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ASSESSING DETERMINANTS OF FARMER PARTICIPATION IN THE USE OF HARVESTED RAINWATER IN DAMS FOR COPING WITH CLIMATE CHANGE IN SIAVONGA DISTRICT

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Abstract: **The study assessed the determinants of farmer participation in the use of harvested rainwater in dams for coping with climate change in Siavonga District. Coping strategies to climate change have involved dam construction for water harvesting and use for economic activities. With five dams constructed in the three agricultural camps (Simamba, Gwena, and Chaanga), three identified coping activities included gardening, fishing, and livestock which were shaped differently by demographic factors. However, the factors were not known to have been compared in the area of how they influenced coping activities. Thus, the objectives of the study were to assess how farmer factors affected coping levels of gardening, fishing, and livestock around the dams; compared levels of effect among the economic activities, identified the dominant factors under each activity and across the three activities. The sample size consisted of 333 farmers in the three agricultural camps and a binary regression model was used for analysis. Empirical findings revealed that the effect differed by type of activity.**

Keywords: **Binary Logistic Model, Climate Change, Coping Mechanism, Harvested Rainwater, Participation.**

1. INTRODUCTION

In the rural parts of Zambia, the source of revenue is mainly agriculture. The poverty levels for the rural population are at 77% according to CSO (2018). Better water management as stipulated by Pretty et. al., (2003) as a sustainable agricultural practice can reduce rural poverty and increase food security through agricultural production. However, a change in climate affects the country mostly the rural-based population whose livelihoods completely depend on agriculture. According to GRZ (2018), Siavonga District has been experiencing dry spells leading to low crop production. The dry spells which usually occur at critical stages of crop growth may have a bearing on the potential yields and may lead to crop failures. According to Siavonga rainfall data for 2019/2020; the District experienced three (3) dry spell periods lasting up to 20 days without rainfall and a total of 730.4mm of rainfall (GRZ, 2019). According to Paul and Oluwasina (2011), 600mm-900mm is enough rainfall for maize cultivation. Siavonga received enough rainfall, but the challenge was the distribution of rainfall. This indicated that Siavonga District has the potential for high utilization of harvested rainwater. This can allow farmers to be able to use the dams during the dry spells as the District experiences more dry days than rainy days. The farmers can be able to bridge the dry spell hence the need to know the determinants of farmer participation in the use of harvested rainwater in dams for coping with climate change in Siavonga district. In 2000, the government of Zambia under a project called Rural Investment Fund constructed Kariba Store Dam in Simamba Agricultural Camp and Nsamuke Dam in Chaanga Agricultural camp of Siavonga District under the World Bank. In the same year, Gwembe-Tonga Rehabilitation and Development project constructed Siambale Dam in Simamba Agricultural Camp. In 2003, the community members in Gwena Agricultural Camp with the help from Harvest Help Organization and technical support from Siavonga Ministry of Agriculture constructed Chibote and Nabutezi Dams (GRZ, 2003). The dams were constructed to harvest rainwater and have been used for gardening, fishing, and livestock as a coping mechanism to climate change.

1.1 Statement of the Problem

The farmers in Siavonga District have over the years experienced frequent dry spells, short growing seasons, erratic, and poor distribution of rainfall, and high temperatures which have been the major constraints for agricultural production (GRZ, 2018). To cope with these climatic conditions, the dams were constructed in the three camps to support small-scale farmers to improve their livelihoods (World Bank,1995) through agricultural activities such as gardening, fishing, and livestock. Despite the harvested rainwater in the dams within the three-study-focused agricultural camps; Chaanga, Simamba, and Gwena, the production as compared to the other camps remains the same (GRZ, 2018). The factors that determined a farmer to participate in the economic activity around the dams were not known to have been compared in the areas on how they influenced coping mechanisms by community members. Hence the need for this study, to assess determinants of farmer participation in the use of harvested rainwater in dams for coping with climate change in Siavonga District. Siavonga District has the potential for high participation in the use of harvested rainwater in dams. The need to assess the determinants of farmer participation in the use of harvested rainwater was urgent especially since the effects of climate change have become adverse on water management (Rockström et. al., 2010). The research has set a strong foundation on how climate adaption strategies such as the use of harvested rainwater in dams can be successfully implemented on any project from farm level to national level.

1.2 Aim of the Study

The study aimed to assess the determinants of farmer participation in the use of harvested rainwater in dams for coping strategies to climate change in gardening, fishing, and livestock of Siavonga District.

1.3 Research Objectives

(a) To assess how farmer factors, affect coping levels of gardening, fishing, and livestock around these dams.

(b) To compare effect levels among the economic activities around the dams.

(c) To determine dominating factors in coping with climate change under each activity and across all the activities.

1.4 Research Questions

(a) How do farmer factors, affect coping levels of gardening, fishing, and livestock around these dams?

(b) What were the effect levels among the economic activities around the dams?

(c) What were the dominating factors in coping with climate change under each activity and across all the activities?

1.5 Significance of the Study

The study provided a more detailed understanding of the determinants of farmers' participation in the use of harvested rainwater in dams for coping with climate change. The study has helped establish farmer support and roles in the implementation of harvested rainwater in dams as promoted and supported by the Ministry of Agriculture and other support partners. The overall contribution of the study to the body of knowledge has contributed to the strategies that improve farmer participation and technical improvement into the implementation of harvested rainwater in dams as support to small-scale farmers. The study has also provided further information to be used in policy formulation/ revision and help in the sustainability of rainwater harvesting techniques.

1.6 Study Conceptual framework

The conceptual framework is illustrated in Figure 1.1.

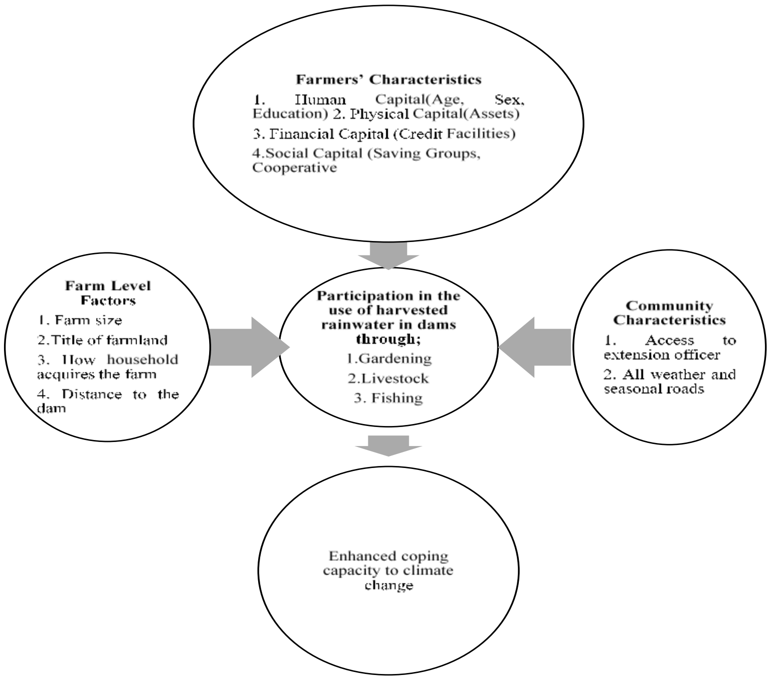

Figure 1.1: Conceptual Framework

The conceptual framework shows the interrelationship among the various farmer characteristic, farm-level characteristics, and community characteristics and how these characteristics lead to the participation of the activities around the dams and influence the coping strategies of climate change. The farmers' character that could influence the farm household's decision on the participation in the use of harvested rainwater in dams included human capital (gender of the head of household and educational level), physical capital (ownership of land, livestock, and machinery ownership), social capital (saving group and cooperative membership), and financial capital (household's saving and credit accessibility).

The farmers' decision to participate in the use of rainwater harvesting techniques was affected by farm-level factors such as (how the farm is acquired, the purpose for which farm is used, farm size, and distance from farm to dams). In addition to this, there were also community characteristics that could influence the farm household's participation in the use of rainwater harvesting techniques (access to the extension officers, the access road from the farm to the dams). The participation of farmers in the use of harvested rainwater in dams could increase the farm household's coping capacity to climate change.

2. LITERATURE REVIEW

2.1 Theories of Coping Mechanism to Climate Change

The population with the least capacity to adapt to changes in climate are the ones with the greatest need to improve agricultural production so that food security is achieved thereby reducing poverty. Irrigation utilization increases agricultural productivity by complementing rainwater through dry spells to increase the seasons for growing, this is a significant coping mechanism (Baethgen et al. 2003; Orindi and Eriksen2005). According to Kandlinkar and Risbey (2000), the following factors reduces the capacity of farmers to cope with climate change; Lack of resources, limited labor, education both formal and informal education (extension services), limited access to market, lack of early warning information and lack of climate and agricultural information. An empirical analysis of the factors of coping mechanism to the change in climate considered the above determinants mentioned. Some determinants were measured as explanatory variables in the model to analyze their effect on the participation of coping mechanisms.

2.2 Analytical Approaches in Farmer Participation of Water Harvesting

Some empirical studies focused on determining the factors that affected participation in rainwater harvesting techniques. Various studies used different empirical methods to analyze the determinants of farmer participation in the use of harvested rainwater in dams for coping with climate change. Examples of models include; Multinomial Probit and Logit Models, Multivariate Probit Model and Binary Logistic Regression model which was used for the study.

2.3 Binary Logistic Regression Model

The binary logistic regression model has a binary outcome of the dependent variable. The model has the probability of a yes or no outcome (Greene, 2012). Some studies have been done to assess in what way the independent variable results in a yes or no probability in the dependent variable. However, this model cannot be used for continuous results. Binary logistic regression is nonlinear; the assumptions on whether there are different groups in the probability for the result or the outcome of a regressor are dependent on the comparison of the groups and the summary of the effects of regressors. Comparing needs careful attention based on an applicable comprehension of the process being modeled and the questions asked (Williams, 2009). The binary logistic regression model can be used in higher-order interactions with many regressors. The model can be extended more by testing for group discrepancies to interpret interactions (Allison, 1999). Additionally, the model also interprets interactions in other regression models. Overall, binary regression can be used in any model where the software can make predictions and estimate marginal effects, for example, Stata and SPost13 packages. Based on the above review, this study established that no study has analyzed the determinants of farmer participation in the use of harvested rainwater in dams for coping with climate change in Siavonga District using the binary logistic regression model. Therefore, this study adopted the binary logistic regression model for the analysis.

3. MATERIALS AND METHODS

3.1 Study Area Location and Description

The research study was conducted in Siavonga District, Southern Province, Zambia in three (3) Agricultural Camps (Simamba, Gwena, and Chaanga); These camps were selected based on the dams that were constructed such as Kariba Store and Siambale Dams found in Simamba Agricultural Camp, Nabutezi and Chabote Dams found in Gwena Agricultural Camp and Nsamuke Dam in Chaanga Agricultural Camp.

3.2 Research Design

The type of research design that was used in this study was a stratified design. This is because three (3) agricultural camps were selected to assess the determinants of farmer participation in the use of harvested rainwater for coping with climate change in Siavonga District.

3.3 Target Population

Siavonga District has an estimated 4903 farmers and 10 Agricultural Camps. However, this research targeted three (3) agricultural camps which have a target of 1997 farmers distributed as follows: Chaanga, 912 farmers, Simamba 676 farmers, and Gwena 409 farmers.

3.4 Sample Size

The sample size consisted of 333 farmers in the 3 (three) agricultural camps of Siavonga District. The sample size was employed using a formula by Yamane (1967) as given below.

$$n = \frac{N}{1 + Ne^2}$$

where N is population, e is margin of error. Given that N is 1997 (farmers in Simamba, Chaanga, and Gwena Agricultural Camp) and e is 5%. Therefore, the Sample size for Chaanga was 152 farmers, Gwena’s target sample was 68 farmers, and Simamba’s sample size was 113 farmers.

3.5 Sampling Procedures

A list of farmers for Siavonga District was exported from Zambia Integrated Agricultural Management Information System (ZIAMIS) database. This allowed selecting farmers that have been active in the past five years for the research. After exporting the farmers’ list in ZIAMIS, convenient sampling was employed to select the respondents for the research in the 3 agricultural camps.

3.6 Data Collection Methods

Primary and secondary data collection was used. Primary data was collected through interviews using a well-structured questionnaire which is in Appendix 1. The secondary data was the ZIAMIS registers that were used for the selection of participants for the research.

3.7 Data Analysis Methods

The data were analyzed using the binary logistic model in Statistical Packages for the Social Sciences IBM (SPSS) version 25.0 (SPSS).

3.7.1 Binary Logistic Regression Model

All the four study objectives were analyzed using Binary Regression Model in SPSS. Three models were analyzed to assess how farmer factors affect coping levels of gardening, fishing, and livestock around these dams, and a fourth model was analyzed identifying dominating factors in coping with climate change in each of the coping activities (Gardening, Livestock, and Fishing). Then a matrix was used to identify dominating factors in coping with climate change across all activities found around the dams. According to Tabachnick and Fidell (2012), this model assumed that the dependent variable should be dichotomous and if the correlation coefficient among the independent variable was less than 0.90 then the assumption was met. Another assumption was that there should be a linear relationship between the odds ratio or EXP(B) and each independent variable. Linearity was demonstrated if the beta coefficients increased or decreased in linear steps.

4. RESEARCH FINDINGS

4.1 Farmer factors affecting coping levels of gardening, livestock, and fishing around the dams

4.1.1 Gardening

The maximum likelihood method using the SPSS 25.0 was used to estimate the coefficients of the binary logistic regression of the determinant of farmer participation in the use of harvested rainwater in dams for coping with climate change. The model fit was tested using the Omnibus tests of model coefficient based on the Chi-Square test. The overall percentage of correct predictions was 82.9%. The *p*-value of 0.00 showed that there is a significant difference between the observed and predicted values of the dependent variables, indicating that the model's estimates fit the data well, at an acceptable level.

Table 4.1: Binary Logit Model Outputs

	Variables in the Equation						
		β	S.E.	Wald	df	Sig.	Exp(β)
1	Male headed household	-1.251	0.418	8.971	1	0.003	0.286
2	Age (Youth)	0.232	0.360	0.416	1	0.519	1.262
3	Education of household head	1.458	0.385	14.300	1	0.000	4.296
4	Education of members of household	-0.264	0.360	0.540	1	0.462	0.768
5	Females use of the dams	2.417	0.373	42.051	1	0.000	11.218
6	Asset (Livestock)	0.761	0.553	1.892	1	0.169	2.140
7	Agricultural Machinery	1.113	0.383	8.427	1	0.004	3.043
8	Membership of a cooperative	0.984	0.361	7.434	1	0.006	2.676
9	Membership of a saving group	-0.267	0.362	0.545	1	0.460	0.765
10	Access to a credit facility	-0.337	0.578	0.340	1	0.560	0.714
11	Farmland ownership	0.317	0.551	0.332	1	0.565	1.373
12	Size of land (>5 acres)	-0.951	0.339	7.857	1	0.005	0.386
13	Distance from farm to dam(>5km)	0.231	0.340	0.459	1	0.498	1.259
14	Accessibility of the road to dam	0.111	0.486	0.052	1	0.819	1.117
15	Contact with extension officers	1.962	0.609	10.367	1	0.001	7.113
	Constant	-5.122	1.132	20.454	1	0.000	0.006
	Number of observations: 333; Omnibus tests of model coefficients : Chi2 =210.084; d.f=15; Sign=0.00; −2log likelihood = 251.405; Nagelkerke R^2 = 0.624; Overall accuracy (correctly predicted): 82.9%						

Note: statistical significance at the 1%, 5%, and 10% probability levels, respectively

4.1.1.1 Gender

The results presented in Table 4.1 showed a statistically-significant positive relationship between male-headed households and the use of harvested rainwater in dams for gardening with a *p*-value of 0.003. The coefficient of the male-headed household was -1.251 implying the decrease in the likelihood of male farmers participating in gardening. The odds ratio was 0.286 indicating that a male-headed household decreased the probability in the participation of gardening by 0.286.

The use of dams by females showed a statistically significant positive effect with a *p*-value of 0.000. A positive coefficient of 2.417 implying an increase in the likelihood of women participating in gardening. The odds ratio was 11.218, indicating that the probability of females using the dams for gardening was increased by 11.218.

4.1.1.2 Age

Age had a statistically significant negative effect on the participation of harvested rainwater in dams for gardening with a *p*-value of 0.519. A coefficient of 0.232 shows that young farmers were less likely to participate in gardening than older farmers. The odds ratio for age was 1.262, implying that a year increase in the age of a farmer increases the probability of participation in gardening by about 1.262.

4.1.1.3 Education

The education status of the head of household had a statistically significant positive effect on the participation of harvested rainwater in dams for gardening with a *p*-value of 0.000. A positive coefficient of 1.458 showed that educated heads of households were more likely to participate in gardening as a coping strategy for climate change. The odds ratio for the education status of the head of the household was 4.296, implying that the educated head of households increased the probability of participation in gardening by 4.296. The education status of members of the household had a statistically significant negative effect on the participation of harvested rainwater with a *p*-value of 0.462 and a negative regression coefficient of -0.264 showing that the education status of the members of households was less likely to participate in gardening. The odds ratio was 0.768 implying that a decrease in the education of members of households affected the participation of gardening by about 0.768.

4.1.1.4 Asset - Livestock

Having assets such as livestock had a statistically significant negative effect on the participation of harvested rainwater in dams for coping with climate change as shown in table 4.1 indicating a *p*-value of 0.169. The odds ratio was 2.140 implying an increase in the probability of farmers who did not have livestock to participate by 2.140.

4.1.1.5 Asset- Agricultural Machinery

The farmers with assets such as machinery (water pumps, ploughs, rippers) had a positive significant influence on the participation of gardening with a *p*-value of 0.004. A positive coefficient of 1.113 as shown in table 4.1 implying that farmers with machinery are more likely to use the gardens. The odds ratio was 3.043, suggesting that farmers who had machinery increased the probability of participating in gardening by 3.043.

4.1.1.6 Membership of a Cooperative

Cooperative membership had a statistically significant positive effect on the participation of gardening with a p-value of 0.006. A positive coefficient of 0.984 indicated farmers who are members of a cooperative were more likely to participate in gardening. The odds ratio for cooperative membership was 2.676, implying that membership increases the probability of participating in gardening at about 2.676.

4.1.1.7 Membership of a Saving Group

Membership of a saving group had no statistically significant effect on the dependent variable gardening with a *p*-value of 0.460. Table 4.1 shows a negative coefficient of -0.267 implying farmers who were members of a saving group were less likely to participate in harvested rainwater for gardening. The odds ratio for saving group membership was 0.765 indicating that the farmers that were members of a saving group reduced the probability of participating in gardening by 0.765.

4.1.1.8 Access to Credit Facilities

Access to credit facilities had no statistically significant effect on the participation of harvested rainwater for gardening showing a *p*-value of 0.560 and a negative coefficient of -0.337 implying that access to credit facilities decreased the likelihood of farmers to participate in gardening. The odds ratio was 0.714 indicating that farmers with access to credit facilities reduced the probability of participation in gardening by 0.714.

4.1.1.9 Farmland Ownership

Having farmland had no statistical difference in the influence of participation in harvested rainwater for gardening showing a *p*-value of 0.565. The odds ratio for having farmland was 1.373 implying that farmers with no farmland increased the probability of farmers participating in gardening by 1.373.

4.1.1.10 Size of Land

The size of land had a statistically significant positive effect on the participation of harvested rainwater showing a *p*-value of 0.005. Size of land had a negative coefficient of -0.951 implying that farmers with a small size of land were less likely to participate in gardening than farmers with a big size of land. The odds ratio was 0.386, indicating that having a small land reduces the participation of farmers in gardening.

4.1.1.11 Distance from Farm to Dam

The distance from the farm to the dam had no significant influence indicating a *p*-value of 0.498. Table 4.1 shows a positive coefficient of 0.231 implying an increase in the likelihood of farmers that had farms closer to the dams to participant in gardening than farms that were far from the dams. The odds ratio was 1.259 indicating that farmers that were closer to the dams increased the probability of participating in gardening by 1.259.

4.1.1.12 Access to all Seasonal Roads

Accessibility of the roads to the dams had no significant influence indicating a *p*-value of 0.819. The odds ratio was 1.117 showing farmers with no access to the roads had an increase in the probability for participation in gardening by 1.117.

4.1.1.13 Access to Extension Services

Contact with extension had a statistically significant positive effect on the participation of harvested rainwater in gardening indicating a *p*-value of 0.001. Table 4.1 shows a positive coefficient of 1.962 implying that farmers who had contact with extension officers were more likely to participate in gardening. The odds ratio for contact with extension services was 7.113, suggesting that farmers who had contact with extension officers increased the probability of participation by about 7.113 times.

4.1.2 Livestock

The model fit was tested using the Omnibus tests of model coefficient based on the Chi-square test. The overall percentage of correct predictions was 87.1%. The *p*-value of 0.000 showed that there is a significant difference between the observed and predicted values of the dependent variables, indicating that the model's estimates fit the data well, at an acceptable level.

Table 4.2: Binary Logit Model Outputs

	Variables in the Equation						
		β	S.E.	Wald	df	Sig.	Exp(β)
1	Male headed household	-0.354	0.422	0.702	1	0.402	0.702
2	Age (Youth)	0.257	0.420	0.376	1	0.540	1.294
3	Education of household head	0.541	0.406	1.771	1	0.183	1.717
4	Education of members of household	0.885	0.482	3.362	1	0.067	2.422
5	Females use of the dams	0.563	0.377	2.235	1	0.135	1.756
6	Asset (Livestock)	3.024	0.568	28.362	1	0.000	20.567
7	Agricultural Machinery	1.913	0.470	16.579	1	0.000	6.770
8	Membership of a cooperative	0.561	0.403	1.934	1	0.164	1.752
9	Membership of a saving group	0.039	0.432	0.008	1	0.928	1.040
10	Access to a credit facility	-0.437	0.585	0.558	1	0.455	0.646
11	Farmland ownership	-0.989	0.839	1.387	1	0.239	0.372
12	Size of land (>5acres)	-0.868	0.400	4.712	1	0.030	0.420
13	Distance from farm to dam(>5km)	-0.490	0.382	1.643	1	0.200	0.613

14	Accessibility of the road to dam	0.907	0.564	2.584	1	0.108	2.476
15	Contact with extension officers	0.889	0.477	3.475	1	0.062	2.432
	Constant	-3.005	1.215	6.119	1	0.013	0.050
	Number of observations: 333; Omnibus tests of model coefficients : Chi2 =185.143; d.f=15; Sign=.000; −2log likelihood = 276.104; Nagelkerke R2 = 0.426; Overall accuracy (correctly predicted): 87.1%						

Note: statistical significance at the 1%, 5%, and 10% probability levels, respectively

4.1.2.1 Gender

The results presented in Table 4.2 showed a statistically-significant negative relationship between male-headed households and the use of harvested rainwater in dams for livestock with a *p*-value of 0.402. The coefficient of the male-headed household was -0.354 implying the decrease in the likelihood of male farmers participating in livestock. The odds ratio was 0.702 indicating that male-headed households decrease the probability in the participation of livestock by 0.702.

The use of dams by females was statistically insignificant in livestock showing a *p*-value of 0.135. The odds ratio was 1.756, indicating that the probability of females not using the dams for livestock increased` by 1.756.

4.1.2.2 Age

Age had a statistically significant negative effect on the participation of harvested rainwater in dams for livestock with a *p*-value of 0.540. The odds ratio for age was 1.294, implying that a year increase in the age of a farmer increases the probability of participation in livestock by about 1.294.

4.1.2.3 Education

The education status of the head of household had a statistically significant negative effect on the participation of harvested rainwater in dams for livestock with a *p*-value of 0.183. The odds ratio was 1.717, implying that members of the households who were not educated increased the probability of farmer participation in livestock by 1.717.

The education of members of the household has a statistically significant effect showing a *p*-value of 0.067. A positive coefficient of 0.885 indicates members of households that are educated are more likely to participate in livestock. The odds ratio was 2.422 implying that educated members of the household increased the probability to participate in livestock by 2.422.

4.1.2.4 Assets-Livestock

Having assets such as livestock had a statistically significant positive effect on the participation of harvested rainwater in dams for coping with climate change in livestock production as shown in table 4.2 indicating a *p*-value of 0.000. A positive coefficient of 3.024 shows farmers who had livestock had a high likelihood to participate in livestock as a coping activity. The odds ratio was 20.567 implying that farmer that owned livestock were 20.567 times likely to participate in the use of harvested dams for their animals.

4.1.2.5 Assets-Agricultural Machinery

farmers with assets such as agricultural machinery had a positive significant influence on the participation of livestock with a p-value of 0.000. The positive coefficient of 1.913 showed that farmers that owned machinery were more likely to participate in livestock. The odds ratio was 6.770, suggesting that farmers who had machinery increased the probability of participating in livestock by 6.770 times.

4.1.2.6 Membership of a Cooperative

Cooperative membership had a statistically significant negative effect on the participation of livestock with a p-value of 0.164. The odds ratio for cooperative membership was 1.752 implying that farmers with no membership increase the probability of participating in livestock by 1.752.

4.1.2.7 Membership of a Saving Group

Belonging to a saving group had no statistically significant effect on the dependent variable livestock with a *p*-value of 0.928. The odds ratio for saving group membership was 1.040 indicating an increase in the probability for farmers who are not members of a saving group to participate in livestock by 1.040.

4.1.2.8 Access to a Credit Facility

Access to credit facilities had no statistically significant effect on the participation of harvested rainwater for livestock showing a *p*-value of 0.455 and a negative coefficient of -0.437 implying that farmers with access to credit facilities were less likely to participate in livestock. The odds ratio was 0.646 indicating that farmers with access to credit facilities reduced the probability of participation in livestock by 0.646.

4.1.2.9 Farmland Ownership

Having farmland had no statistical difference in the influence of participation in harvested rainwater for livestock showing a *p*-value of 0.239. Table 4.2 showed a negative coefficient of -0.989 indicating the decrease in the likelihood of farmers with farmland to participate in livestock. The odds ratio for having farmland was 0.372 implying that having farmland decreased the probability of participating in livestock by about 0.372.

4.1.2.10 Size of Land

The size of land had a statistically significant positive effect on the participation of harvested rainwater showing a *p*-value of 0.030. The coefficient was -0.868 implying that farmers with a small size of land were less likely to participate in gardening. The odds ratio was 0.420, indicating that having a small land reduces the participation of farmers in livestock.

4.1.2.11 Distance from Farm to Dam

The distance from the farm to the dam had no significant influence indicating a *p*-value of 0.200. Table 4.1 showed the coefficient of -0.490 implying a decrease in the likelihood of farmers that had farms far from the dams to participant in livestock than farms that were near the dams. The odds ratio was 0.613 indicating that farmers that were far from the dams decreased the probability of farmers participating in livestock by 0.613.

4.1.2.12 Access to all Seasonal Roads

Accessibility of the roads to the dams had no significant influence indicating a *p*-value of 0.108. The odds ratio was 2.476 implying farmers that had no access to the roads increased the probability of the participation of livestock by 2.476.

4.1.2.13 Access to Extension Services

Contact with extension had a statistically significant positive effect on the participation of harvested rainwater in livestock indicating a *p*-value of 0.062. The positive coefficient of 0.889 showed that farmers that had contact with extension services increased the likelihood of participating in livestock. The odds ratio for contact with extension services was 2.432 suggesting that farmers who had contact with extension officers increased the probability of participation by about 2.432 times.

4.1.3 Fishing

The model fit was tested using the Omnibus tests of model coefficient based on the Chi-Square test. The overall percentage of correct predictions was 81.4%. The *p*-value of 0.00 showed that there is a significant difference between the observed and predicted values of the dependent variables, indicating that the model's estimates fit the data well, at an acceptable level.

Table 4.3: Binary Logit Model Outputs

	Variables in the Equation						
		β	S.E.	Wald	df	Sig.	Exp(β)
1	Male headed household	-0.978	0.394	6.144	1	0.013	0.376
2	Age (Young)	0.233	0.310	0.563	1	0.453	1.262
3	Household head literacy	1.438	0.432	11.075	1	0.001	4.213
4	Members of household literacy	0.193	0.331	0.339	1	0.560	1.213
5	Females use the dams	1.827	0.452	16.377	1	0.000	6.218
6	Asset (Livestock)	0.885	0.719	1.516	1	0.218	2.422
7	Agricultural Machinery	0.558	0.413	1.827	1	0.176	1.747
8	Membership of a cooperative	1.434	0.407	12.389	1	0.000	4.193
9	Membership of a saving group	-0.661	0.341	3.757	1	0.053	0.516
10	Access to a credit facility	-1.379	0.694	3.949	1	0.047	0.252
11	Farmland	-1.008	0.565	3.181	1	0.075	0.365

12	Size of land (big more than 5KM)	0.277	0.328	0.714	1	0.398	1.319
13	Distance from farm to dam	0.015	0.323	0.002	1	0.963	1.015
14	Accessibility of the road to the dam	-1.204	0.496	5.884	1	0.015	0.300
15	Contact with extension officers	0.804	0.718	1.255	1	0.263	2.235
	Constant	-3.378	1.195	7.993	1	0.005	0.034
	Number of observations: 333; Omnibus tests of model coefficients : Chi2 =130.901; d.f=15; Sign=.000; −2log likelihood = 276.104; Nagelkerke R2 = 0.461; Overall accuracy (correctly predicted): 81.4%						

Note: statistical significance at the 1%, 5%, and 10% probability levels, respectively

4.1.3.1 Gender

The results presented in Table 4 showed a statistically-significant positive relationship between male-headed households and the participation of harvested rainwater in dams for fishing, a coping activity for climate change with a *p*-value of 0.013. However, a negative coefficient of -0.978 implying that male-headed households were less likely to participate in fishing. The odds ratio for a male-headed household was 0.376, implying that a male farmer reduced the probability to participate in fishing at 0.376. The use of the dams by females was statistically significant with a *p*-value of 0.000. The positive coefficient showed a value of 1.827 indicating that female farmers were more likely to use the dams for fishing. The odds ratio on the use of the dams by females was 6.218, implying that females are more likely to use the dams 6.218 times for fishing than males.

4.1.3.2 Age

Age had a statistically significant negative effect on the participation of harvested rainwater in dams for fishing with a p-value of 0.453. The odds ratio for age was 1.262, implying that a year increase in the age of a farmer increases the probability of participation by about 1.262.

4.1.3.3 Education

The education status of the head of household had a statistically significant positive effect on the participation of harvested rainwater in dams for fishing with a *p*-value of 0.001. The positive coefficient of 1.438 showed that educated head of the household was more likely to participate in fishing. The odds ratio was 4.213, implying that educated male-headed households increased the probability of farmers participating in fishing by 4.213.

The education status of the members of the household had no statistically significant effect on the participation of harvested rainwater with a *p*-value of 0.560. The odds ratio was 1.213 implying that members of households that were not educated increased the probability to participate in fishing by 1.213.

4.1.3.4 Assets-Livestock

Having assets such as livestock had no statistically significant effect on the participation of harvested rainwater in dams for coping with climate change as shown in table 4.5 indicating a *p*-value of 0.0218. The odds ratio was 2.422 indicating that farmers that had no livestock increased the probability of participating in fishing as a coping activity by 2.422.

4.1.3.5 Assets- Agricultural Machinery

Farmers that had assets such as agricultural machinery had no statistically significant effect on the participation in fishing indicating a *p*-value of 0.176 and an odds ratio of 1.747 implying that farmers with no machinery increased the probability of participation in fishing.

4.1.3.6 Membership of a Cooperative

Cooperative membership had a statistically significant positive effect on the participation of harvested rainwater in fishing with a p-value of 0.000. Table 4.3 showed the coefficient of 1.434 indicating that farmers who are members of a cooperative were more likely to participate in fishing. The odds ratio for cooperative membership was 4.193, implying that membership increases the probability of participation by 4.193 times.

4.1.3.7 Membership of a Saving Group

Belonging to a saving group had no statistically significant effect on the dependent variable fishing showing a p-value of 0.053. A negative coefficient of -0.661 showed that farmers who were members of a saving group were less likely to participate in fishing. The odd ratio was 0.516 showing that farmers in saving groups decreased the probability to participate in fishing at 0.516.

4.1.3.8 Access to Credit Facilities

Access to credit facilities had no statistically significant effect on the participation of harvested rainwater for fishing with a p-value of 0.047. A negative coefficient of -1.379 indicated that farmers who had access to credit facilities were less likely to participate in fishing. The odds ratio of 0.252 showed that farmers that can access credit facilities decreased the probability of participating in fishing by 0.252.

4.1.3.9 Farmland Ownership

Having farmland had no statistical difference in the influence of participation in harvested rainwater for fishing showing a *p*-value of 0.075. Table 4.3 showed a negative coefficient of -1.008 indicating the decrease in the likelihood of farmers with farmland to participate in fishing. The odds ratio for having farmland was 0.365 implying that having farmland decreased the probability of participating in fishing by 0.365 times.

4.1.3.10 Size of Land

The size of land had a statistically significant negative effect on the participation of harvested rainwater showing a *p*-value of 0.398. The odds ratio was 1.319 indicating that having a small land increases the participation of farmers in fishing by 1.319.

4.1.3.11 Distance from Farm to Dam

The distance from the farm to the dam had no significant influence indicating a *p*-value of 0.963. The odds ratio was 1.015 indicating that farmers that were near the dams increased the probability of farmers participating in livestock by 1.015.

4.1.3.12 Access to all Seasonal Roads

Accessibility of the roads to the dams had a significant influence indicating a *p*-value of 0.015. The negative coefficient of -1.204 implied that farmers who had access to the roads were less likely to participate in fishing. The odds ratio was 0.300 implying farmers that had access to the roads reduced the probability in the participation of fishing by 0.300.

4.1.3.13 Access to Extension Services

Contact with extension officers had no statistically significant effect on the participation of harvested rainwater in fishing indicating a *p*-value of 0.263. The odds ratio for contact with extension services was 2.235 suggesting that farmers who did not have contact with extension officers increased the probability of participation in fishing by 2.235.

4.2 A Comparison of Effect Levels among the Economic Activities (Gardening, Livestock, and Fishing) around the Dams.

The table below showed the determinants that have statistically significant differences on the dependent variables; gardening, livestock, and fishing as well as the determinants that had no statistically significant difference on the dependent variables indicated as **ns.** It also shows the variables that were neutral indicating **0**. The statistical significance is at the 1%, 5%, and 10% probability levels, respectively.

Table 4.4: Binary Logit Model Output

Economic Activity around the Dam	**Gardening**		**Livestock**		**Fishing**	
Equation	β	Sig.	β	Sig.	β	Sig.
Constant	-4.192	***	-2.783	***	-3.453	***
Male headed household	-1.304	***	0	ns	-0.962	***
Age (Youth)	0	ns	0	ns	0	ns
Education of head household	1.381	***	0	ns	1.75	***
Education of household members	0	ns	1.092	**	0	ns
Use of dams by Females	2.326	***	0	ns	1.75	***
Livestock ownership	0	ns	3.003	***	1.451	0.029
Agricultural Machinery	1.224	***	2.102	***	0	ns

Cooperative membership	0	ns	0	ns	1.494	***
Member of saving group	0	ns	0	ns	0	ns
Access to credit facility	0	ns	0	ns	-1.783	***
Farmland ownership	0	ns	0	ns	0	ns
Size of Land(>5 acres)	-0.926	***	-1.012	***	0	ns
Distance from farm to dam(>5km)	0	ns	0	ns	0	ns
All seasonal road	0	ns	0	ns	-1.398	***
Contact to extension services	2.192	***	0.978	**	0	ns

*Note: *** means p<1%, ** means p<5%, * means p<10%* **ns** *means p>10%*

4.2.1 Gender

Table 4.4 showed that male-headed households had a statistically significant difference on the dependent variables gardening and fishing with the *p*-value 0.001 and 0.009 respectively. Table 4.4 further showed a negative coefficient of -1.304 and -0.962 for gardening and livestock respectively implying that male-headed households were less likely to participate in the use of the dams for gardening and fishing. Male-headed households had no statistically significant difference on the dependent variable livestock indicating they were neutral in the participation in the use of the dams as shown in Table 4.4. The use of the dams by females was statistically significant for gardening and fishing showing a p-value of 0.000 and 0.000 respectively. The positive coefficient of 2.326 and 1.75 for gardening and fishing respectively indicated that the use of dams by females is likely to increase the participation of gardening and fishing. The results further showed that the use of the dams by females is statistically insignificant for livestock.

4.2.2 Age

Age had no statistically significant difference in the dependent variable gardening, livestock, and fishing. Being young did not influence the participation of harvested rainwater in dams for all coping activities according to Table 4.4.

4.2.3 Education

The education status of the head of the house had a statistically significant positive effect on the dependent variables gardening and fishing with both having the *p*-value of 0.000. and positive coefficients of 1.381 and 1.75 respectively implying that education of the head of household increased the likelihood of participating in gardening and fishing. While the education status of the member of the household had no significant difference in farmer participation in gardening and fishing. However, the education status of the head of household had no statistically significant influence on livestock but had a statistical influence on the education of the members of the household to read and write with a *p*-value of 0.014.

4.2.4 Membership of a Cooperative

Cooperative membership had no statistically significant difference on the dependent variables gardening and livestock but had a statistically significant difference on fishing with a p-value of 0.000 and a coefficient of 1.494 indicating that farmers that belonged to a cooperative were more likely to participate in fishing.

4.2.5 Assets- Agricultural Machinery

Machinery ownership had a statistically significant difference on the dependent variables gardening and livestock with *p*-values of 0.001 and 0.000 respectively. Table 4.4 shows the coefficients of 1.224 and 2.102 for gardening and livestock respectively indicating farmers that owned machinery were more likely to participate in gardening and fishing. Machinery ownership had an insignificant difference in fishing according to table 4.4.

4.2.6 Assets-Livestock

Livestock ownership showed a statistically significant difference in livestock and fishing as coping activities with *p*-values 0.000 and 0.029 respectively. The positive coefficients of 3.003 and 1.451 for livestock and fishing respectively imply that the likelihood of farmers owning livestock increased the participation of livestock and fishing as coping activities. However, having assets such as livestock had no statistically significant difference in gardening.

4.2.7 Membership of a Saving Group

Being a member of a saving group had no statistically significant difference on the dependent variables gardening, livestock, and fishing.

4.2.8 Access to Credit Facilities

Access to credit facilities had no statistically significant difference on the dependent variable gardening and livestock but a statistically significant difference on the dependent variable fishing with a p-value of 0.007 and a negative coefficient of -1.783 indicating that access to credit decreased the likelihood of farmer participation in fishing.

4.2.9 Access to all Seasonal Roads

Having access to the road had no statistically significant difference on the dependent variables gardening and livestock as shown in Table 4.4 but had a statistically significant influence on fishing with a p-value of 0.003 and a negative coefficient of -1.398 indicating that access to the road is less likely to decrease the participation of fishing.

4.2.10 Distance from Farm to Dam

The distance from the farm to the dam had no statistically significant difference on the dependent variables gardening, livestock, and fishing.

4.2.11 Size of Land

The size of land had a statistically significant difference on the dependent variables gardening and livestock with *p*-values of 0.004 and 0.006 respectively and negative coefficients of -0.926 and -1.012 respectively, indicating that size of the land is less likely to decrease the participation of gardening and livestock. Nonetheless, the size of the land had no statistically significant influence on fishing.

4.2.12 Access to Extension Services

Contact with extension staff had a statistically significant difference on the dependent variables gardening and livestock showing p-values of 0.000 and 0.031 and positive coefficient of 2.192 and 0.978 respectively. This indicated that the contact with extension increased the likelihood of farmer participation in gardening and livestock. However, table 4.4 shows that contact with extension services is statistically insignificant for fishing.

4.3 Dominating factors in coping with climate change under each activity (gardening, fishing, and livestock) and across all activities.

Table 4.5: Relative coefficients of gardening, fishing, and livestock by farmer factor

Table 4.5 The table below shows the matrix showing the relative importance of each factor in the coping process and was determined by the highest-ranking relative coefficient in each row (or each economic activity). Then vertical comparisons determined the relative importance of the factors among the economic activities using vertical ranking.

$$\begin{bmatrix} G \\ L \\ F \end{bmatrix} = \begin{bmatrix} -4.192 \\ -2.783 \\ -3.453 \end{bmatrix} + \begin{bmatrix} -0.139 & 0 & 0.148 & 0 & 0.249 & 0 & 0.131 & 0 & 0 & 0 & 0 & -0.099 & 0 & 0 & 0.234 \\ 0 & 0 & 0 & 0.022 & 0 & 0.001 & 0.502 & 0 & 0 & 0 & 0 & -0.242 & 0 & 0 & 0.234 \\ -0.091 & 0 & 0.165 & 0 & 0.165 & 0.137 & 0 & 0.141 & 0 & -0.168 & 0 & 0 & 0 & -0.132 & 0 \end{bmatrix} \begin{bmatrix} MHH \\ Age \\ HHE \\ MHE \\ FUD \\ A.L \\ A.M \\ M.C \\ MSG \\ ACF \\ LND \\ S.F \\ DST \\ S.R \\ CEO \end{bmatrix} + \begin{bmatrix} e_v \\ e_L \\ e_F \end{bmatrix}$$

Key; ***MHH*** *(Male Headed household),* ***Age*** *(Young less than 35),* ***HHL****(Head of Household Education)* ***MHL****(Members of Household Education),* ***FUD*** *(Use of dams by females),* ***A.L*** *(Assets like Livestock,)* ***A.M*** *(Assets like Machinery),* ***M.C(****Member of a cooperative,* ***MSG*** *(Member of Saving Group,* ***ACF*** *(Access to Credit Facility,* ***LND****(Land Ownership*

S.F*(Size of Farmland,* ***DST*** *(Distance from farmland to dam,* ***S.R*** *(Seasonal all Roads)* ***CEO*** *(Contact with Extension Officer.*

4.3.1 Gardening

Table 4.5 showed that the use of dams by females is the major determinant of farmer participation in coping activity gardening with the highest coefficient of 0.249 while being a male-headed household was the least important determinant in the participation of harvested rainwater for gardening as a coping activity with the lowest coefficient of -0.139.

4.3.2 Livestock

According to Table 4.5, having assets such as farm machinery was the major determinant of farmer participation in the use of harvested rainwater in dams for coping activity livestock to climate change with the highest coefficient of 0.502 while the size of farmland was the least influential determinant in the participation of harvested rainwater in dams for livestock with the lowest coefficient of -0.242.

4.3.3 Fishing

Table 4.5 above, showed the education status of the head of house as the major determinant of farmer participation in the use of harvested rainwater in dams for coping activity fishing with the highest coefficient of 0.165 while access to credit facilities as the least influential determinant in the participation of harvested rainwater in dams for fishing with the lowest coefficient of -0.168.

4.4 Dominating factors in coping to climate change across all activities

Table 4.5 showed that having assets such as machinery is a major determinant of farmer participation in the use of dams for all coping activities (Gardening, Livestock, and Fishing) indicating the highest coefficient of 0.502 while access to credit is the least determinant in influencing farmer participation in all three coping activities to climate change with the lowest coefficient of -0.168.

5. DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1 Farmer Factors Affecting Coping Levels of Gardening, Fishing, and Livestock

5.1.1 Gender

Gender is an important factor when coping with climate change in gardening and fishing activities. But has no influence when coping with livestock activity. The finding shows that more men are heading homes yet more women use the dams than men for both gardening and fishing. The possible reason for this finding is that Siavonga District is a home for fish, and has more women selling fish and vegetables than men. This finding is supported by Oladele (2012) stating that women are often likely to participate in water issues as compared to men. This is because of women’s cultural role to be concerned with water problems and can be expected to completely influence the participation of harvested rainwater than men. In addition, like most African countries, women have more decision-making power and responsibilities in socioeconomic aspects at the household level as they are responsible for family sustenance. For example, in the eastern and western parts of Africa vegetable gardening is mostly done by women (Hope et al. 2009). Furthermore, Awoke and Okonji (2003) in their study showed how rural women, have traditionally accomplished more compared to their disadvantaged position at the household level and also farm level. Women contribute vastly to agricultural productivity (Awoke and Okonji, 2003).

5.1.2 Age

The finding shows that the youth below thirty-five years don't influence the participation of harvested rainwater in dams for coping activities gardening, livestock, and fishing. The potential cause to this finding is that agriculture has mainly been related to the older generation, this can be supported by a study done by Gebregziabher et. al., (2013) that states that age implies the experience in farming and indigenous knowledge learned over the years. This implies older people tend to participate in harvested rainwater than the younger generation to cope with climate change. The older generation has seen and full-fledged the impacts of climate change therefore, it becomes easier for older farmers to participate in adaptational ways of climate change. Contrary to the findings, Wynn et al., (2001) stated that age could be a vital variable as the young are more willing to change and move with time. The study conducted by Sidibé, (2005) within the theory of human capital declared that the probabilities of adoption increase with younger age and contrariwise.

5.1.3 Education

The education status of the head of house influenced coping activities such as gardening and fishing but did not influence livestock as a coping activity. The possible reason for this finding is that most heads of households in rural Siavonga prefer their children to herd livestock than be in school. The study has shown that education is significant because it improves life skills which can increase agricultural productivity and cope with climate change (GRZ, 2018). This is consistent with the findings conducted in Nepal by Ganesh and Surendra (2005) which stated that the participation of farmers in the use of harvested water is influenced by the education level and amount of training.

Education has been used as a significant and influencing determinant in the adoption studies (Adesina and Chianu, 2002; He et al., 2007). Farmers with an advanced level of education are likely to participate in agriculture technologies as compared to those that are uneducated (He et al., 2007). However, the adult illiteracy rate of Siavonga District stood at 49.1% (GRZ, 2018) which is very critical. If farmers take education seriously, they will be able to identify new opportunities for improving their livelihoods in this changing climate.

5.1.4 Membership of a Cooperative

Belonging to a Cooperative does not influence the participation of farmers in the use of harvested rainwater in dams to cope with climate change for gardening and livestock activities but has a strong effect on fishing as a coping activity to climate change. Contrary to this finding as conducted by Asnarulkhadi et. al., (2013), being in a cooperative enables members to have greater chances of credit access hence invest in technologies as compared to those who don't belong in one. Contrary to the findings Baiyegunhi (2015) stated that participation in various types of social groups is a common element of village life and plays a significant role in the spread of knowledge, information, and innovation. Furthermore, members of Cooperatives are entitled to provisions such as credit and training, which may be used as an incentive to adopt a technology (Sidibé, 2005). Climate adaptation will demand community members to work together, and this can be possible if formal structures such as a cooperative are activated. This will ensure that cooperative members share the climate risks and build adaptive capacity amongst each other.

5.1.5 Agricultural Machinery

Machinery ownership has an influence on coping activities such as gardening and livestock and no effect on fishing as shown in table 4.4. In combating climate change, organizations such as Conservation Farming Unit (CFU) and United Nations Development Programme (UNDP) have been training farmers in Conservation Agriculture and provide machinery such as rippers to lead farmers. This agriculture practice can help farmers adapt and mitigate climate change through the minimum tillage principle and permanent soil cover with crop residues and live mulches principle (GRZ, 2020).In mitigating climate change and at the same time improving the efficiency of agricultural production, Khondoker et. al., (2016) advocate for the use of agricultural machinery on their lands to improve agricultural productivity. Machinery has potential production cost savings and reduces manual labor. Machinery in Siavonga rural is often used at a fee which comes as an extra income and can help farmers adapt to climate change.

5.1.6 Member of saving group

Being a member of a saving group does not influence coping activities such as gardening, livestock, and fishing. The possible reason for this finding is that Saving Groups in Siavonga District have recently evolved for example Girls Education, Women Empowerment, and Livelihoods (GEWEL) project under the Ministry of Community Development and Social Services has a component on saving groups (GRZ 2016). This, if properly utilized can help farmers buy agricultural inputs unlike waiting for the government under the Farmer Input Support Programme (FISP) to do so. Inputs usually come late, savings can enable farmers to afford to buy improved and early maturing varieties to cope with the changing climate. The study conducted by Lee (2005); Pender and Gebremedhin (2007); Wollni et. al.,(2010) commends that social networks such as saving groups enables farmers to exchange agricultural information and have access to inputs and credit. Social groups enable farmers to sell their produce in bulk, this contributes to their income thereby improving their adaptive capacity.

5.1.7 Access to Financial Services

Access to financial services has a negative effect on the participation of farmers in the use of dams to coping activities such as gardening and livestock but a positive effect on fishing as a coping activity. The findings contradict the previous studies done by Arun et. al., (2012) that stated that access to credit is another factor influencing participation in harvested rainwater for agricultural production. It has been argued by IPAR (2007) that lack of access to finance contributes to the poverty levels even further for the developing countries. Burgess and Pande (2003) provide the argument that finance access is essential as it enables the underprivileged to be able to change systems of production creating an avenue for them out of poverty. Accessing finance credit helps the smallholder farmers to build their assets, which improves their productive and adaptive capacity (IPAR, 2007). Access to credit is an important element in improving agricultural productivity for local communities (DBSA, 2005). Accessing financial services can help farmers purchase irrigation systems that can complement agricultural productivity thereby enhancing the adaptive capacity for farmers.

5.1.8 Contact with Extension Staff

Contact with extension staff has a positive influence on farmer participation in the use of harvested rainwater in dams for coping activities such as gardening and livestock but negatively affects fishing. Siavonga Ministry of Agriculture has one extension officer per camp (GRZ, 2021). Having access to extension services enables farmers to have adequate knowledge and information on how the dams can be used as a coping mechanism to the changing of climate. According to GRZ (2021), 50% of the extension staff in Siavonga district do not stay in their agricultural camps due to lack of accommodation which is likely to affect agricultural production as farmers do not get the much-needed extension services as often as they could. This can lead to a low adaptive capacity for climate change for the farmers. A study conducted by Kloeppinger and Sharma (2010) stated that access to extension services increased agricultural productivity. However, the problem for the farmers in developing countries to access extension services was also highlighted. Makate et. al., (2019) suggested improving accessibility of extension services for farmers can contribute to the participation of harvested rainwater techniques.

5.1.9 Accessibility of the road (All seasonal roads)

Having access to the road has no positive effects on the participation of farmers in the dams for gardening and livestock coping activities but has a positive influence on fishing. Contrary to this finding conducted by Asnarulkhadi et. al., (2013) having all seasonal roads increases accessibility to market access, this, in turn, motivates farmers to grow more produce thereby affecting production in all the coping activities. According to FAO (2005), the network of the road has a positive impact on agricultural production. Inadequate and unreliable roads faced by rural African families affect their daily lives. Limited access to roads affects the ability of rural farmers to be above the poverty line. The availability of roads in rural areas facilitates the provision of extension services and increases access to market opportunities that encourage the take up of technologies that are recommended by extension support.

5.1.10 Distance from farm to dam

The distance from the farm to the dam does not affect coping activities such as gardening, livestock, and fishing. This finding is supported by Goletti et al. (2001) who found that the distance from a farm to a harvested dam has no quantifiable effect on a farmer's rate of productivity. The attribute of distance covered did not highlight any considerable output on the net return per capita; the net return per hectare of usable land, and the net return per unit of labor in the study conducted (Goletti et al., 2001).

Contrary to the findings, Awoke and Okonji (2003) through a study undertaken in the Ebonyi State of Nigeria indicated that farm location contributes negatively to land utilization, which denotes that land use decreases as distance increases. Further, Ekbom (2001) also indicates that the number of distances moved by farmers to access water for production leads to a reduction in the rate of productivity. Hau and Von Oppen (2002) of Thailand, highlighted that an increase in productivity by 0.94 can be attributed to a reduction of distance covered to access farming resources even by 1 percent.

5.1.11 Size of land

Increased productivity in gardening and livestock due to enhanced farmer participation in dam coping activities, is positively attributed to the size of land they have. Studies conducted by Thessaly et al., (2002) found that the participation levels in agricultural productivity increased with the size of land. Vanslembrouck et al., (2002) studying participation in Flanders and Wallonia showed the opposite, that the farmers who had small and average-sized farms participated more than the farmers with big land. Despite farmers having a big size of land in Siavonga District, the soils have a low water-holding capacity, vulnerable to erosion, and shallow topsoil depth, these factors affect agricultural production and reduces the coping capacity of farmers to climate change (GRZ, 2018). Due to these factors, farmers must diversify their agricultural activities by also engaging in livestock as a coping mechanism to climate change.

5.2 To compare effect levels among the economic activities around the dams

5.2.1 Effect levels in the use of dams for gardening

The participation of gardening as a coping activity was increased by the education status of household heads, use of dams by females, machinery ownership, and contact with extension services. However, male-headed households and the size of land decreased participation in gardening. Age, education status of members of the household, livestock ownership, members of cooperatives and savings, access to credit facilities, distance from the farm to the dam, and all seasonal roads were neutral in gardening as a coping activity to climate change.

5.2.2 Effect levels in the use of dams for livestock

Livestock as a coping activity was found to increase with education status of the members of the household, ownership of assets such as livestock and machinery, and contact to extension services but decreased with the size of the land and was neutral with male-headed household, age, education status of the head of household, use of the dams by females, cooperative and saving group membership, access to credit facilities and ownership of farmland.

5.2.3 Effect levels in the use of dams for fishing

Fishing as a coping activity increased with education status of the head of household, use of the dams by females, assets ownership like livestock, membership of cooperative and decreased with male-headed households and access to credit but neutral with age, education status of members of households, machinery ownership, membership of the saving group, farmland ownership, size of land, distance from the farm to the dam and contact with extension services.

5.3 Dominating factors in coping to climate change under each coping activity (gardening, fishing, and livestock) and across all coping activities

5.3.1 Gardening

5.3.1.1 Major Dominating Determinant – Use of Dams by Females

Females are more likely to take up coping activities to climate change in gardening. This finding is supported by a study conducted by Diiro et. al., (2018) in Kenya where the finding indicated that agricultural productivity increased more among the smallholder farmer households. The study stated that women are effective agents of social development and display an important role in garden production. Furthermore, the finding is supported by Hope et al., (2009) that stated most of the agricultural work is done by women as men spend most of their time in town. It has been known that when the men leave their native homes, they leave the women to play to do garden work. This results in women having more roles in undertaking farming activities, growing their knowledge and skills in agricultural practices. Their gained experiences enable them to change agriculture activities based on acquired knowledge over the years. In support of Hope et al. (2009), an estimation was done by FAO (2015) stating 70 to 80 percent that women in Sub-Saharan Africa contribute to the household. In many countries, men migrate to urban areas in search of non-agriculture-based employment opportunities, this leads to women taking up men's traditional tasks while attending to their families' household needs.

5.3.1.2 Least Dominating Determinant – Male Headed Household

Being Male headed household is the least influential determinant in the participation of harvested rainwater for gardening as a coping activity. The possible reason is that in sub-Saharan Africa, women provide most of the labor force in the agriculture sector. Despite the importance of women in the agriculture sector, their agricultural productivity remains low due to the gender disparities that exist to the accessibility of land titles, ownership of livestock, accessibility to extension services, and financial services (Diiro et. al., 2018). Women farmers are expected to perform all agricultural activities at the farm while men return the roles of providing cash from other sources for the household as well as remaining in charge of the farmland. The trend of reciprocal responsibilities tends to present an unequal balance in the responsibilities of rural women as their duties consume a lot of time compared to men (Awoke and Okonji, 2003).

5.3.2 Livestock

5.3.2.1 Major Dominating Determinant-Assets such as Machinery

Assets such as machinery are the most dominant determinant in the coping activity of livestock. The possible reason for this finding is the common use of draught animal power that has been used for crop production and transportation for many years. A study conducted by Kiguli and Kiguli (2004) stated how animate power was found to be inadequate in maintaining schedules hence the recommendation of mechanical power to improve agricultural productivity and cope with climate changes. Kiguli and Kiguli (2004) further stated how commonly mixed farming is in sub-Saharan Africa. Livestock is a source of income to many families in the rural population which is further used for draught animal power. Livestock indirectly contributes to the improvement of nutrition to manage the labor intensity and the agricultural machinery.

5.3.2.2 Least Dominating Determinant- Size of Farmland

The size of farmland is the least influential determinant in the participation of harvested rainwater in dams for livestock. The possible reason for this finding is that animals in Siavonga District move in herds in search of food and are not limited to the farm. This finding is opposed to the study conducted by Kurukulasuriya and Mendelsohn (2006) that stated farmers are likely to invest in technology with a big size of land. However, a study conducted by Kiguli and Kiguli (2004) stated that the size of the land is an important factor because most farmers cannot afford to buy fertilizer, the manure from the animals can be spread evenly on a small size of land.

5.3.3 Fishing

5.3.3.1 Major Dominating Determinant – Education of Male Headed household

The education status of the male-headed household is a major determinant of farmer participation in the use of harvested rainwater in dams for coping activity (fishing). Tietze et al., (2009) in their study stated how an educated male-headed household increased the probability of fishing as a coping activity. Farmers that can read and write are progressive farmers that can be used as targets to promote coping mechanisms. Contrary to the finding by Fatunla (2000), fishing communities have lower levels of literacy than other alternative activities. Factors that further disadvantage attainment of education are migratory lifestyles, the tendency to social marginalization, the significance of child labor, and common activities of post-catch processing and marketing. Patterns of child labor may contribute to inconsistent school attendance and low educational aspirations due to the failure of pupils to see benefits in education. The fishermen parents feel that education is too strictly programmed to let their children help in the fishing.

5.3.3.2 Least Dominating Determinant- Access to Credit Facilities

Access to credit facilities is the least influential determinant in the participation of harvested rainwater in dams for fishing. The possible reason for this finding is the lack of credit facilities in the rural areas of Siavonga District. The study conducted by Arun et. al., (2012) showed that credit availability improves the production of fish thereby increasing income through marketing and processing of the fish. Contrary to the study finding, credit can be a powerful tool for poverty reduction and help elevate the lives of the farmers in the rural population (Burgess and Pande, 2003). Fishermen and women lack opportunities to access credit and market their fish which can enable them to add value to the fish (Arun et. al., 2012).

5.4 Dominating factor in coping to climate change across all activities

5.4.1 Major Dominant Determinant in all Coping Activities- Assets (Agricultural Machinery)

Having assets such as agricultural machinery is a major determinant of farmer participation in the use of dams for all coping activities (Gardening, Livestock, and Fishing). The possible reason for this finding is that farmers are now working smart through the utilization of machines. This finding is supported by Khondoker et. al., (2016) who in their findings found that farmers that owned machinery had high agricultural productivity than those who did not have it. Other findings were that the ones who owned machinery took agriculture production seriously, had access to markets, and were aware of the adaptation strategies to climate change. To improve agricultural productivity, Mekuria et. al.,(2020) stated in their findings the need for technological inputs. Farmers need to be introduced to modern technology so that they can enhance their agricultural production.

5.4.2 Least Dominating Determinant in all Coping Activities-Access to Credit Facilities Access to credit is the least determinant in influencing farmer participation in all the three coping activities to climate change found around the dams. The possible reason for this finding is the lack of financial literacy among farmers in Siavonga District. This finding contradicts a study conducted by Orindi and Eriksen, (2005) that stated that farmers with access to credit and markets have higher probabilities of coping with changing climatic conditions. Access to reasonable credit increases the money resources of farmers and their ability to fulfill dealing prices related to the assorted adaptation choices they may need to require with additional money and different resources at their disposal, farmers can modify their management practices in response to climate change (DBSA, 2005).

5.5 Conclusions

This study attempted to find out the determinants of farmer participation in harvested rainwater in dams for coping with climate change in Siavonga District. The coping activities included in the study were gardening, fishing, and livestock.

Firstly, in coping with climate change under gardening, the following were the determinants that increased farmer participation in harvested rainwater in dams; The use of dams by females, the education status of the head of the house, farmers that owned assets such as machinery and farmers who had contact with extension officers. The determinant that decreased the participation of farmers includes; Male headed household and size of land. Some factors that were neutral include age, education status of household members, cooperative and saving group membership, access to credit, farmland ownership, distance from farm to land, and access to all seasonal roads.

Secondly, in the coping activity livestock, some of the determinants that increased the participation of farmers in livestock include; Education status of members of the households, farmers that owned livestock as an asset, machinery ownership, and contact with extension services. The determinants that reduced the likelihood of participation were the size of land and the neutral determinants were; Male headed household, age, education status of head of household, use of dams by females, cooperatives and saving group membership, access to credit, and farmland ownership.

Thirdly, in coping with climate change under fishing, the determinants that increased participation were the education status of head of household, use of dams by females, livestock ownership, and membership of a cooperative. The determinants that reduced the participation were the male-headed household and access to credit. The neutral factors were age, education status of members of the household, machinery ownership, membership of saving groups, farmland ownership, size of land, distance from farm to the dam, and contact with extension services.

The dominant determinants and the least important determinants were identified in all the three coping activities to climate change; For gardening, females were a dominant determinant in the activity, and the male-headed household was the least important determinant in this coping activity. For livestock, having assets such as machinery was the most important determinant, and the size of the land was the least important determinant. In the fishing coping activity, the literacy of the head of the house was the most dominant determinant and access to credit facilities was the least dominant determinant. In addition, the dominating factor in coping to climate change across all the activities was identified; Having assets such as machinery was the most dominating determinant and access to credit was the least dominating determinant for all coping activities.

5.6 Recommendations

This study recommends the following measures to be done for high farmer participation in rainwater harvesting in dams for coping with climate change

In gardening as a coping activity, the following are the recommendations

I. There is a need for the government and other organizations to involve more women in gardening and empower them with irrigation techniques to enhance their productivity and improve their coping capacity to climate change.

II. There is a need for public and private partnerships to strengthen non-formal education to improve the education status of heads of households.

III. There is a need to advocate the use of agricultural machinery such as rippers, this will increase the adoptive levels of Conservation Agriculture and enable farmers to mitigate and adapt to climate change.

IV. There is a need for NGOs and agricultural training institutions to be engaged in providing extension services to farmers focusing on gardening, unlike the current state where extension services are only provided by the public sector in Siavonga District.

In Livestock as a coping activity, the following are the recommendations

I. There is a need to increase public and private investment and active involvement of Non-Governmental Organizations (NGOs) and voluntary organizations for the promotion of education for members of the head of household.

II. In the adaption of climate change, there is a need for people to invest in livestock such as goats and sheep that are resilient to harsh climatic conditions.

III. There is a need for farmers to invest in machinery that they can use with cattle for draught animal power, this can affect agricultural productivity.

IV. One of the impacts of climate change is the increase in pests and diseases, successful livestock production demands close contact with extension services. There is a need for livestock farmers to maintain contact with extension officers.

In Fishing as a coping activity, the following are the recommendations

I. There is a need for the private and public sectors to empower women in fishing at all levels in the value chain for fishing. This can increase their income and improve their coping capacity to climate change.

II. There is a need for the head of households to improve their education status

III. There is a need to strengthen social capital at the village level and encourage community members to join cooperatives and actively participate in the groups for fishing as a coping activity.

Therefore, in coping with climate change, for effective gardening, females need to be more involved as this was a dominant determinant, while for effective livestock as a coping activity machinery ownership needs to be encouraged and adopted and the education status of the head of house needs to be enhanced for effective fishing as a coping activity. Farmers need to ensure that they have agricultural machinery as this is a dominant determinant that can help them manage climate change in all coping activities.

5.7 Suggestions for future research

This study focused on the determinants of farmer participation in the use of harvested rainwater in dams for coping with climate change. From the results, females have been identified as a dominant determinant for gardening and fishing indicating that women are more involved in agricultural productivity than men. A study will be needed on factors that would determine the participation of women than men in agricultural productivity in the adaptation and mitigation of climate change.

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