EFFECTS OF SHIRORO DAM IRRIGATION FARMING ON LIVELIHOOD SHOCKS AMONG RURAL HOUSEHOLDS IN NIGER STATE, NIGERIA

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ABSTRACT
Dry season farming in Shiroro Dam (SD) project serves as a resilience to avert climate change, environmental, socio-economic and production shocks among rural households in Nigeria. The project is expected to have some impact on the livelihood of surrounding communities. The study assessed the effects of SD dry season farming on livelihood shocks among rural households in Niger state, Nigeria. Primary data were collected with the aid of structured questionnaire. A multistage sampling procedure was used to select 165 farming households from 291 Shiroro Dam project participants. Descriptive statistics, net farm income, regression models and shock index were used to analyze the data. Results indicated that majority of SD farming household heads were male (90.9%), married (93.3%) with mean age ($\bar{\bar{X}}$) and farming experience of 49 and 19 years respectively. The mean net farm income in dry season farming amounted to ₦88,907.05 which account for 45.5% of total income realized from all livelihood activities throughout the year. The result of the coefficients of irrigation income (0.634), rain-fed income (0.006), fishery income (0.129) and agricultural wage labor (-0.050) were statistically significant factors influencing earning accrued to farming households. Result also revealed that socio-economic and institutional variables were major determinants in the decision and intensity to cope with production shocks. Thus, the study recommended farmers should strengthen their cooperative associations and collaborate with extension agents to harness production and marketing information, and other critical resources that will assist them in preventing and coping with production shocks, climate change and other environmental challenges.
Keywords: Livelihood activities, production shocks, rural households, Shiroro dam project, Nigeria

INTRODUCTION

Nigeria's food supply and demand is made up of local production dominated by smallholder farmers and partly imports from other countries. However, as a developing country with high dependence on importation of staple food such as rice, fish and finished agricultural products, efforts to break this trend and improve self-sufficiency in food production and reduce demand-supply gaps have always been met with a number of problems (Oladimeji, Abdulsalam, Damisa, Ajao and Sidi, 2013). One of such predicaments is agricultural shocks comprising production and marketing shocks. Choularton, Frankenberger, Kurtz and Nelson (2015) define shocks as external short-term deviations from long term trends that have substantial negative effects on farmer's current state of well-being, level of assets, livelihoods, safety or their ability to withstand future shocks. It is also resultant negative outcome caused by climate change, extreme adverse natural events such as droughts, storms, flood, and erosion and market-related events including fuel, food, input and output price fluctuations, volatilities and price hikes (Food and Agricultural Organization FAO, 2016). In addition, rural farming households are exposed to varying and unpredictable elements of nature, such as uncertainty in biological processes related to weather, diseases, pests, and infertility (Oladimeji, Galadima, Hassan, Sanni, Abdulrahman and Egwuma, 2019) which may also cause shocks. Hence, the complex nature of weather and climate as well as physical and environmental factors exposed farmers to shocks.

Shocks in agriculture are not only of natural disaster or weather related such as rainfall or temperature variability, but also related to changes in market demand and supply (Ngenoh, Kebede, Bett and Bokelmann, 2018) as well as human induced such as land dispute, theft and herdsmen farm invasion. Most of these shocks may have negative effects on their production systems, food markets and local economies, all of which have direct effects on crop yields, livestock performance, food and livelihood security and this may aggravate poverty. In addition, shocks received from adverse effect of agricultural production impact on household income and welfare and in extreme, may cause illness and eventual death of affected farmers.

Ngenoh *et al.* (2018) examined the determinants of agricultural production and marketing shocks among indigenous vegetable smallholder farmers in Kenya. Using two-part model computational approach, the results showed that institutions and access- related variables were the main significant factors informing smallholder farmers' decision to cope with shocks. Seyi, Olapade-Ogunwole and Raufu (2011) used Probit analysis to determine the relationship between socio-economic characteristics and shocks of rural households in Oyo state, Nigeria. The results revealed that a large share of households experience multidimensional shocks, which are determined by ecological, socio-economic and demographic factors. While the impacts of shocks on poverty and coping strategies have been widely studied in developing countries (Heltberg and Lund, 2009; Mabuza, Ortmann, Wale and Mutenje, 2016; Ngenoh *et al.,* 2018), the decision and extent of factors influencing shocks in agricultural production and irrigation nexus are rare in literature and has not been thoroughly analysed. Hence, the broad objective of this study was to assess the effects of Shiroro dam irrigation farming on livelihood shocks among rural households in Niger state, Nigeria. The specific objectives include to: (i) describe the socio-economic and institutional status of farmers; (ii) identify and describe types and magnitude of livelihood shocks and value of crop loss; (iii) estimate the share of Shiroro dam crop irrigation in farmers' livelihood diversification; (iv) analyse costs and returns of livelihood diversification to irrigation farming and compare to rain-fed farming; (v) estimate factors influencing income accrued to SDF; (vi) estimate the factors that influence decision and intensity of coping with livelihood shocks and (vii) describe strategies adopted to mitigate livelihood shocks.

METHODOLOGY

This study was conducted in Niger state, north central Nigeria. Specifically, the populations of Shiroro and Muya LGAs which are the main beneficiaries of Shiroro irrigation farming activities are projected in 2021 to be 333,251 and 146,304 persons respectively using recommended 3.2% growth rate on the population of the two LGAs in 2006 census (NPC, 2006). The climate, edaphic features and hydrology of the state permit the cultivation of most of Nigeria's staple crops and allow sufficient opportunities for livestock rearing, artisanal fisheries and aquaculture production.

Primary data were collected in 2019 farming season, with the aid of a structured questionnaire and trained field enumerators for the study. A multistage sampling procedure involved purposeful selection of two LGAs: Shiroro and Muya out of the 25 LGAs in Niger state because of location of Shiroro dam. With the assistance of extension agents of Niger state Agricultural Development Program (NSADP) during reconnaissance survey, 21 villages adjacent to the Shiroro dam were listed and 13 villages were purposefully selected due to intensity of households' involvement in Shiroro dam farming. The villages selected were Chiri, Zumba, Kwata, Shiroro, Shakwana, Kam, Galadimakogo, Guni, Tungalemu, Tungaalhaji, Gwada, Bakko and Dangunu. The list of farming households in each village was compiled and 165 Shiroro dam farmers were randomly selected from 291.

Descriptive statistics, net farm income (NFI), multiple and two-step regression models were used to analyze the data. NFI analysis was used to measure the benefit accrued to Shiroro Dam Farmers from irrigation farming. The model is mathematically expressed following Abdulazeez, Abdulrahman and Oladimeji (2019) as follows:

$$\mathrm{TR} = Q * Py \quad (1)$$

$$TC_{ij} = TVC_{ij} + TFC_{ij} \quad (2)$$

$$\pi = TR - TC \quad (3)$$

Where: TR = total revenue (Naira/ha); TC = total costs (Naira/ha); TFC = total fixed cost (Naira/ha); TVC = total variable cost (Naira/ha), π = net return; P_i = average price of output i (₦/kg) and Q_i = quantity of output i (kg/ha).

Multiple regression models were used to determine factors influencing profit of SDF. The Cobb-Douglas function is explicitly specified as follows:

$$\ln Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + u_i \quad (4)$$

Where: Y is the SDF profit per ha. X_1= irrigation income (₦); X_2= remittance and gifts (₦); X_3 = livestock worth (₦); X_4= non-farm income (₦); X_5= fishery income (₦); X_6= rain-fed income (₦); X_7= agricultural wage labor; βo = constant; $\beta_1 - \beta_7$ = parameter to be estimated.

The determinants of decision and intensity to cope with livelihood shocks were accomplished using two-step regression models as originally proposed by Cragg (1971) adopted in agricultural project participation and technology adoption studies such as Matthews., Newman and Henchion (2003), Idowu, Ojiako and Ambali (2013) among others. According to Greene (2012), two-step regression otherwise known as double hurdle model can be used to determine the decision of whether to engage in irrigation to minimize livelihood shocks that may emanate from crop rain-fed farming and other farming activities. Therefore, the first step was accomplished by MLE Logit regression model. The dependent variable was binary choice. Yes or participate in farming in Shiroro dam =1 and 0 otherwise. In this case the total sample size was 165 randomly selected farmers.

On the other hand, Tobit regression model determines the extent of coping with livelihood shocks by participation in Shiroro dam. The dependent variable was measured as livelihood shocks index calculated by dividing the amount realized from irrigation farming by the total livelihood income from all sources (McPeak, 2004; Beegle, Dehejia and Gatti, 2006; Heltberg and Lund, 2009; Choularton *et al.*, 2015). The sample size was 128, that is, the number of Shiroro dam farmers that engaged in irrigation in Shiroro dam.

Logistic regression model which expressed the decision to livelihood diversification (Pi) is given as:

$$Z_1 = \beta_0 + \beta_1 X_1 + \cdots + \beta_{12} X_{12} + u \quad (5)$$

Y_i = 0 or 1. It is a binary answer, that is, experiencing livelihood shocks =1 and zero otherwise). β_0 = constant term, $\beta_i - \beta_{12}$ = coefficients, u_i = error term with zero mean ($\bar{X}$) and constant variance. The independent variables fitted in the model were operationalized in subsequent results.

Tobit regression which determines extent of coping with livelihood shocks is expressed as:

$$Y_i = \beta_0 + \beta_1 X_1 + \ldots + \beta_{12} X_{12} + u \quad (6)$$

Where: Y_i is livelihood shocks index measured by dividing irrigation income by the total livelihood income from all sources. It should be noted farmers that experience livelihood shocks in the last three years were sampled. The independent variables fitted in the model were operationalized in subsequent results.

RESULTS AND DISCUSSION

Socioeconomic and institutional status of Shiroro Dam Farmers (SDF)

Socioeconomic and institutional status of SDF is presented in Table 1. The mean age ($\bar{X}$) and farm experience of the farmers were estimated to be 49 and 19 years respectively. Farmers within this age range are believed to be in their active ages, implying that the farmers are capable of high productivity and are likely to utilize new technologies. In addition, many years of experience implies that farmers will be able to make sound decisions that are technically feasible as regards to resources allocation and management of their economically worthwhile farm operations. The mean household size was estimated as 8 persons per farmer, an indication that there is a likelihood of reduced cost of labor, as adequate family labor will be available for farming operations *ceteris paribus*. The coefficient of variation of distance to market (68.0%), non-farm income (92.4%), credit utilised (152.1%) and extension contacts (88.4%) were high indicating there is high variability and deviation in these parameters.

Table 1: Summary statistics of variables used in shocks determinants regression model

Variables	Min.	Max.	$\bar{\bar{X}}$	δ	CV (%)
Age	21	79	49	7.5	15.3
Farming experience	6	63	19	1.7	8.9
Level of education	0	15	8.5	3.9	45.9
Household size	3	32	7.8	2.5	32.1
Farm size	0.4	11	0.5	0.5	94.2
Cooperative membership	0	15	6.7	2.2	32.8
Distance to markets	0.3	17	2.5	1.7	68.0
Total farm income ('000)	22.9	765.2	183.6	52.9	28.8
Non-farm income ('000)	5.9	118.6	11.8	10.9	92.4
Credit accessed ('000)	0	250.0	36.8	56.0	152.1
Extension contact per season	0	5	1.0	0.8	88.4
	F	**%**			
Sex: Male	150	90.9			
Marital status: married	154	93.3			
Irrigation: traditional	94	57.0			
total observation	165				

Source: Computed from field survey data, 2019. Note δ denote standard deviation and $\bar{\bar{X}}$ denote mean

Types and magnitude of livelihood shocks and value of crop loss among SDF

Figure 1 depicts types and magnitude of livelihood shocks and level of assets impaired among SDF. Results show that flooding is most prevalent shock experienced by majority of farmers (94.5%) with average value of crop loss of 64.5%. This was followed by drought with proportion of farmers affected being 77.6% and 57.2% crop loss. These two agricultural shocks, flooding and drought imposed more damages because the duos are natural disasters compared to erosion (49.2%) which is predictable and preventable. Others livelihood shocks include fuel hikes (42.8%), pilfering (31.9%), herdsmen farm invasion (23.3%), price fluctuation (17.4%), and diseases and pests (12.8%). Although crop shocks are transitory and are a plausibly exogenous source of variation at the household level (Beegle, Dehejia and Gatti, 2006), if persistent and recurrent in the same families over time, might pick up unobserved household characteristics rather than identifying an exogenous source of variation.

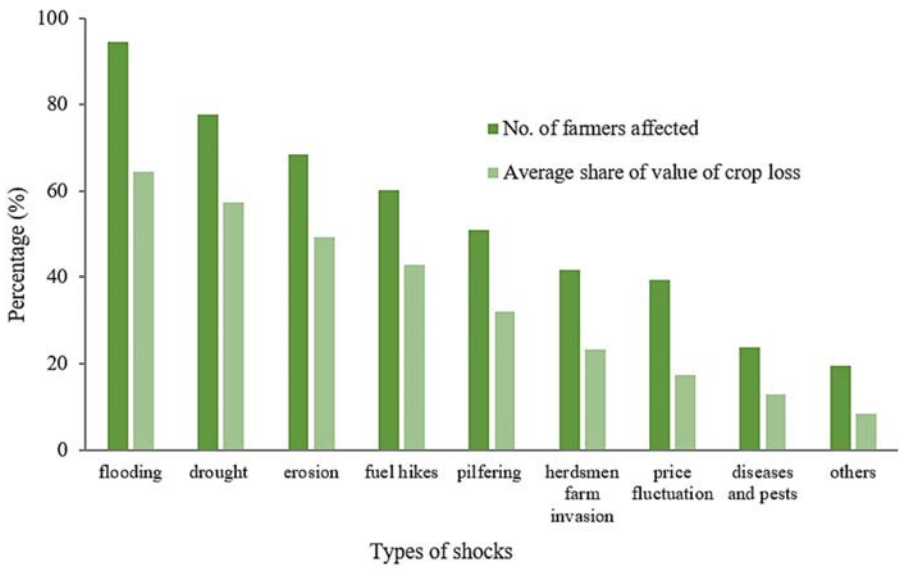

Figure 1: Distribution of types and magnitude of livelihood shocks
** Multiple Responses allowed

Share of Shiroro dam crop irrigation in farmers' livelihood diversification

The shares of incomes from different livelihood activities are summarized by sectors in Figure 2. Although all activities were important sources of livelihood income for the SDF sampled, farming activities were the most important source of livelihood sum up to 72.1%, comprising of the share of income from Shiroro dam irrigation and rain-fed farming amount to 57.4% and 45.5% of farm income and total income respectively. Off-farm incomes play a lesser role as a source of livelihood with a proportion of 14.7% from the pooled activities. The result demonstrated that income from Shiroro dam can significantly make impact on the livelihood of the farmers in the study area when livelihood shocks such as erosion and flooding occurs. This is comparable to the study of Eneyew, Alemu, Ayana and Dananto (2014) that irrigation use has a positive impact on households' livelihood from crop in rural area of Ethiopia.

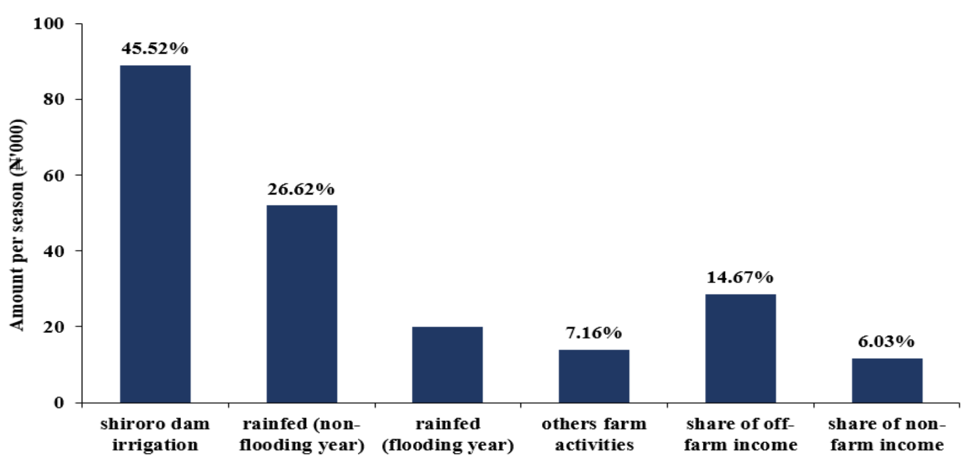

Figure 2: Summary of livelihood activities and income earnings by SDF per season

Costs and returns of livelihood diversification to Shiroro dam farming versus rain-fed farming system

The results of estimate of the cost incurred and benefit accruing from Shiroro dam farming activities and rain-fed during flood and non-flood farming season are compared and presented in Table 2. The net margin per ha in irrigation farming amount to ₦88,907.0 compared to rain-fed farming without flooding (₦52,002.1) and rain-fed with flooding (₦19,876.9). This shows that dry season irrigation plays a significant role in alleviating livelihood shocks emanating from flooding during the raining season. In addition, irrigation acts as succor and livelihood strategies to farming household during the off-farm season. This agrees with findings of Oladimeji and Abdulsalam (2014) on dry season irrigated farming in Asa river of Kwara state, Nigeria.

Table 2: Estimate benefits of using Shiroro dam and rain-fed for farming practices

Variables (₦)	Shiroro dam ₦ha^{-1}	Rain-fed (non-flooding year) ₦ha^{-1}	Rain-fed (flooding year) ₦ha^{-1}
output (tons)	1,894.5	1,363.9	513.1
total revenue	232,996.4	186,225.5	169,309.0
total variable cost , TVC	83,754.0	110,001.0	121,000.0
total fixed cost (TFC)	60,335.4	24,222.5	28,432.1
total costs, TC	144,089.4	134,223.5	149,432.1
gross margin	149,242.4	76,224.5	48,309.0
net margin/ha	88,907.0	52,002.0	19,876.9
return on investment (ROI)	1.6	1.4	1.1
gross ratio	0.6	0.7	0.9

Note TVI denote Total value of irrigated facilities; crop output was converted into maize output using grain equivalent weight (GEW)

Regression analysis of factors influencing income accrued to Shiroro dam farmers

Results in Table 3 indicated that the postulated explanatory variables explained about 72.1% in the variations of factors influencing income accrued to SDF in the study area. The F-test also revealed that the model was statistically significant at 1% hence the model has a good fit. The coefficients of irrigation income (0.634), livestock worth (-0.231), fishery income (0.129), rain-fed income (0.006) and agricultural wage labor (-0.050) were statistically significant variables influencing income accruing to SDF. The significant and positive coefficients on irrigation, fishery and rain-fed incomes carried *a priori* signs which support the hypothesis that these variables play a significant role in amount accrued to farmers in livelihood diversification strategies.

Table 3: Regression analysis of factors influencing income accrued to SDF

Variable	β	SE	P > //Z//
Constant	0.338***	0.093	0.0012
irrigation income	0.634***	0.192	0.0026
remittance and gifts	0.04e-5	0.039e-5	0.6731
livestock worth	-0.231**	0.104	0.0372
non-farm income	0.001	0.0012	0.8218
fishery income	0.129**	0.053	0.0205
rain fed income	0.006***	0.002	0.0029
agricultural wage labor	-0.050*	0.027	0.0832
no of observation=165	R^{-2}=0.721	F-value=18.1	

Note: **β** denote coefficient; SE = standard error; * * *; * * and * denote significance at l, 5 & 10 % respectively.

A unit increase in any of the variable whose coefficient is positive implies an increase in income by corresponding units. It implies that amount earned from any of these positive and significant variables also play a momentous role in preventing and ameliorating livelihood shocks. However, the negative coefficients of livestock (-0.231) and agricultural wage labor (-0.050) implies that these variables play a lesser role in livelihood diversification of Shiroro dam farmers and will lead to a decrease in livelihood income earned by 0.231 and 0.050 units, respectively.

Factors that influence decision and intensity of coping with livelihood shocks

The MLE estimates of factors that determine the decision to cope with shocks are presented in Table 4. The logistic regression results showed that the marginal effects of age (0.045), marital status (-0.239), household size (-0.087), distance to markets (0.078) and credit accessed (-0.284) were the main significant factors influencing Shiroro dam farmers' decision to cope with livelihood shocks. The marginal effects of age and access to markets play a prominent role in decision to cope with agricultural shocks. This implies that households who are young and active are likely to have access to market information on modern farm technologies, high-value market chains farm produce, input acquisition and are more likely to increase their extent of coping strategies to livelihood shocks. This is in line with the study of Ngenoh *et al.* (2018). Furthermore, access to high-value market chain enables farmers to plan their production efficiently and effectively, and even facilitates access to financial credit from formal institutions, boosting their ability to cope with production shocks.

However, statistically significant but negative marginal effects of marital status (-0.239), household size (-0.087), and credit utilized (-0.284) for farm activities implies that farmers are less likely to withstand agricultural shocks considering large household size and inability to access credit for farm production. This finding supports the argument that credit access enables farming households to accumulate assets, and invest in new farming technologies that gives them a solid basis for coping with production shocks as observed by McPeak (2004). This is because access to credit services relaxes liquidity constraints and thus enhances the adoption of appropriate technology that would reduce the impacts of production shocks.

Table 4: MLE Logit regression model of the decision to cope with agricultural shocks

Variable	β	dy/dy	t-value	P > //Z//
Age	0.396***	0.045	3.67	0.000
Marital status	-0.005*	-0.239	-1.69	0.084
Level of education	0.2e-4	0.9e-4	0.67	0.417
Household size	-0.637**	-0.087	-2.14	0.028
Farm size	-0.008	-0.290	-1.14	0.127
Cooperative	0.004	0.135	0.80	0.291
Distance to market	0.186*	0.078	1.92	0.063
Irrigation income	-0.2e-6	-0.41e-3	-1.05	0.145
Information on shocks	0.321	0.270	0.37	0.621
Non-farm income	0.4e-8	0.98e-6	1.11	0.138
Credit accessed	-0.277***	-0.284	-2.80	0.002
Extension contact	0.008	0.118	1.33	0.106
Constant	-0.003***	-0.067	-3.00	0.001
Diagnostic statistic	n = 165	prob > chi^2=0.00		
Log likelihood =-73.06	R^{-2}=0.329	LR Chi^2 (12)=52		

Note: * * *; * * and * denote significance at l, 5 & 10 % probability level respectively. **β** denote coefficient, *dy/dx* is marginal effect

MLE estimates of the intensity / extent / level of coping with agricultural shocks

The Tobit regression results of the parameter estimates of intensity of coping with agricultural shocks are presented in Table 5. The results reveal that the coefficients of household size (0.401) and information on agricultural shocks (0.512) were negative and statistically significant at 1% level of probability. The negative coefficients implied a unit increase in these variables will lead to decrease in the probability of coping with livelihood shocks. On the contrary, age (0.328), irrigation income (0.502), credit accessed (0.2e-6) and extension contact (0.0090) were positive and significant at 1% level of probability except credit accessed at 5% level. These significant variables determine the intensity of coping with production shocks among Shiroro dam households. This implied that the positive and significant variables increased the probability of coping with production shocks. That is a unit increase in any of these positive and significant variables will lead a corresponding increase in intensity / extent / level of coping with agricultural shocks. Ngenoh *et al.* (2018) opined that access to extension services, explicitly field visits, is a powerful tool that can be used to encourage farmers to change and build their resilience and capacity to deal with agricultural shocks. In addition, frequent interactions between farmers and extension agents expose farmers to modern farming technologies and disaster controls, and hence stimulate communication and reflections on their associated benefits. Oladimeji and Abdulsalam (2014) observed that modern irrigation technologies save water and are therefore efficient and effective at combating the negative effects of agricultural shocks when compared to traditional types.

Table 5: MLE Tobit regression estimates of the extent (intensity) of coping with shocks

Variable	β	SE	t-value	P > //Z//
Age	0.328***	0.094	3.49	0.000
Marital status	-0.111	0.862	-0.13	0.421
Level of education	0.01e-6	2.00e-08	0.5	0.106
Household size	-0.401***	0.155	-2.59	0.002
Farm size	0.299	0.189	1.58	0.108
Cooperative	-0.1e-4	0.15e-4	-0.67	0.176
Distance to market	0.267***	0.064	4.17	0.000
Irrigation income	0.502***	0.172	2.92	0.001
Information on shocks	-0.512***	0.201	-2.55	0.002
Non-farm income	-0.3e-8	0.29e-8	-1.03	0.125
Credit accessed	0.2e-6**	0.09e-6	2.22	0.025
Extension contact	0.009***	0.003	3.01	0.000
Constant	0.213**	0.097	2.20	0.021
Log likelihood=112.03	R^{-2}=0.302	n=128	prob > chi^2	=0.000
LR Chi^2 (12)=77.09				

Strategies adopted to mitigate livelihood shocks

Figure 3 depicts strategies adapted in mitigating livelihood shocks by Shiroro dam farmers. The results show that majority of the coping strategies used by Shiroro dam farmers were informal. These include on-farm irrigation (72.1%), reducing food consumption (63.6%), diversifying to non-farm income earning (53.9%) and migration to less fertile land (44.2%). Other less strategies employed by farmers such as savings (11.5%), selling assets (26.7%) and borrowing (31.5%) have short and long-term effects of these coping strategies (depletion of available resources), especially among those households that have low consumption growth, limited savings, and limited access to non-exploitative credit. Only 3% of sampled farmers insured their farm. This implies that Shiroro dam farmers should embark on irrigation to mitigate livelihood shocks due to variance of weather most especially flood and drought rather than reducing consumption or sale their assets.

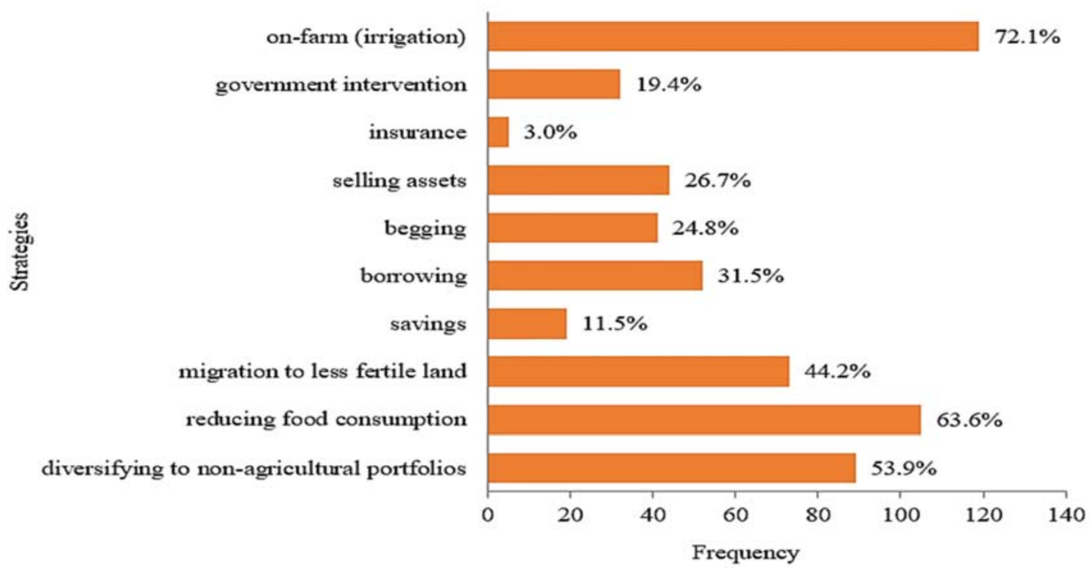

Figure 3: Strategies adopted to mitigate livelihood shocks
Note: *Multiple Responses

CONCLUSION AND RECOMMENDATIONS

Flooding, drought and erosion were the most critical livelihood shocks experienced by Shiroro Dam Farmers in agricultural production activities. The study established that Shiroro dam irrigation as the most important livelihood source in the area. The study revealed factors that influence decision to cope with livelihood shocks were in variance with those that affect intensity of coping with shocks. It is suggested that Shiroro dam farmers should strengthen their cooperative organization to harness credit facilities, insurance scheme, extension services, market information and government intervention to minimize natural disaster. Cooperative will helps Shiroro dam farmers to access critical services and resources needed to implement relevant and appropriate livelihood coping strategies to deal with shocks. Farmers should also prioritize dry season irrigation to minimize shocks associated with flooding, drought and other natural disaster.

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