Edo	0.465	21.7	0.475	0.148	0.40
6.	Rivers	0.633	22.8	0.616	0.367	0.50

Source: Extracted from NBS, (2005), Human Development Indicators, (2008)

Table 4. Socioeconomic characteristics of respondents

S/No.	Variable	Frequency	Percentage (%)
1.	Age (years)		
	20-40	65	25.0
	41-60	135	52.0
	61 & Above	60	23.0
	Total	260	100.0
	Mean age=51 years		
2.	Sex		
	Male	216	83.0
	Female	44	17.0
	Total	260	100.0
3.	Educational status		
	No formal Education	55	21.0
	Primary Education	109	42.0
	Secondary Education	75	29.0
	Tertiary Education	21	8.0
	Total	260	100.0

4.	Membership of organization		
	Yes	239	92.0
	No	21	8.0
	Total	260	100.0
5.	Household size		
	1-5	174	67.0
	6-10	65	25.0
	11 &Above	21	8.0
	Total	260	100.0
	Mean Household Size=5		
6.	Land ownership		
	Owned	216	83.0
	Rented	34	13.0
	Leased	10	4.0
	Total	260	100.0
7.	Annual income (N000)		
	20-40	70	27.0
	41-60	164	63.0
	61 & Above	26	10.0
	Total	260	100.0
	Mean income =N60,502.50		

Source: Field Survey, 2013

Table5. Poverty status of respondents

Poverty index	Ogoja zone	Ikom zone	Calabar zone	Total
Po (alpha=0)	0.3716	0.1952	0.2268	0.3078
P1 (alpha=1)	0.0308	0.0146	0.0203	0.0303
EDE (Naira/	114,675.50	54,359.17	75,581.59	112,813.90
P2 (alpha=2)	0.0429	0.0197	0.0347	0.0384
Poverty line (N)	37,232.31	37,232.31	37,232.31	37,232.31

Source: Extracted from poverty analysis in DAD software, 2013

Analysis of upland farm households' vulnerability to climate variability in the Niger Delta, Nigeria

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ABSTRACT

The study analysed the vulnerability of upland farm households to climate variability in the Niger Delta. Three states - Akwa Ibom, Ondo and Rivers were selected from the nine states that make up the Niger Delta region. A total of 120 respondents from upland communities of the Niger delta were used for analysis. Household questionnaire and vulnerability questionnaire using Cost Route method were the instruments used for data collection and analysed using Vulnerability Profile and Vulnerability / Risk Framework. The results of the analysis show that both male and female headed households in all the upland communities were vulnerable to flooding, windstorm, erosion and drying up of streams. Important factors that made households vulnerable to climate hazards were low agricultural output and income, non-availability of irrigation facilities, insufficient farm labour and lack of storage facilities. Technical capacities of household members were assessed using both science-based knowledge as well as indigenous knowledge of climate change as indicators to adaptation to climate variability. It was assumed that the adaptive capacity of households could be enhanced by the number of persons with either science-based knowledge or indigenous knowledge across the region. Expenditure on carbohydrate was higher across the region during disaster time, followed by expenditure in protein, vitamin/minerals and fat and oil and other classes of food, implying that more carbohydrate food is consumed during disaster period than any other class of food. Certain geographical factors such as distance to coastline and population have direct impact on climate variability in the Niger Delta Region. Recommendations include establishment of emergency evacuation systems, income opportunities and support programmes as well as capacity building on climate change knowledge, enterprise development and management.

Key words: Farm households, Nigeria, poverty, rural areas, smallholder farmers

INTRODUCTION

Vulnerability is central in climate change discussions and has been described by the. Intergovernmental Panel on Climate Change (IPCC 2001a) as the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. It includes susceptibility as well as the ability to adapt. The level of vulnerability determines whether an ecosystem or society can be resilient in the face of climate change. Similarly, vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. As documented by IPCC (2001b), vulnerable populations to climate change include small holder agriculturalists with inadequate resources, pastoralists, rural landless labourers, and urban poor. Reduced food supplies and high prices immediately affect landless labourers who have little savings. The effect on agriculturalists and pastoralists depends on how much surplus they produce and the relative terms of trade. Ecological dimension has also featured in vulnerability studies. According to Watson *et al*. (1998), people who live on arid or semi-arid lands, in low-lying coastal areas, in water-limited or flood-prone areas, or on small islands are particularly vulnerable to climate change. In the same vein, IPCC, (2001b) stated

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that climate change will, in many parts of the world, adversely affect socio-economic sectors, including water resources, agriculture, forestry, fisheries and human settlements, ecological systems, and human health, with developing countries being the most vulnerable. Developing countries have lesser capacity to adapt and are more vulnerable to climate change damages, just as they are to other stresses. This condition is most extreme among the poorest people (IPCC, 2001c). According to the IPCC report on the regional impacts of climate change cited by Watson *et al* (1998), Africa is the continent most vulnerable to the impacts of projected changes because widespread poverty limits adaptation capabilities. According to the report, the importance of agricultural activities for the economies of most African countries, combined with the farming sector's reliance on the quality of rains during the rainy season, make countries in the region particularly vulnerable to climate change. Thus, from the point of view of food security, the increasing incidence of drought represents a very serious threat. It has been argued that, in Africa, drought hazard and vulnerability "are likely to be the most damaging locus of impacts of climate change" (Downing, *et al* 2001).

Despite the Vulnerability of Nigeria's Niger Delta region to the impact of climate change, there is limited comprehensive studies aimed at analysing farm households' vulnerability to climate variability in the region. The natural terrain and hydrology of the Niger Delta have always caused certain environmental problems, especially flooding, siltation, occlusion, erosion and the shortage of land for agriculture and development. Communities, roads and farmlands are partially or totally submerged from channels or by water flowing over the levees. In the mangrove swamp forest areas, diurnal tidal movements result in floods exacerbated by rising sea levels, coastal erosion and land subsidence. The floods also cause continual modification of river courses in the area, rendering the rivers useless as modes of transportation. This also has significant impacts on the pattern of human life and on the economy. Communities have been displaced and forced to relocate as a result of it. Public facilities, houses and other economic assets have been lost. These problems which the local people (who are mainly farmers and fisher folks) have lived with for many years are being exacerbated by climate change impact. Table 1 shows clearly the

Table 1: Impact of Sea Level Rise (SLR) in the Niger Delta Region

Type of Impact	Unit of Measure	Present	1m SLR	2m SLR
Erosion rate	m/year	10-15	16-19	20-25
Area lost to erosion	Km^2	26-45	55-120	130-230
Inundation and erosion	Km^2	3,000	7,000	15,000
Per cent of area lost	%	15	35	75
Villages impacted	No	50	200	350
People displaced	Million	0.15	1-2	2-3

Note: Total area of Niger Delta is about 2 million hectares
Source: Awosika et al., 1992

There is therefore a need to close the knowledge gap in the subject matter of vulnerability to climate variability on agriculture in the region. It is a strongly held opinion that any assessment at the national level must take account of regional patterns of vulnerability within the country and the distribution of vulnerability within the national community (Adger, *et al*, 2004). This study addresses this concern. Moreover, it has been asserted that it is less meaningful to aggregate vulnerability across scales since the processes that cause vulnerability are different at each scale (Adger, *et al*, 2004). We share in this opinion and extend the argument to include sectors of the economy. For instance, it is obvious that the activities and operations taking place in the industrial sector are not exactly the same as those in agriculture

or mining. And the intense petroleum exploration and production in the Niger Delta region of Nigeria which have resulted in gas flaring with adverse effects on the environment, (Ibeanu, 2000) is also peculiar to the region. Therefore, it is important to develop our understanding of vulnerability and adaptation to climate variability by examining each sector and region separately. And, several authorities (IPCC, 2001c, Nwosu, 2008 and Speranza, 2010) have reported that agriculture is the most vulnerable of all sectors, particularly in developing countries and regions like Nigeria's Niger Delta. In spite of the global concern and the obvious vulnerability of the Niger Delta region to climate variability given its coastal nature and industrial activities, empirical investigation of climate variability and long term change, particularly, households' vulnerability are yet to be given sufficient attention. This study therefore analyses households' vulnerability to climate variability in the region and fills this gap.

2. MATERIALS AND METHODS

2.1 The Study Area

The Niger delta was chosen for this study because it is particularly vulnerable to climate change being a low-lying coastal area, with flood-prone communities lying 96m above sea level and approximately 50m below the sea level. It is also of immense value to the economic survival of Nigeria because of the abundance of petroleum and natural gas in the region.The Niger Delta is located between latitude 5.3261° N and longitude 6.4708° E. It is found along the Atlantic Coast of Southern Nigeria. The Niger Delta is an area of over 70,000 square kilometres and among the three largest wetlands in the world and the largest mangrove swamp in Africa. About 2,370 square kilometres of the Niger Delta area consist of rivers, creeks and estuaries while stagnant swamp covers about 8600 km^2. (Constitutional Rights Project, 1999). The mangrove swamp spans about 1900 square kilometres and has a coastline spanning about 450 kilometres terminating at the Imo River entrance (Uyigue, and Agbo 2009). The Niger Delta is characterized by two seasons- the dry and rainy seasons. The rainy season stretches from March to October and could be as high as 3800mm to 4500mm. Relative humidity is above 60% on the average. High and long rainfall cause flooding leading to loss of valuable properties including crops and livestock. Loss of lives has also been recorded in some flood incidences. The dry season is only experienced for a few months in some coastal sections of the region.

The Niger Delta is richly endowed with mineral-rich sedimentary formations which yield minerals such as petroleum, clay, glass sands, marble and limestone. The exploitation of petroleum accounts for over 90% of the Federal government export revenue (Ibeanu, 2000). The soils support a variety of food and cash crop production. Aquatic resources such as fish, shrimps, crabs, etc. are in abundance in the region. The region has been adjudged the largest shrimp ground in West Africa. Crop farming, livestock rearing, fishing and petty trading are important livelihoods of the people of the Niger Delta. Food crops such as cassava, yam, cocoyam, rice, plantain and vegetables are cultivated because of the rich loamy soil type found in the region. Important cash crops grown include oil palm, *raphia* palm, coconut, cocoa and rubber.

2.2 Sample Size and Sampling Procedure

The Niger Delta is made up of nine States namely: Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Rivers and Ondo. Multistage sampling procedure was employed in the study. Three States of the Niger Delta –Akwa Ibom, Ondo and Rivers States were purposively selected for the study in the first stage. In the second stage, two upland communities were selected from each State. Information on the total number of households was obtained from official census figures of 2006. Also, the knowledge of the researchers and officials of the Agricultural Development Project (ADP) and State Ministries of Agriculture in each of the selected States was relied upon to select communities with high concentration of farming activities. Emphasis was placed on selecting communities with intense farming activities by majority of the population. Thus, the six communities were selected purposively. The third and last stage of sampling was the selection of farming households for a detailed study. Again, none availability of household listing in the communities was a serious challenge to the study. The principle of disproportionate sampling was employed to validate the selection of households in the communities used for the study. However, investigation revealed disproportionate distribution of male and female households, roughly in the ratio of 4:1. Under this circumstance, more male headed households could be expected. The estimated number of households from the three states is about 3,141,367 this was derived by dividing the

total population as per each state by the average household sizes. In line with the skewed distribution of households, the proportion of households sampled was adjusted to 15 male headed and 5 female headed per community. A total of 40 upland households were selected from each State to give a total of 120 respondents.

2.3 Data Collection

A combination of quantitative and qualitative data collection techniques were employed in the study. These were administration of a set of open ended household questionnaires (quantitative data collection) to collect cross sectional data, and administration of Vulnerability questionnaire using Cost Route Method. The open ended questionnaire was pretested and modified before administering it across the three States selected for the study. The response rate was normally distributed across the region. Data used for the study were collected from a panel of five households from each of the study community on a fortnightly basis for six months. In addition, two Focus Group Discussions (FGD) and two In-depth-interviews (IDI) were conducted in each community. The FGD groups were male group and female group. One male and one female key informant were also interviewed in each community in the States selected for the study.

2.4 Methods and Data Analysis

Two broad approaches were adopted for the analysis of farm households' vulnerability to climate variability. These were (i) Vulnerability profile and (ii) Vulnerability/risk Framework. These frameworks make for a quick assessment of household strength and weaknesses. These assessments allow for understanding of where to concentrate efforts in vulnerability reduction and capacity building.

2.4.1 Vulnerability profile: Separate indicators representing different elements of household vulnerability to climate variability were constructed. In all, nine (9) indicators - economic factors, health and nutrition, education, empowerment, ecology, poverty, physical infrastructure, conflict and social capital, and geographical factors were constructed. Since vulnerability is geographically and socially differentiated (Adger, *et al* 2004), we adopt inductive approach to characterize the indicators. This is in agreement with the work of Ramachandran and Eastman, (1997).

2.4.2 Vulnerability/Risk Assessment Framework: We adopted the vulnerability/risk framework of Downing *et al*, (2001) and the Vulnerability Assessment Framework of Jones (2001). This framework focuses on current vulnerability, risk of present and future climatic variations, and responses to reduce present vulnerability and improve resilience to future risks. This framework places the stakeholder at the center of the research. We consider this very important since we assume that the people in the Niger Delta region have developed indigenous knowledge system that have enabled them to cope so far with climate variability. We examined factors that predispose households to being vulnerable. These factors include irrigation water availability, precipitation, drought, agricultural productivity and production, labour availability and land tenure, food storage and processing, transportation and distribution, population factors, income and conflicts. These factors were scored on a scale ranging from 1 to 3 (where 1 indicates that the factor does not appear to be a key determinant of vulnerability, 2 suggests that it is important and 3 that it is very important). The mean score of the respondents on the importance of each factor was computed and compared with the maximum expected score (5). The value of the mean score was then used to ascertain the importance of a given factor in pre-disposing households to the impact of climate change.

3. RESULTS AND DISCUSSION

3.1 Vulnerability Profile

3.1.1 Food Supply and Expenditure: Extant literature reveals that one aspect of household life that is usually adversely affected by any shock from adverse event is food consumption. Consumption expenditure on major food items was estimated during normal period as well as period of climate event/disaster (Table 1). The results show that for Akwa Ibom State, climate disaster time expenditure on all the food items considered was lower than normal time expenditure. For instance, on the average, normal time expenditure on carbohydrate by households is NGN9924.49 while mean disaster time expenditure is NGN5711.76. This amount is lower than the normal time expenditure by NGN4211.73. This is also the case for other important food items. Figure 1 below present total expenditure on food during periods of extreme climate conditions across the three states in the region. About NGN 35959.56 was spent on carbohydrates, NGN23049.06 on protein, NGN10137.07 on tamins/minerals, NGN5567.71 on fat/oil while

vitamins/minerals, NGN5567.71 on fat/oil while NGN2923.44 was spent on other food items. The situation reveals inadequate food to purchase during climate disaster. Akwa Ibom State depends on states such as Cross River, Benue, among others for most of its food supply. Occurrence of disaster may restrict the movement of traders, thus reducing the food supply to the disaster communities. The situation could lead to hunger and starvation by households thereby making them more vulnerable to other adverse conditions. The situation in Ondo State is similar to Akwa Ibom. However, the amounts expended on these food items are lower in Ondo State than Akwa Ibom State. During periods of extreme weather conditions, expenditure on protein food is NGN2639.66 while that of normal time is NGN2132.42. In Rivers State (adverse weather conditions such as flooding or drought) food expenditure is higher than normal time expenditure. The general pattern observable from this result is that across the State, more money is spent by households on carbohydrates followed by protein, vitamins/minerals and fat and oil in that order. This means that more carbohydrate foods are consumed by households than any other type of food in the Niger Delta region.

Table 2: Mean monthly expenditure on basic/important food components

Food component	Akwa Ibom		Ondo		Rivers	
	Normal Time expenditure (NGN)	Disaster Time (or extreme weather conditions) expenditure (NGN)	Normal Time expenditure (NGN)	Disaster Time expenditure (NGN)	Normal Time expenditure (NGN)	Disaster Time expenditure (NGN)
Carbohydrate	9924.49	5711.76	3844.44	4000	5373.24	7105.63
Protein	5295.81	2639.66	3636.11	2132.42	4274.64	5070.42
Vitamin/mineral	2757.88	1589.33	765.44	434.98	2109.86	2479.58
Fat & oil	1793.18	153.63	598.33	677.50	1098.59	1246.48
Others	766.20	175	278	267.62	535.21	901.41

Source: Field data, 2011

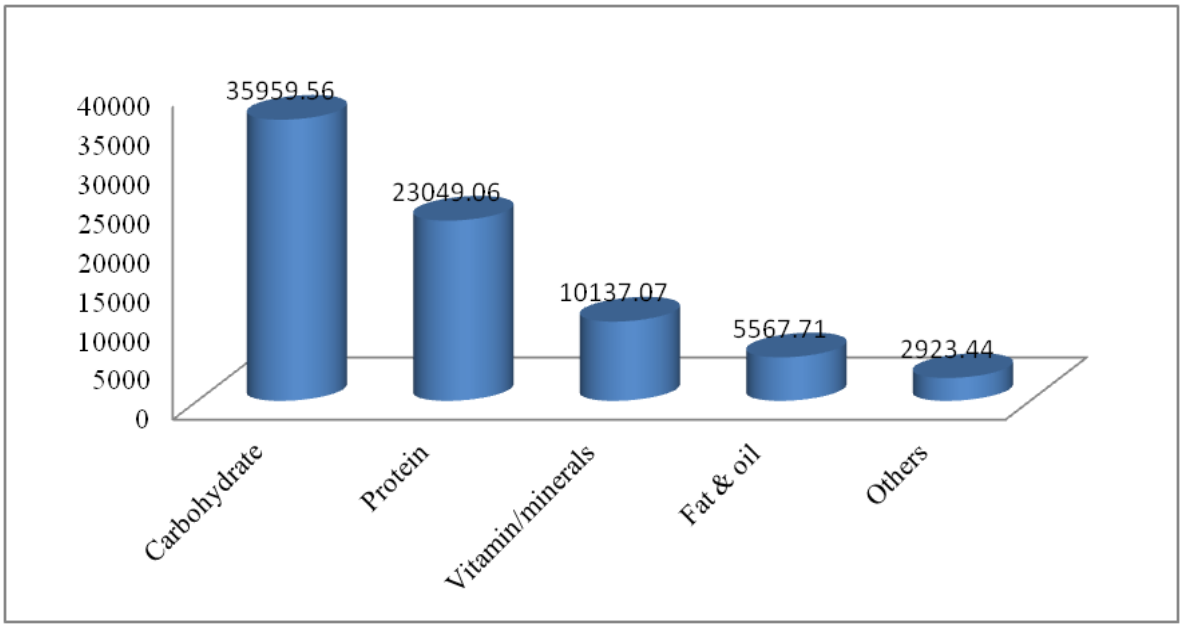

Figure 1: Expenditure Profile on Food

3.1.2 Technical Capacity: The number of household members with science-based knowledge as well as indigenous knowledge of climate change has been used as indicator of the technical capacity of households to adapt to the impact of climate variability and long-term change (Adger *et al*, 2004). In this study, we used the number of male and female household members enrolled in science-based courses in tertiary institutions or who have graduated from science-based disciplines. In addition, the number of male and female household members with indigenous knowledge of climate issues was also considered. The assumption is that the adaptive capacity of households could be enhanced by the number of persons with either science or indigenous knowledge. Result presented in Table 3 shows that the number of male and female household members who graduated in science-based courses is higher in Rivers State followed by Akwa Ibom and Ondo States. The general pattern across the State and community type is that a large percentage of the households do not have many of their household members either enrolled in science-based courses or having graduated from science based courses. The result is presented in Table 3.

Table 3: Percentage distribution of respondents by their household's technical capacity

Technical capacity	Respondent	Akwa Ibom				Ondo				Rivers			
		Number of Household members				Number of household members				Number of household members			
		Nil	1- 3	>3	Total	Nil	1- 3	>3	Total	Nil	1-3	>3	Total
Science-based Knowledge													
Male household members in Science based courses	Male	90.4	7.9	1.6	100	95.4	4.6	0	100	71.4	28.6	0	100
	Female	93.8	6.3	0	100	98.2	2.8	0	100	33.3	66.7	0	100
Female household members in Science based courses	M ale	95.2	4.8	0	100	96.9	3.1	0	100	71.4	28.6	0	100
	Female	87.5	12.5	0	100	94.3	5.7	0	100	33.3	66.7	0	100
Male graduate household members in Science based courses	Male	95.2	4.8	0	100	95.5	3.1	1.5	100	64.3	35.7	0	100
	Female	100	0	0	100	95.4	5.6	0	100	33.3	66.7	0	100
Female graduate household members in Science course	Male	93.7	4.3	0	100	95.9	3.1	0	100	78.6	21.4	0	100
	Female	87.5	12.5	0	100	92.2	7.8	0	100	33.3	66.7	0	100
Indigenous Knowledge													
Male household members with indigenous knowledge	Male	82.5	11.1	6.3	100	93.8	4.6	1.6	100	64.3	35.7	0	100
	Female	75	25	0	100	100	0	0	100	0	100	0	100
Female household members with indigenous knowledge	Male	50.8	49.2	0	100	95.4	4.6	0	100	71.4	28.6	0	100
	Female	56.3	37.5	6.3	100	100	0	0	100	0	33	67	100

Source: Field data, 2011

In none of the female households has their member any indigenous knowledge of climate change. The result on the indigenous knowledge should be interpreted with some caution. The attitude of discussants at the FGD shows that the current was that persons with local/indigenous knowledge are looked upon as possessing weird knowledge capable of harming people. For this reason, people do not want to admit they have this knowledge although they use such skills on occasions e.g. in rain-making. Adaptation intervention may target legitimizing and popularizing this knowledge to reduce the vulnerability of farming communities to the impacts of climate change. In upland communities of Rivers State, some households have 1 to 3 male and female member either enrolled or have graduated from science-based courses. The same pattern is obvious on non-science based courses. The fact that very few households have members with science-based and tertiary level knowledge has serious implications for adaptation to climate change knowledge and the use of it are what the households need to, first, reduce human induced climate hazards and, second take informed actions to mitigate the impact of climate change. When this is lacking, adoption of adaptation measures may be hindered. Technical capacity of households need to be built if Nigeria will respond effectively to the impact of climate variability and long-term climate change. Result further indicates that some households have 1-3 members with indigenous knowledge of climate change. The result also reflects the submissions of participants in FGDs in some of the communities. In each community, members have a way of ascertaining if rain will fall or not. Sometimes, the direction of the rain forming-clouds or appearances of certain insects or birds are used as indicators of how the weather will look like in the near future.

3.1.3 Geographical factors: Geographical factors such as distance from coastline, population within 100km of coastline have been identified as capable of making households vulnerable to climate change impact (Heger, and Paddison, 2008). The proposition is that the nearer households and communities are to climate hazard prone sites such as the coast, ravine and erosion sites, the more vulnerable they are to climate change impact. The distribution of the respondents in the three States studied according to the location of their homes from the coast, ravine and erosion sites is presented in Table 3.

Table 4: Percentage distribution of respondents by the distance of their homes to the coast, ravine and erosion sites

Community Type	Distance	Coast		Ravine		Erosion Site	
	(Km)	Male	Female	Male	Female	Male	Female
		%	%	%	%	%	%
Akwa Ibom	≤ 1	33.9	26.7	1.6	80.0	56.9	33.3
	2 – 3	40.0	13.3	21.5	20.0	24.6	46.7
	≥ 3	26.1	60.0	76.9	0.0	18.5	20.0
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Ondo	≤ 1	23.1	6.7	7.7	6.7	26.1	66.7
	2 – 3	30.8	26.7	53.8	33.3	58.5	13.3
	≥ 3	46.1	66.6	38.5	60.0	15.4	20.0
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Rivers	≤ 1	7.1	0.0	7.3	0.0	22.9	10.5
	2 – 3	0.0	0.0	0.0	0.00	27.1	19.5
	≥ 3	92.9	100.0	92.7	100.0	50.0	70.0
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Field data, 2011

What seems to be common to both male and female households is their nearness to erosion sites. The houses of more than a half of the male respondents and 33.3% of the female were found to be located less than 1 kilometer from erosion sites. With these features, it can be inferred that these communities may be easily affected in event of climate hazards/events. The location of the male and female respondents in the upland communities of Ondo State according to the distance of their homes from the coast, ravine and erosion sites respectively is presented in Table 4. The results show that the upland households are closer to ravine and erosion sites than they are to the coast. More than 60% of the female headed households live within a distance of less than 1kilometer from erosion site. The results tend to indicate that most households in the Niger Delta region are close to hazard sites or the other. The implications of the findings are that households in the Niger Delta are vulnerable to climate change impact.

The distribution of the households in Rivers State according to the location of their homes from the coast, ravine sites as well as erosion sites is also presented in Table 4. All the female respondents (100%) in the upland communities live more than 3 kilometers away from the coast. However, a smaller percentage of the respondents live close to ravines as well as erosion sites. Although, the percentage of respondents living close to ravine and erosion site is less than those living close to the coast, it is high enough to give attention, particularly in the face of "increasing climate variability"(IPCC, 2001c).

3.1.4 Economic: Many studies report that agriculture is one sector that is very vulnerable to climate variability. For this reason, the economic factor that can make households vulnerable to climate change impact considered is the extent of households' dependence on agriculture. Extent of dependence is measured by number of household members in agriculture as well as offering services as hired agricultural labour. The result is presented in Table 5.

Table 5: Percentage distribution of households by proportion of members in agriculture and as hired labour

Community Type	Proportion of household members	Household Members in Agriculture		Household members as Hired labour	
		Male	Female	Male	Female
		%	%	%	%
Akwa Ibom	None	7.9	0.0	55.6	50.0
	½	6.4	0.0	34.9	50.0
	More than ½	85.7	100.0	9.5	0.0
	Total	**100.0**	**100.0**	**100.0**	**100.0**
Ondo	None	36.9	33.3	92.3	80.0
	½	63.1	66.7	7.7	6.7
	More than ½	0.0	0.0	0.0	13.3
	Total	**100.0**	**100.0**	**100.0**	**100.0**
Rivers	None	57.1	100.0	100.0	100.0
	½	14.3	0.0	0.0	0.0
	More than ½	28.6	0.0	0.0	0.0
	Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Field data, 2011

Findings from the study show that a high percentage of male and female households in upland communities of Akwa Ibom State have more than half of their members in agriculture as well as hired agricultural labour. In the upland communities, 85.7% of the male respondents said more than ½ of their household members are in agriculture. All the female headed households (100%) have more than half of their members in agriculture. This implies agriculture is more of an occupation of women headed households. Discussants were quick to point out that due to rural- urban migration, there is scarcity of hired agricultural labour in the rural communities. They submitted that farmers rely more on exchange labour, though this is insufficient and thus limit the size of land cultivated. The implication of this situation is that income of the household from this livelihood will be low leading to poverty and reduction in adaptive capacity of farming households. In Ondo State, most households-male and female, have at least half of their members in agriculture. In the upland communities, 63.1% of the male respondents and 66.7% respondents report that a half of their household members are in agriculture. It can be inferred from this result that agriculture is the primary occupation in the communities studied. Because agriculture is highly vulnerable to the impact of climate change, it can be deduced that these farming households are prone to the impacts of climate change.

The distribution of respondents in Rivers State by the proportion of their household members in agriculture or being agricultural labourer is also presented in Table 4. Findings show that 28.6% of the male respondents in upland communities have more than a half of their household members in agriculture.

4. Current Vulnerability: Rating of Factors that make Households in the study area Vulnerable to Climate Variability. The result on the farmers' rating of factors that make them vulnerable to the impact of climate change is presented in Tables 6, 7 and 8.

4.1 Rating of factors that make households in Akwa Ibom State vulnerable to climate variability and climate change hazards

Table 6: Percentage distribution of respondents by their rating of factors that make their households vulnerable to the impacts of climate variability in Akwa Ibom State

Factor	Sex	Rating				m= ranking by Males m= ranking by Females
		Not Important (1)	Important (2)	Very Important(3)	Mean	
Non availability of irrigation facilities	Male	75.00	71.43	49	2.72	m 2
	Female	25.00	28.57	15.52	2.69	f 4
	All	**100.00**	**100.00**	**100.00**	2.71	
Non availability of water for livestock	Male	84.62	80.95	80.00	2.07	m 8
	Female	15.38	19.05	20.00	2.19	f 10
	All	**100.00**	**100.00**	**100.00**	2.11	
Low agricultural output	Male	90.00	90.91	75.00	2.45	m3
	Female	10.00	9.09	25.00	2.85	f 1
	All	**100.00**	**100.00**	**100.00**	2.59	
Insufficient farm labour	Male	88.24	72.73	80.77	2.45	m3
	Female	11.76	27.27	19.23	2.74	f 3
	All	**100.00**	**100.00**	**100.00**	2.55	
Non availability of agricultural land	Male	82.35	80.00	81.40	2.32	m5
	Female	17.65	20.00	18.60	2.63	f 6
	All	**100.00**	**100.00**	**100.00**	**2.43**	
Insufficient food storage facilities	Male	80.95	80.00	83.33	2.06	m9
	Female	19.05	20.00	16.67	2.22	f 9
	All	100.00	100.00	100.00	2.11	

Inadequate processing facilities	Male	96.30	70.00	78.26	1.89	m11
	Female	3.70	30.00	21.74	2.22	f 9
	All	**100.00**	**100.00**	**100.00**	2	
Inadequate means of transportation and distribution	Male	95.24	84.38	66.67	1.96	m 10
	Female	4.76	15.63	33.33	2.41	f 8
	All	**100.00**	**100.00**	**100.00**	2.11	
Increased population	Male	76.92	82.61	80.95	2.09	m7
	Female	23.08	17.39	19.05	2.07	f 11
	All	**100.00**	**100.00**	**100.00**	2.09	
Low income	Male	90.91	88.00	75.00	2.4	m4
	Female	9.09	12.00	25.00	2.63	f 6
	All	100.00	100.00	100.00	2.44	
Conflict	Male	87.50	66.67	81.82	2.14	m6
	Female	12.50	33.33	18.18	2.65	f 5
	All	**100.00**	**100.00**	**100.00**	2.32	

Source: Field data, 2011

Female farmers in Akwa ibom state rated low agricultural output as number one factor that can make their households vulnerable to the impacts of climate variability and long term climate change as shown in Table 6. This was followed by insufficient farm labour, conflict and non-availability of water for irrigation facilities, in that order. For the men, inadequate storage facilities were rated as number one factor that can expose their households to the impacts of climate variability and change. Following closely in their rating were non-availability of irrigation facilities and insufficient farm labour. While non-availability of water for livestock was rated as important by women, rainfall, low-agricultural output, insufficient farm labour, insufficient food storage facilities, inadequate means of transportation, distribution and increased population were considered as factors that can predisposed households to the impact of climate change. Most of the other factors listed were rated as not important.

4.2 Rating of factors that make households in Ondo State vulnerable to climate variability and climate change hazards

For Ondo state, insufficient farm labour and non-availability of agricultural land were rated as important. Inadequate food storage facilities and conflict were rated as unimportant in exposing households to the impact of climate (Table 7). On the basis of the percentage of the respondents reporting on a given factor, it can be seen that the females paid more attention to non-availability of agricultural land, insufficient food storage facilities, and inadequate means of transportation and distribution. No female mentioned these factors as being not important whereas men rated land as not important. This finding may be attributable to the land tenure system whereby land ownership is mainly through inheritance, and male children are primarily the heir to family land. This probably makes female respondents more vulnerable to land related climate change impact. In the Niger Delta region, as in most parts of Nigeria, making food available to the household is primarily the responsibility of women. This could inform why food storage and processing facilities are rated as important by women than men. However, in any intervention directed at reducing the vulnerability of upland farming households in Ondo State to climate variability, those rated as unimportant in predisposing households to impact of climate change need to be the focus. These include rainfall, farm labour, land, food storage and processing facilities, transportation, population and income.

Table 7: Percentage distribution of upland respondents by their rating of factors that make households vulnerable to the impact of climate vulnerability on Ondo State

		Not Important	Important	Very Important	Mean	Rank
						m= ranking by males, f= ranking by females
Non availability of irrigation facilities	Male	82.1	66.7	91.7	1.46	M= 11
	Female	17.9	33.3	8.3	1.4	f =10
	All	100	100	100	1.45	
Non availability of water for livestock	Male	79.4	70.6	89.7	1.98	m =8
	Female	20.6	29.4	10.3	1.73	f =9
	All	100	100	100	1.94	
Rainfall	Male	80	66.7	85	2.72	m =1
	Female	20	33.3	15	2.53	f =4
	All	100	100	100	2.69	
`Drought	Male	88.9	65.2	83.3	1.54	m =10
	Female	11.1	34.8	16.7	1.8	f =8
	All	100	100	100	1.59	
Low agricultural output	Male	81.5	77.8	84.6	2	m =7
	Female	18.5	22.2	15.4	1.93	f =7
	All	100	100	100	1.99	
Insufficient farm labour	Male	82.6	61.1	89.7	2.25	m =6
	Female	17.4	38.9	10.3	2	f =6
	All	100	100	100	2.2	
Non availability of agricultural land	Male	100	81.8	75	2.2	m =5
	Female	0	18.2	25	2.73	f =3
	All	100	100	100	2.56	
Insufficient food storage facilities	Male	0	81.8	79.4	2.68	m =3
	Female	0	27.2	20.6.	2.8	f =1
	All	0	100	100	2.71	
Inadequate food processing facilities	Male	100	72.7	81	2.71	m =2
	Female	0	27.3	19	2.8	f =1
	All	100	100	100	2.71	
Inadequate means of transportation &distribution	Male	0	69.2	82.3	2.71	m =2
	Female	0	30.8	17.7	2.73	f =2
	All	0	100	100	2.71	
Increased population	Male	100	73.3	81.7	2.68	m =4
	Female	0	26.7	18.3	2.73	f =2
	All	100	100	100	2.69	
Low income	Male	82.9	85.7	77.4	1.92	m =9
	Female	17.1	14.3	22.6	2.07	f =5
	All	100	100	100	2.07	
Conflict	Male	80.6	85.7	100	1.12	m =12
	Female	19.4	14.3	0	1.07	f =12
	All	100	100	100	1.11	

4.3 Rating of factors that make households in Rivers State vulnerable to variability and climate change hazards

Seven factors were rated as predisposing households to the impact of climate change by both male and female upland farmers in Rivers State (Table 8). Similar factors were considered by both sexes as important except that while females did not consider lack of storage facilities, non-availability of agricultural land, as important, the male farmers rated these alongside other factors as being important. On the other hand, the females considered low agricultural output, drought, among other factors as those that can make them vulnerable to impact of climate change, whereas male respondents rated those as not important. The common factors that can expose both male and female farmers in Rivers state to the impact of climate change are rainfall, non-availability of farm labour, increased population, low income and conflict. The result is in conformity with the situation in Rivers State. The state experiences heavy rainfall almost all year round. This, in extreme cases may affect farming adversely. Similarly, because of better pay in the oil related industry, there is migration of labour from agriculture to the oil industry. This adversely affects agricultural production, thus making farming households vulnerable to the impact of climate change.

Table 8: Percentage distribution of respondents by their rating of factors that make upland farming households in Rivers State vulnerable to impacts to climate variability

	Sex	Not Important	Important	Very Important	Mean	Ranking M = ranking by males f = ranking by females
Non availability of irrigation facilities	Male	84.4	50	60	1.94	M 6
	Female	15.6	50	40	1.33	f 6
	All	100	100	100	1.35	
Non availability of water for livestock	Male	100	75	50	1.79	m 9
	Female	0	25	50	1	f 8
	All	100	100	100	1.82	
Low agricultural output	Male	50	87.5	75	1.94	m 6
	Female	50	12.5	25	2.67	f 1
	All	100	100	100	2.41	
Insufficient farm labour	Male	60	80	80	2	m 5
	Female	40	20	20	2.33	f 3
	All	100	100	100	2.06	
Non availability of agricultural land	Male	71.6	60	87.5	2.21	m 4
	Female	28.4	40	12.5	1	f 8
	All	100	100	100	2.12	
Insufficient food storage facilities	Male	50	81.2	71.4	2.21	m 4
	Female	50	18.8	28.6	1.67	f 5
	All	100	100	100	2.12	
Inadequate food processing facilities	Male	50	91.7	50	2.36	m 3
	Female	50	8.3	50	2	f 4
	All	100	100	100	2.12	
Inadequate means of transportation &distribution	Male	50	80	75	2.4	m 2
	Female	50	20	25	1.3	f 7
	All	100	100	100	2.2	
Increased population	Male	100	72.3	66.7	2	m 5
	Female	0	27.7	33.3	2	f 4
	All	100	100	100	2	
Low income	Male	100	72.3	71.4	2.2	m 4
	Female	0	27.7	28.6	2.6	f 2
	All	100	100	100	2.3	
Conflict	Male	75	75	75	2	m 4
	Female	25	25	25	2	f 4
	All	100	100	100	2	

Source: Field data, 2011

5. CONCLUSIONS, POLICY IMPLICATIONS AND RECOMMENDATIONS

The study concludes that both male and female headed households in the upland communities of the Niger delta are vulnerable to flooding, windstorm, erosion and drying up of streams. This result concurs with earlier studies by Zabbey, (2007) that due to its characteristic lowlands, the Delta region is potentially vulnerable to any rise in sea level. Those factors that are considered very important to household vulnerability to climate hazards are: low agricultural output and income, non-availability of irrigation facilities, insufficient farm labour and lack of storage facilities. Except in Rivers State, farming households tend to spend less on food during disaster. This presupposes lack of income to buy food. Most households lack technical capacity to adapt to climate variability and change. There is a high level of dependence on agriculture, and households are located close to areas susceptible to the impact of climate hazards thus, are vulnerable to climate change impact. Communities in the Niger Delta have limited adaptation measures to climate change related events and extremes. Some of these measures may not be sufficient given their vulnerability to climate variability.

The result of the study indicates that farming households are vulnerable to flooding, windstorms, and drying up of streams and other water bodies, and erosion. Several factors are rated as "very important" in exposing the farmers to the impacts of climate hazards. These are low agricultural output, non-availability of irrigation facilities, insufficient farm labour, and lack of agricultural commodities/food storage facilities, low income and inadequate means of transportation. Besides the current climate related hazards, farmers believe they are likely to have mud and landslides in their communities. From the fore goings, it can be safely concluded that farming communities in the Niger Delta are affected by and can be exposed to more climate related hazards. To assist the communities adapt to these hazards, it is recommended that early warning system on extreme climatic events be established. Without this warning, such events could destroy crops or kill livestock that farmers rely on for livelihood. Emergency evacuation systems should also be established. This is to evacuate farmers in the event of extreme climatic event. Of particular importance is the need for the creation of climate information agency to regularly disseminate climate information to the farmers.

Climate variability has impacted on the communities in many ways. Chief among these are loss of income, poor crop yield, loss of properties and health problems (skin rashes, etc). These affect men and women alike. Therefore, programmes that will reduce the vulnerability of farmers' livelihoods to climate change impact will be useful. Income opportunities and income support programmes and capacity building on climate change knowledge, enterprise development and management are recommended. Income support and capacity building on enterprise will enable the farmers diversify their income sources in order to reduce their vulnerability to climate variability and change.

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Growth performance and carcass yield of finisher Broilers fed *Gmelina arborea* lead meal in partial replacement for Palm Kernel Cake

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ABSTRACT

A study was conducted to investigate the effect of *Gmelina arborea* leaf meal on the growth performance, dressed carcass yield and internal organs of broiler chickens at the finisher phase. 180 day old Hubbard chicks were used. The birds were grouped into 4 treatments (T1 – T4). Each treatment was replicated thrice having 15 birds per replicate. The experiment was arranged in a completely randomized design (CRD). Diet containing no leaf meal was fed at the starter phase. Feeding of experimental diets started at the end of four weeks which marked the end of the starter phase. Diet fed to control group (T1) did not contain the leaf meal, while T2 –T4 diets contained 1.00, 2.00 and 3.00 % of the leaf meal respectively in replacement of palm kernel cake. Feed and water were given *ad libitum* for the 4 weeks the experiment lasted. At the end of the feeding period, the birds were dressed and cut into carcass parts and the internal organs separated. Proximate analysis indicated that *Gmelina arborea* leaf meal contained 18 % crude protein and 3591Kcal gross energy. The leaf meal did not significantly (P>0.05) influenced all growth indices except feed: gain ratio that was negatively affected by 3.0 % level compared to control. There was no negative impact of the leaf meal on dressed carcass and internal organs. Therefore, 3.0 % *Gmelina arborea* leaf meal could be incorporated in diets for finishing broilers.

Key words: broiler chickens, dressed carcass, *Gmelina arborea*, leaf meal, internal organs, palm kernel cake

INTRODUCTION

Palm kernel cake and wheat offal have been the major high fibre low protein feedstuffs used to produce poultry feeds in Nigeria (Ndelekwute, 2012). Their inclusion specifically is to reduce cost of feed. Feed accounts for 60 – 70 % of the total production cost in modern poultry production (Oluyemi and Roberts, 2000, pp. 147-168). Furthermore, Smith (1990, pp. 69-121) had shown that nutrition has a great effect on poultry growth, egg production and meat quality. In achieving good level of nutrition standard, farmers have encountered high level of cost of production due to expensive feedstuffs such as maize and soya bean meal which constitute over 80 % in broiler diets. This has resulted to low profit maximization. This situation has created the need to look for cheap, available and less competitive and non expensive feed ingredients. In achieving this, potentials of high fibre protein feedstuffs which have little or no monetary value could be explored for finishing broilers.

The use of forages has been suggested to be a viable alternative source of proteins, fibre, vitamins and minerals for poultry feeding (Church 1991, pp. 150-165). Plant leaves are commonly processed into leaf meals, for use in poultry feed. Available information showed that forage resources from *Leucaena leucocephala, Gliricidia sepium, Sesbania sesban, Manihot spp* have been widely used in feeding non-ruminants and especially poultry for improvement of their productivity (Lopez, 1986; D'Mello *et al.,* 1987). However, the use of leaf meals is limited by their high fibre contents and in some cases, presence of varying quantities of antinutritional factors or metabolism inhibitors in their biomass. These affect the optimal utilization of forage by

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monogastric animals. Consequently, levels higher than 5 – 10 % depending on type of forage have been reported to be detrimental on survival and production of animals **(**Cariaso, 1988; Alefor and Omodara, 1994; Onwuka, 1994; Onwuka, 1996; Osagie, 1998**)**. One of such forages that could be used in feeding animals is *Gmelina arborea* leaf.

Gmelina arborea (knonw as *Gmelina* or white teak tree) is a medium-sized, fast-growing deciduous non-leguminous tree of up to 40 m tall and 140 cm in diameter (Jensen, 1995). It is usually planted in gardens and avenues. It is all season tree, drought tolerant, resistant to most diseases and pests. lt has a high biomass yield per hectare, can grow well in marginal areas and has a protein value which can support livestock production. Jensen (1995) reported that *Gmelina arborea* leaves contained 12.5 % crude protein and 1.72 % tannic acid. However, Ahamefule *et al.* (2006) reported higher protein level of 16.80 % and hence could be regarded as good source of cheap protein to farm animals especially monogastrics. The problem of feeding forage to poultry has been among others the absence of teeth. Birds do not masticate their food, hence processing forages that have potential into meal could be a good strategy. *Gmelina arborea* leaf could be said to have such potentials and it abounds in the tropics. On dry matter basis, it contains high level of protein. Therefore, the objective of this work was to determine the effect of *Gmelina arborea* leaf processed into meal on growth and carcass mass and internal organs of finisher broiler chickens.

MATERIALS AND METHODS

Site of the experiment

The experiment was carried out at the Poultry unit of Teaching and Research Farm of University of Uyo, Akwa Ibom State, Nigeria. The mean rainfall during the experiment was 2500 mm, with relative humidity of 70 %.

Experimental Procedure Adopted

Preparation of Gmelina arborea leaf meal

The *Gmelina arborea*_leaves were harvested from a *Gmelina* plants cultivated and maintained by Forestry Department of University of Uyo, Nigeria where the research was carried out. Leaves were cut from trees over twelve months old. The leaf petiole (stalks) was removed including the midrib to reduce the fibre content. The leaves were chopped into pieces sun dried and milled to powder form. The meal was stored in an air tight bag throughout the duration of the research. The palm kernel cake used was obtained from a vegetable oil factory. Proximate composition of both the leaf meal and palm kernel cake (Table 2) was determined according to Association of Analytical Chemists (A.O.A.C., 1999).

Formulation of Diets for the Experiment

Starter and finisher diets were formulated to conform to the requirements for broiler chickens in the tropics as recommended by National Research Council (NRC. 1994). Trial and error method according to Olomu (1995, pp. 218-224) was adopted. The starter diet contained crude protein 22 %, ether extract 4.65 %, crude fibre 4.05 %, calcium 1.21 %, phosphorus 1.0 %, lysine 1.12 %, methionine 0.50 % and energy 2865 KcalME/kg. It did not contain *Gmelina arborea* leaf meal, while the finisher diets contain different levels of *Gmelina arborea* leaf meal in replacement for palm kernel cake (Table 2).

Design of the Experiment

A total of 180 day old chicks of Hubbard strain were used. They were grouped into four treatment (T1 – T4) groups of 45 birds each. The treatments were replicated thrice, each having 15 birds. Treatment one (T1) served as the control diet which contained no *Gmelina arborea* leaf meal. Treatments 2 – 4 diets contained respectively 1.00, 2.00 and 3.00% of the leaf meal. The experiment was arranged on completely randomized design (CRD). The experiment lasted for 4 weeks starting from the fourth week which was the end of the starter phase. At the starter phase, diet containing no *Gmelina arborea* leaf meal was fed to all the birds. At the end of the brooding which lasted for 3 weeks the birds were transferred together to the rearing house. At the fourth week, they were randomly separated into treatment groups, making sure that the treatment groups have similar average live weight.

Management of Experimental Chicks

The chicks were managed in a deep liter open sided house. Birds were brooded for three weeks during which gumboro and Newcastle disease vaccines were administered twice on 10^{th}, 17^{th} and 1^{st} , 19^{th} day respectively. On the first day D-glucose solution was given to the chicks. From the second day antibiotic and vitamins were added to the drinking water for one week. Both feed and water were offered *ad libitum* to the birds till the end of the experiment.

Prophylactic measures against *coccidiosis* and chronic respiratory disease were observed. Adequate hygiene and routine management of liter were observed also.

Data Collection and Analysis

Data collected were on live weight, feed intake, dressed carcass and internal organs The values of feed intake and live weight were used to calculate feed: gain ration. Birds were killed, dressed and dressed carcass parts and internal organ parameters were collected according to Scott *et al*. (1969) as reported by Oluyemi and Roberts (2000, pp. 196-198) and Ndelekwute *et al*. (2012). The dressed carcass weight was expressed as percentage live weight; cut-parts weight as percentage dressed weight and weight of internal organs as percentage live weight. All percentage values were transformed using arc sine according to Preston (1996). All data were subjected to the Analysis of Variance (ANOVA) and significant means separated using Duncan Multiple Range Test according to Steel and Torrie (1980).

RESULTS

The proximate composition of the *Gmelina arborea* leaf meal is presented in Table 2. It contained high level of crude protein and nitrogen free extract. The crude fibre and energy content were low. The performance parameters of finisher broiler chickens fed *Gmelina arborea* leaf meal (Table 3) indicates that there were no significant ($P>0.05$) differences in final live weight and weight gain. However, significant difference ($P<0.05$) was observed in feed intake and feed: gain ratio. Birds that fed diet containing 3% leaf meal consumed more feed compared to the control. Nevertheless, this did not translate to improved live weight. It was further observed that the feed: gain ratio of broilers fed 3 % leaf meal was higher compared to the control. Results of carcass and internal organ analyses (Tables 4 and 5) revealed that there were no significant differences in all the parameters measured.

DISCUSSION

The crude protein of the leaf meal obtained was higher than the 12.50 % reported by Jersen (1995) but closer to 16.80 % published by Ahamefule *et al.* (2006). Similarly, the value fell within the range of 15.30 to 33.30 % reported by Mecha and Adegbola (1980) and Okoli *et al.* (2001). This variability might be due to soil types and age of the plant. This is in line with report by Ahamefule *et al.* (2006) who stated that forages of Nigerian rangeland differed in chemical composition owing to variability in soil types and constitution. It was also observed that the crude fibre content was low compared to 18 % contained by some cereal grains and oil seeds byproducts such as wheat offal, brewer's dried grains and palm kernel cake conventionally used to formulate diets for chickens (Olomu 1995, p. 60). The low fibre content is an indication that it could not hinder nutrient utilization. High level of fibre is detrimental to broiler performance. In addition, the low fibre level could have resulted from proper processing of the *Gmelina arborea* leaves (for instance, the leaf stalks were removed from the leaves which would have increased the fibre content).

The non significant difference in live weight was in contrast to the findings of Gadzirayi *et al.* (2012) who observed significant improvement in live weight. Significant increase in both daily and total feed intake by broilers fed leaf meals has been reported. Kakengi *et al.* (2007) reported significant increase in feed intake of birds fed *Moringa oleifera* leaf meal diets. It was however in contrast with Gadzirayi *et al.* (2012) who observed no significant difference in feed intake of broilers fed leaf meal. Higher feed: gain ratio at 3 % level is indicating poor utilization of the feed. This could be as a result of probable presence of antinutritional factors especially tannin which was reported to be the major antinutritional factor in *Gmelina arborea* leaf (Jensen, 1995). Though, the leaves were dried, it could be that the drying method and duration of drying were not enough to remove the tannin or reduce it to a level that could not affect productivity negatively. Antinutritional factors are known to induce negatively on chicken and other farm animals performance (Olomu, 1995, p. 286; McDonald *et al*., 1995, pp. 434-444; Onwuka, 1996)). This was not the case for the feed intake which could imply that any toxic factor in the leaf meal could not have occurred at level that could have negatively affected feed intake but rather the metabolic processes, thereby being only detrimental to the utilization of the feed. In addition higher feed intake recorded by 3.0% level compared to the control could be as a result of the difference in energy content of the two diets. Control diet contained 50 kcal/kg more. Chickens have been reported to consume more diets at lower energy level (Oluyemi and Roberts 2000, pp. 147-168). Therefore, the higher feed intake could be related to the lower energy

content of diet of treatment 4. This result was in line with Olugbemi *et al.* (2010).

All internal organs examined were not negatively affected signifying that there were no detrimental effects of the leaf meal on them. The same applies to carcass yield indicating that the *Gmelina arborea* leaf meal could not have interfered negatively with the muscle development.

CONCLUSION

Where as inclusion of *Gmelina arborea* leaf meal did not negatively affect the live weight, carcass yield and internal organs of the broilers, it could be considered for in broiler chicken diets. Hence, level of 2.0 % at the finisher phase is recommended.

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Table 1: Ingredient and nutrient composition of diets

Ingredients	T_1	T_2	T_3	T_4
Maize	53.00	53.00	53.00	53.00
Soyabean meal	25.00	25.00	25.00	25.00
Gmelina leaf meal	-	1.00	2.00	3.00
Fishmeal	3.00	3.00	3.00	3.00
Palm kernel cake	12.00	11.00	10.00	9.00
Wheat offal	3.00	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25
Total	100	100	100	100
Nutrient Composition (Calculated)				
Crude protein	20.50	20.50	20.50	20.50
Ether extract	4.56	4.56	4.55	4.53
Crude fibre	6.55	6.55	6.50	6.45
Lysine	1.15	1.15	1.15	1.15
Methionine	0.55	0.55	0.55	0.55
Calcium	1.05	1.05	1.05	1.05
Phosphorus	0.85	0.85	0.85	0.85
Energy (Kcal/ME/kg)	2850	2810	2820	2800

*Per kg finisher diet): vitamin 10, 0001.u., vitamin D_3 12,0001.u. Vitamin E 201.U., Vitamin K 2.5mg, thiamine 2.0mg, Riboflavin 3.0mg, pyridoxine 4.0mg, Niacin 20mg, cobalamin 0.05mg, pantthemic acid 5.0mg, Folic acid 0.5mg, Biotin 0.08mg, choline chloride 0.2mg, Manganese 0.006g, Zinc 0.03g, Copper 0.006g, Iodine 0.0014g, Selenium 0.24g, cobalt 0.25g and antioxidant 0.125g.

Table 2: Proximate composition of dry *gmelina arborea* leaf meal (GALM) and palm kernel cake (PKC)

Nutrients	(GALM)	(PKC)
Crude protein (%)	18.20	18.50
Ether Extract (%)	2.73	7.85
Crude Fibre (%)	5.65	18.22
Ash (%)	8.00	5.65
Nitrogen Free Extract (%)	65.42	49.78
Energy (Kcal/GE/kg)	3591	5321

Table 3: Effect of diets growth performance of broiler chickens

Parametrs	T1 (0.00 %)	T2 (1.0 %)	T3 (2.0 %)	T4 (3.0 %)	Sem
Initial live weight (g/bird)	736	741	746	745	8.9
Final live weight (g/bird)	2109	2105	2098	2040	54.30
Weight gain (g day)	49.04	48.71	48.29	46.25	10.8
Total Feed intake (g/bird)	4256^{b}	4340^{ab}	4480^{ab}	4620^{a}	202.01
Daily feed intake (g/bird)	152^{b}	155^{ab}	160^{ab}	165^{a}	20.43
Feed: gain ratio	3.10^{b}	3.18^{ab}	3.31^{ab}	3.57^{a}	0.40

abc means along the same row with different superscripts are significantly different ($P<0.05$
SEM = Standard Error Mean

Table 4: Effects of diets on carcass yield of broiler chickens

Parametrs	T1 (0.00 %)	T2 (1.0 %)	T3 (2.0 %)	T4 (3.0 %)	Sem
Live weight (g)	2017	2083	1980	1975	75.32
Dressed weight (%)	65.29	64.81	64.49	64.56	36.7
Breast weight (%)	32.67	31.87	32.08	32.55	8.43
Thigh weight (%)	20.65	20.88	21.23	19.95	6.67
Drumstick (%)	16.21	15.98	16.04	16.01	5.03
Backcut (%)	25.45	24,95	26.06	25.87	7.23
Wing (%)	13.66	14.01	13.22	13.24	4.25
Fat (%)	0.85	0.87	0.79	0.75	0.18

Table 5: Effect of diets on internal organs of broiler chickens

Parametrs	T1 (0.00 %)	T2 (1.0 %)	T3 (2.0 %)	T4 (3.0 %)	Sem
Gizzard	1.94	1.97	1.96	2.03	.0.51
Heart	0.71	0.79	0.81	0.82	0.20
Liver	2.55	2.61	2.45	2.56	0.62
Kidney	0.72	0.81	0.78	0.80	0.26
Pancreas	0.45	0.39	0.40	0.41	0.08
Spleen	0.08	0.09	0.08	0.09	0.07
Intestine	6.77	5.98	6.45	6.67	1.44

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Spawning of stripped eggs with milts collected using syringe from live African Catfish (*Clarias anguillaris*)

Kingsley Omogiade IDAHOR

ABSTRACT

In quest for alternatives to end the killing or operating on the male African Catfish (*C. anguillaris*) in captive breeding, syringe was used in milts collection from 180 live African Catfish at $\Delta 45^{o}$ caudally, $\Delta 45^{o}$ cranially and $\Delta 90^{o}$ vertically. Milts collected were used in fertilizing eggs stripped from 30 female African Catfish following hormone administration. Pectoral fin length taken as the starting point in this study were 5.25 cm, 5.38 cm and 5.61 cm in left and 5.26 cm, 5.39 cm and 5.59 cm in right recorded for 0.6 – 0.7 kg, 0.8 – 0.9 kg and ≥1.0 kg treatment groups respectively. The results showed that only 8 (representing 2.2 %) were successfully fertilized that is, 3 (representing 0.8 %) in the right testis and 5 (representing 1.4 %) in the left testis. This observation probably demonstrated the possibility of milts collection with syringe without killing the male fish and using the milts collected in captive fish reproduction. Unfortunately, it was somewhat observed that the fish position during milt collection, angle of syringe insertion, chances of spermatozoa alteration, tiny needle with small hollow centre and slanted end, may have drastically reduced the effectiveness and prospects of this technique. This was evidently reflected in the little or no milts harvested using syringe recorded in the experiment.

Key words: African Catfish, morphology, testes, spawning strategy.

INTRODUCTION

Fishes live in most natural aquatic habitats on earth except very salty water like the Dead Sea and the Great Salt Lake of Utah. Fishes are distributed across the sunny surface of the ocean down to the darkest depths where light never penetrates. Some can live in the hot desert pools at temperature of more than 38^{o}C where other animals may not thrive (Compton's Encyclopedia, 1998). In the tropics, some fishes are able to flop and crawl across mud flats and wet fields in search of food. While some species burrow into the mud when the water pools dry up, others could be dormant until favourable conditions are restored for active live (Bruton, 1996). According to Ferraris et al. (2007), more than 20,000 each of living and fossil kinds of fishes are known and new species are being discovered every year. This is more than all the other kinds of backboned animals combined. The sizes of these fishes differ as much as their shapes and there are over 2,000 species of Catfishes. Thus, they are one of the largest fish orders of the *Siluriformes* belonging to 34 families. These include the Old-world Catfish, Thorny Catfish, electric Catfish, naked Catfish and African Catfish – *Clarias gariepinus* (Sullivan, 2006).

African Catfish belongs to the family – *Claridae* characterized by poor swimming capability, hardiness and ability to withstand poor water quality and unfavourable climatic conditions that other species may not withstand (Okunsebor and Idahor, 2009). These attributes have perhaps made it possible for them to thrive well in captivity except for their inability to reproduce yet artificial reproduction techniques (i.e. captive spawning and brooding) have slowly improved. The reproductive organs of fish are the testes in males and ovaries in females. While the testes produce spermatozoa contained in fluid called milts, the ovaries produce eggs also referred to as "roe" or "spawn". Notably, all fish

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hatch from eggs and usually the females and males release their eggs and milts respectively into the water where they are fertilized and hatched resulting in fry or larvae (Mazzoldi et al., 2007). Meanwhile, there are some species that are livebearers, where the eggs are formed and hatched within the female (ovoviviparous) before birth. Some other species do not lay eggs but the young ones obtain nourishment through an umbilical-like cord or secretions (viviparous) before birth (Brito and Bazzoli, 2003).

Although some fish species reproduce freely in community tanks, most species require spawning triggers. In the difficult-to-spawn species like African Catfish (*C. anguillaris*), the natural conditions are simulated and hormones (such as Phenyl, Human Chorionic Gonadotropin and Puberogen) are often administered with skillfulness before stripping. Unfortunately for the males, they are often killed or at best operated on to strip the milts with attendant low recovery rate and death. This unkind act will definitely result in colossal economic wastages, loss of valuable time to rear another brood stock and genetic unpredictability yet, there is little or no proven artificial reproduction techniques so far to end this cruelty practice. Hence, this novel scientific advancement using syringe to collect milts for spawning stripped eggs in order to stop killing the male fish was propounded.

MATERIALS AND METHODS

Climatic description of the experimental location

The experiment was performed in the month of November at the Hatchery Unit, Department of Fisheries, Nasarawa State University Keffi, Shabu-Lafia Campus. Situated on latitude 8^{o} 35′ N and longitude 8^{o} 32′ E, altitude 181.53 m above sea level with temperature range of 32 – 34^{o}C, relative humidity varying between 40 and 60 % and mean day light of 11 hrs (NIMET, 2013).

Experimental design, data collection and analysis

Although a total of 210 African Catfish comprising 180 males and 30 females were used in this study, only the males of about 11mths old were randomly distributed into three treatment groups:- 0.6 – 0.7 kg, 0.8 – 0.9 kg and ≥ 1.0 kg respectively with 60 replicates per treatment for morphological parameters measurements. The males were further redistributed randomly into three sub-treatment groups according to the syringe insertion points with 20 replicates each per $\Delta 45^{o}$ caudally, $\Delta 90^{o}$ vertically and $\Delta 45^{o}$ cranially. The females were only sources of the needed eggs for the investigation thus each female was stripped using hormone (Ovaparim® Syndel Laboratories Ltd, Canada) according to the manufacturer's prescription. The eggs stripped from one female were divided into thirty-six separate spawning bowls such that it will match up with the milts collected from six males (i.e. one female provided the eggs for milts processed from 6males). Syringe was inserted into the right and left testes at $\Delta 45^{o}$ caudally, $\Delta 90^{o}$ vertically and $\Delta 45^{o}$ cranially taken the end of pectoral fins on the abdominal region as the starting point as reported by Idahor (2013). After every attempt to collect milts, the fish was immediately returned to water bath containing clean water. The inserted syringe was emptied into a beaker containing physiological saline to obtain diluted milts as described by de Graaf (1989). Although the stripped eggs and the milts volumes were not measured in this study, the milts so-collected were mixed with the divided stripped eggs in each of the spawning bowls, using aspirator and aerator at room temperature and were incubated according to de Graaf et al. (1995). See plates I – V.

Prior to allotment of the male fish to the three treatments, they were weighed using table scale (Five Goats Brand®). The distance between the mouth and the caudal fin base and end of the caudal fin were estimated as standard body length and total body length respectively using measuring tape (Butterfly Brand®). The right and left pectoral fins length as well as the papilla length were determined using measuring tape (Butterfly Brand®) as described by Idahor (2013). The values gathered were subjected to analysis of variance according to SPSS (2007) software package. Meanwhile, the data on spawn fertilization were subjected to simple descriptive statistics according to Adesoye (2004).

RESULTS

The morphological characteristics of male African Catfish are given in Tab. 1. There were no statistical differences ($P>0.05$) among the treatment groups. Meanwhile, the live weight values ranged between 0.72 – 1.04 kg, standard body length (44.31 – 46.46 cm), total body length (50.2 – 52.51 cm) whereas, the papilla length values ranged from 1.29 cm in 0.6 – 0.7 kg fish to 1.38 cm in ≥1.0 kg fish. Similarly, the left pectoral fin length was least (5.25 cm) in 0.6

– 0.7 kg fish and highest (5.61 cm) in ≥1.0 kg fish and the right pectoral fin length ranged from 5.26 – 5.59 cm.

Shown in Tab. 2 is the fertilization of eggs with milts collected with syringe from African Catfish. It was observed that out of the 180 males in which syringe was inserted six times (i.e. $\Delta 45^o$ caudally, $\Delta 90^o$ vertically and $\Delta 45^o$ cranially in both right and left testes) only 8 representing 2.2 % were successfully fertilized (See Plate V). Three (representing 0.8 %) of the fertilized eggs were recorded in the right testis at $\Delta 90^o$ vertically collected milts from 0.6 – 0.7 kg and 0.8 – 0.9 kg fish respectively. Five (representing 1.4 %) were recorded in the left testis also at $\Delta 90^o$ vertically collected milts but in 0.8 – 0.9 kg and ≥ 1.0 kg respectively.

DISCUSSION

It was observed that all the values of parameters measured, were within the values reported for healthy fish at similar age range (Okunsebor and Idahor, 2009; Viveen *et al*., 1996). More interestingly, it was observed that all the morphological characteristics measured, were increasing with increase in live weight indicating that the fish were probably still growing as reported by Okunsebor and Idahor (2009) and Gilbert (1994). The results perhaps reflected that there were no morphological differences in the male African Catfish (*Clarias anguillaris*) at 10 – 11 months of age and weighing between 0.6 and 1.0 kg live weight.

Also, it was observed that some of the incubated eggs were fertilized with the milts collected with syringe. The hatchlings recorded in this trial probably demonstrated the possibility of spawning stripped eggs with milts collected using syringe as proposed by Idahor (2013) from any of the testes without killing the fish. However, the low fertility rate recorded could be solely attributed to the short, slanted end and small hollow centre needle used in the study and partially due to possible distortion of the spermatozoa morphology during the study. Also, it could be probably due to the water quality and Hatchery Units environmental conditions that de Graaf et al. (1995) reported could affect incubation and hatching of spawned eggs.

In this novel scientific procedure to stop killing the male fish before milts harvesting, end of the pectoral fin length in the abdominal region, testicular depth and angle of syringe insertion were keenly considered. It was however observed that the fish restrictive position during milt collection, angle of syringe insertion, chances of spermatozoa alteration, tiny needle with small hollow centre and slanted end may have drastically reduced the effectiveness and prospects of this artificial reproduction technique in African Catfish. This was evidently reflected in the little or no milts harvested with the syringe during the experiment. Consequently, for better outcome in subsequent studies, fish restrictive position, syringe insertion points, longer needle with wider hollow centre and round end should be considered. This will immensely enhance the adoption or otherwise of this artificial reproduction technique in captive African Catfish.

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Table 1: Morphological characteristics of male African Catfish (*Clarias anguillaris*)

Measurements	Live weight					
	0.6–0.7 kg	**0.8–0.9 kg**	**≥1.0 kg**	**Mean**	**SEM**	**Prob.**
No. of fish	60	60	60	-	-	-
Age (months)	10.90	11.00	11.25	11.05	0.191	0.416
Live weight(kg)	0.72	0.91	1.04	0.96	0.072	0.213
Standard body length (cm)	44.31	45.97	46.46	45.58	1.446	0.547
Total body length (cm)	50.20	51.77	52.51	51.49	1.455	0.522
Left pectoral fin length (cm)	5.25	5.38	5.61	5.42	0.150	0.242
Right pectoral fin length (cm)	5.26	5.39	5.59	5.41	0.152	0.332
Papilla length (cm)	1.29	1.35	1.38	1.34	0.043	0.296

Values on the same row without superscripts did not differ statistically at 5% probability test; ^{SEM}: Standard error of means; $^{Prob.}$: Probability.

Table 2: Spawning of eggs with milts collected with syringe from the male African Catfish (*Clarias anguillaris*)

Treatment	Right testis (††)				Left testis (††)			
	Fertilized		Unfertilized		Fertilized		Unfertilized	
	Freq	%	Freq	%	Freq	%	Freq	%
0.6 – 0.7 kg								
Δ45° caudally	0	0.0	20	5.6	0	0.0	20	5.5
Δ90° vertically	1	0.3	19	5.3	0	0.0	20	5.6
Δ45° cranially	0	0.0	20	5.5	0	0.0	20	5.5
0.8 – 0.9 kg								
Δ45° Caudally	0	0.0	20	5.5	0	0.0	20	5.6
Δ90° vertically	2	0.6	18	5.0	4	1.1	16	4.4
Δ45° cranially	0	0.0	20	5.6	0	0.0	20	5.5
≥1.0 kg								
Δ45° caudally	0	0.0	20	5.6	0	0.0	20	5.6
Δ90° vertically	0	0.0	20	5.5	1	0.0	19	5.5
Δ45° cranially	0	0.0	20	5.5	0	0.3	20	5.5
Total	3	0.9	177	49.0	5	1.4	175	48.7

Freq: Frequency; (††): Volumes of the stripped eggs and the milts were not determined.

Step 1

Plate I: Spawned eggs

Step 2

Plate II: Milts collection

Step 3

Plate III: Incubation

Step 4

Plate IV: Hatching

Step 5

Plate V: Fertilized eggs

GUIDE FOR AUTHORS

The Journal of South Pacific Agriculture (JOSPA) welcomes papers that can contribute to the development of agriculture and allied industries in the Pacific Islands.

TYPES OF CONTRIBUTIONS
The following types of contributions will be considered, on priority basis, for publication in JOSPA:

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ii. Review papers on topics of relevance to agriculture in the tropics.
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This section is mainly for reviews of new books relevant to the areas covered by JOSPA. Reviews can also cover other areas, such as relevant CD-ROMS, computer packages and, where appropriate, conference/workshops. The format for reviews should follow those in past issues of JOSPA.

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Electronic format:
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The arrangement of the various components of the manuscript should follow this order:

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- Key Words (3 – 6 items)
- Introduction
- Materials and Methods
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- Conclusion
- Acknowledgements
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***International System of Units (SI)*:**

- Use SI units (i.e. modern metric system).
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- Should be numbered according to sequence of appearance in the paper, have a clear descriptive caption directly above the table, do not embed in text, place one table per page.
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- Use brief but informative column headings. Standard abbreviations of units of measurements should be included in parentheses.
- Do not use bold type for titles or other contents.
- Line spacing: single.
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- Use horizontal borders to demarcate heading rows and to underline the last row of data entry.
- Use tabs to align contents into columns, leave sufficient space between columns.
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Graphs:

- Should have a clear descriptive caption placed directly below the graph.
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With the exception of common domestic animals and crops, the preferred scientific name of organisms (according to the International Codes of Nomenclature) should be given in full at the first mention of the English common name. Thereafter, the common name may be used, provided there is no ambiguity. Common names should be avoided in titles and abstracts (but English common names of crops may be used, provided there is no ambiguity).

Names of pesticides
The internationally recognised common names (names of active ingredients) of pesticides and other chemicals should be used. Commercial (trade, brand) names may be used in inverted commas (but the internationally accepted common name should still be provided at first mention). Example:

> Glyphosate is the common name (or active ingredient) in Roundup, and Roundup is the commercial (or trade) name of a herbicide.

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  **Chemical names may also be used where appropriate.

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  LINDSAY, W. L. 1972. Zinc in soils and plant nutrition. *Advances in Soil Management*, **24**:147-186.
- When present, the issue/part number should be written in parenthesis after the journal volume. Example:
  LINDSAY, W. L. 1972. Zinc in soils and plant nutrition. *Advances in Soil Management*, **24** (2):147-186.
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  MAJOR, R. & GREEN, V. S. 1980. *Growing Rice in the Savannas*. 2nd edition. Marquee Publishers, Brenton, 250 pp.
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- References to online publications (articles, ejournals, ebooks):
  BROWN, K.C. 2008. Growing button mushroom. *Urban Agriculture Newsletter*, [Online]. 42 (6). Available at: http://www.veg.ug/articles [Accessed 20 Jan. 2010].

  MVUNGI, J. B. & MATHI, C. J. 2000. A new incubation technique for small-scale poultry farms. *Poultry Digest*, [Online] 2 Feb., 13 (2):1-6. Available at: http://get.fraf.cw.twn/ejournals/ [Accessed 12 Feb. 2009].

  PASCAL, W. 2002. *The third degree.* [e-book] Herman: Zorrow Press.
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