The Effects of Household Wealth on Adoption of Agricultural Related Climate Change Adaptation Strategies in Zambia

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Abstract

Despite increased emphasis targeting climate change adaptation strategies towards the poorer sections of communities, few adoption studies assess the uptake of these practices by these groups in a systematic and comprehensive manner. In this study, we used a combination of participatory rapid approaches and quantitative principal component analysis to determine each household's wealth status, and to assess the relationship between wealth and the adoption of various agricultural related climate change adaptation strategies. Evidence from a random sample of 1231 households across six districts of Zambia showed that the more well-endowed households than their poorly endowed counter parts, adopted most of the climate change adaptation strategies. The relatively well-endowed households had a high probability of 10.6%, 9.5%, 7.1%, and 5.5% to embrace crop rotation, minimum tillage, fertiliser trees and change crop varieties due to climate change, respectively, than their poorly endowed counter parts. Most, if not all of these strategies require some level of resource investment hence only those households who could afford such resources are most likely to adopt them. The influence of household resource endowment on the uptake of several climate change adaptation strategies call for the subsidising of the relatively poor endowed households to encourage adoption of these strategies among this category of farmers.

Keywords: Adaptation strategies, principal component analysis, wealth indicators, Zambia

1. Introduction

In recent times climate change has taken centre stage in most parts of the world. In countries like Zambia where the majority of rural communities depend on agriculture, knowing what modifications to agricultural practices have been put in place to cope with climate change could form a good platform in informing policy. Agricultural adaptation strategies could be viewed in the context of new technologies for improving the well being of farmers in the midst of vulgaries associated with climate change. Due to the increasingly high poverty levels of small scale farmers in most developing countries including Zambia (whose poverty level stands at about 60% of total population, World Bank, 2014), policy makers have placed great emphasis on the development and dissemination of new technologies that could improve the well being and enhance food security among the rural poor. In the same vein, it would be important to know whether the relatively poor farmers are embracing adaptation strategies (both proposed by scientists and those emanating from farmers themselves) that enhances their livelihood.

Grandin (1988) noted that poor farmers were likely to have different needs, problems and resources than their better-off counter parts, and thus were likely to have a reduced capacity to adopt new technologies. When the argument is adoption of adaptation strategies on the basis of their potential to mitigate climate change and thus alleviate rural poverty, it is pertinent to know how welfare affects adoption. Thus the objective of this study was to assess the adoption rates of climate change adaptation strategies between relatively well and poorly resource endowed farming households in rural communities of Zambia. Among the adaptation strategies analysed included; changing crop varieties, changing planting dates, crop diversification, crop rotation, planting of

fertiliser trees and implementing some form of conservation farming (minimum tillage through potholing and ripping).

Farmers who face challenges such as prolonged drought spells due to climate change would opt for early maturing crop varieties or would indeed switch their crop planting dates to synchronise with the availability of the rains. Similarly, farmers would want to grow more crops at the same time (diversifying) to ensure that some of the crops would survive the negative effects of climate change. Crop rotation involves varying successive crops in a definite order on the same ground, especially to avoid depleting the soil and to control weeds, diseases, and pests that could have built up as a result of changes in climate. Fertiliser trees are leguminous in nature and are planted in order to achieve one or more of the aims of natural fallows within a shorter time or on a smaller area (Kuntashula & Mungatana, 2015). The trees help in increasing the productivity of smallholder farmers as well as improving on-farm biodiversity that is important in mitigating climate change. According to Arslan et al. (2014) conservation farming has the technical potential to help farmers adapt to climate change and thus contribute to increased food security.

Relatively well resource-endowed farmers have a better ability to cope with production and price risks and consequently are more willing to adopt new technologies than their less resource-endowed counterparts (Hardaker et al., 1997). The well resource-endowed farmers may also be willing to try out adaptation strategies that involve redeployment of available resources. It can thus be argued that novel climate change adaptation strategies might be undertaken by relatively well to do households, thus condemning the poorer households into even deeper poverty levels. The distribution of productive assets among farmers is different (Langyintuo & Mungoma, 2008). The resources required to adopt climate change adaptation strategies will also differ according to inherent requirement of a strategy. The availability of resources at the farmers' disposal, the competition for these resources among farm enterprises, including the need to deploy them in the uptake of climate change adaptation strategies becomes an intricate balancing act by the farmer. The study attempted to seek answers to questions such as what type of adaptation strategies are being adopted by the different wealth groups? This is the first contribution to the body of knowledge on climate change and adaptation strategies in Zambia. However, before this question was answered the study was faced with yet another challenge on how best to categorise farmers into the well-endowed and poorly endowed categories. This study used a combination of farmer participatory and quantitative methods to place households into wealth categories and then proceeded to interrogate the causal relationship between wealth and adoption of various climate change adaptation strategies. This served as the study's second contribution to literature on climate change in the country. Generally, the study found that household wealth has an effect on adoption of most of the climate change adaptation strategies.

The rest of the paper is organized as follows: the next section presents the study areas and data sources. This is then followed by the analytical framework and estimation techniques. Thereafter the results and discussions are presented immediately after this section. Finally the paper gives major conclusions and some policy recommendations.

2. Methodology

2.1 Study Areas and Data Sources

The study areas for this study included six districts (Choma and Sinazongwe in the Southern Region, Nyimba and Petauke in the Eastern Region, and Serenje and Mpika in the Northern Region) of Zambia. The data used in this study was collected in two steps. First, a Climate Change supplemental survey was implemented in 2013 by the Indaba Agricultural Policy Research Institute (IAPRI) and University of Zambia (UNZA) on 1231 households who participated in a nationally representative Rural Agricultural Livelihood Survey of 2012 (RALS 2012) conducted by the Zambia Central Statistics Office (CSO) and IAPRI. The 1231 households were part of a bigger sample that was randomly selected across all the 72 districts of Zambia to serve as a panel for RALS beginning 2012, and to be interviewed every four years. The panel sample was selected through the CSO's national randomisation process (Kuntashula et al., 2014).

Second, complementary data on wealth indicators from the study districts was collected during the farmer participatory wealth ranking exercises of 2013 and 2014. The farmer participatory wealth ranking indicator identification exercises involved community meetings composing key informants of about 15 – 20 farmers in each district. The groups were given the objective of defining wealth groups based on wealth endowment within their communities. First, they listed all wealth indicators in the community. Second, the informants defined wealth categories (very poor, poor etc) of community members. Third, the informants described the differences between the wealth categories based on the wealthy indicators. The list of wealth indicators from these exercises

(complemented with indicators reviewed from literature) formed the basis for computing the wealth indices of the individual households involved in the RALS (2012) and IAPRI/UNZA (2013) supplemental survey.

2.2 Conceptualising Wealth and Other Factors Affecting Adoption of Climate Change Adaptation Strategies

Households have various assets that define their wealth status. These assets fall in various categories including human, natural, physical, financial capital and social capital. Human capital represents the skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives. Natural capital such as land refers to the natural resource stocks from which resource flows and services useful for livelihoods are derived. Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods. Examples of physical capital include various durable and liquid assets. Financial capital denotes the financial resources that people use to achieve their livelihood objectives. These may include access to credit facilities by the households. Social capital refers to the social resources upon which people draw in pursuit of their livelihood objectives. These are developed through networks and connectedness; to membership formalised groups; and relationships of trust, reciprocity and exchanges that facilitate co-operation and may provide the basis for informal safety nets amongst the poor.

In order to maximize utility, households are involved in many activities including adoption of climate change adaptation strategies where necessary. The households' decisions on what to produce with what inputs and what to consume including marketing decisions in a given period are usually derived from the maximisation of expected utility. The wealthier the household is, the more it is likely to maximise this utility. Maximisation of utility is however constrained by a number of factors such as the farmer's budget, access to credit and the availability of information on both the adaptation strategies and other inputs used in the production process. The adoption of adaptation strategies will occur only if adoption is expected to be profitable or will make households better off than in the absence of adoption. Following Ali and Abdulai (2010), the adoption decision can be modeled in a random utility model. The difference between the utility from adoption (U_{AS}) and non-adoption (U_{NS}) of a strategy may be denoted as G^*, such that a utility-maximizing household, i, will choose to adopt a strategy, if the utility gained from adopting is greater than the utility of not adopting ($G^* = U_{AS} - U_{NS} > 0$). Utility is never observed but can be expressed as a function of observable elements in the following latent variable model:

$$G_i^* = \beta X_i + \mu_i \ \text{ with } \ G_i = \begin{cases} 1 & \text{if} \quad G_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where G is a binary indicator variable that equals 1 if a farmer adopted an adaptation strategy and zero otherwise; β is a vector of parameters to be estimated; X is a vector of explanatory variables that favours or hinders adoption of a particular strategy; and μ is the error term.

Most agricultural related climate change adaptation strategies could be viewed as new technologies to farmers. Therefore most literature on agriculture technology adoption logically fits well in conceptualising the adoption of adaptation strategies. The decision to adopt a strategy is affected by the characteristics of the farm household head and the household at large. Household heads are the final decision makers who may decide on adoption of new technologies or strategies on a farm.

Characteristics such as the household's age, education, marital status etc could have an effect on whether the farmer adopts a particular strategy or not. For instance younger farmers may be more innovative and have lower risk aversion behavior although they may also have less farming experience hence the relationship between age and adoption of climate change adaptation strategies may be ambiguous. Female headed households may respond less favourably to adoption of technologies than male headed households due to wealth differences (Ajayi et al., 2003). Some educated farmers could be more willing in trying out new strategies while others would be more conservative in getting involved in unproven practices. Thus, the level of education of the household head is also expected to either enhance or discourage adoption of climate change adaptation strategies. Among the household characteristics, availability of labour is expected to positively affect the farm household's decision to adopt the strategies. Labour directly affects the wealth position of a household.

In most rural parts of Zambia, similar to other developing countries, there are other factors affecting adoption of climate change strategies through their linkage to the wealth status of households. These include the owning of various assets such as farm sizes, livestock, bicycles, radios, belonging to agricultural groups, access to information etc. These variables provide production services and are expected to increase the likelihood of adoption for a given household. In this study all the wealth related variables entered the adoption model through

the wealth index. The variables which were not used in the calculation of the wealth index entered the model as individual variables.

2.3 Calculating the Wealth Index

Ranking households on a wealth scale pose an enormous challenge since each asset contributes differently to households' wealth status. Households can directly be asked to value the different assets in their possession. The draw back with this approach is that different values could be attached to the same asset by various households, as they generally perceive the value of assets differently. Therefore, finding a common factor which could meaningfully be applied to all the many assets owned by the households becomes problematic (Filmer & Pritchett, 1998). To tackle this problem, the same authors suggested the construction of a set of weights based on a common factor which can be applied to all the indicators (such as market or shadow prices). However, the reliability on common factors such as market prices in areas with highly imperfect markets found in rural Zambia renders this option inappropriate for the study. An alternative suggestion by Filmer and Pritchett (1998) is performing a multivariate regression analysis with all assets as unconstrained variables. The challenge with this option is that most assets contributing to the wealth status of households are somehow related; therefore running a multivariate regression could produce misleading regression coefficients due to multi-collinearity problems. However, since this option sounds more plausible, finding possible solutions to the multi-collinearity problem could render this method relevant.

The multi-collinearity problem in the multivariate regression analysis could be solved by using the principal component regression (Filmer & Pritchett, 1998; Wooldridge, 2006). Principal component regression commonly referred to as principal component analysis (PCA) entails extracting from a set of variables or assets those few orthogonal linear combinations of the variables that capture the common information most successfully. Therefore, among the considered options, the PCA technique was found to be a satisfactory approach for this study. To ensure completeness of assets or wealth indicators used in PCA, we carried out a key informant group wealth ranking exercises to identify the important indicators farmers considered in categorising themselves. The wealth indicators from these exercises and from literature were used in the computation of the wealth indices.

2.3.1 The PCA Approach

To compare different forms of assets so that ranking households is objective, normalising the assets becomes necessary. Normalising household assets involved constructing indices scaled from 0 to 1 for each asset. The indices were later aggregated to obtain a composite index that was used for ranking the households. Following Filmer and Pritchett (2001), the indices were scaled from 0 to 1 as follows:

$$i = \frac{x_l - x_{min}}{x_{max} - x_{min}} \tag{2}$$

where i is the index, x_l is the level, while x_{min} and x_{max} are the minimum and maximum values of x, respectively taken from the actual data collected. Once scaled (or normalised), the indicators can be added together without the element of distortion which would be introduced by widely differing value ranges.

With the normalised indices, PCA techniques (Langyintuo, 2008) were used to extract from a set of variables those few orthogonal linear combinations of the variables that capture the common information most successfully. Intuitively the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information that is common to all of the variables. From the normalised indices and PCA output, an overall 'wealth index', for each household was constructed by applying the following formula:

$$W_j = \sum_{i=1}^{k} [b_i(a_{ji} - x_i)]/s_i \tag{3}$$

where: W_j is a standardized wealth index for each household; b_i represents the weights (scores) assigned to the (k) variables on the first principal component; a_{ji} is the value of each household on each of the k variables; x_i is the mean of each of the k variables; and s_i the standard deviations.

A negative index ($-W_j$) means that, relative to the communities' measure of wealth, the household is poorly endowed and hence worse-off while a positive figure (W_j) signifies that the household is well-off. A zero value,

which is also the sample mean index, implies that the household is neither well-off nor worse-off. In this analysis, PCA was run on selected 23 assets or indicators using SPSS as discussed by Langyintuo (2008).

2.4 Analysing Wealthy and Adoption of Climate Change Adaptation Strategies

To evaluate how likely it was that any observed difference between the wealth categories of poorly and well-endowed sets and whether the households had adopted an adaptation strategy or not, arose by chance, a Pearson's chi-squared tests (χ^2) were done. The Pearson's chi-squared tests (χ^2) were complemented by the use of more robust binary probit modeling (Maddala, 2007)whose marginal effects analyses indicated the probability of adopting a strategy given the wealth status of a household.

3. Results and Discussion

3.1 Demographic Characteristics of Households

The descriptive statistics of the sample households are presented in Table 1. The average household size among the surveyed sample was about six members. The households had farm sizes of approximately 3 hectares from which slightly above half, was cropped. Regionally, the farm sizes were slightly smaller in the Northern part of the country compared to Eastern and Southern parts of Zambia. The cropped areas similarly followed this trend. Generally most female headed households have limited resources to adopt certain agricultural practices that could be adaptive to vulgaries of climate change. The overall sample comprised about 20% female headed households. With respect to marital status, 74% of the household heads were monogamously married while 7% were polygamously married. A further12% were widowed with 4% divorced while 1%were separated with 1% never married and 0.1% cohabited. Age of smallholder farmers has an impact on the productive capacity and adopting various climate change strategies. The estimated mean age of the households head in the sample was about 46 years. Furthermore, about 86% of those interviewed had some formal education. Of these, 57% had primary education and 37% had secondary education. About 3% of the respondents reported that they had post-secondary education. The regional distribution of these demographic and socioeconomic characteristics is also shown in Table 1.

Table 1. Descriptive and socioeconomic statistics of sampled households

	Region			Whole sample
	Southern	Northern	Eastern	
Household size	6.3 (0.15)	6.4 (0.13)	5.8 (0.096)	6.1 (0.070)
Age of head (years)	46.6 (0.85)	46.9 (0.82)	45.8 (0.62)	46.3 (0.43)
Farm size (ha)	3.2 (0.22)	2.3 (0.24)	3.2 (0.12)	3.0 (0.10)
Cropped area (ha)	1.8 (0.099)	1.1 (0.064)	2.0 (0.078)	1.7 (0.053)
Female headed households (%)	18.4	20.7	19.4	19.6
Education level of head (%)				
None	6.2	5	22.1	13.6
Primary education	61	55.8	56.6	57.4
Secondary	27.6	36.7	19.9	26.6
Post-secondary	5.1	2.5	1.3	2.5
Marital status of head (%)				
Never married	2.6	0	0.8	1
Married (one wife)	62.1	77.6	76.9	73.8
Married (>one wife)	20.6	2.2	4.7	7.5
Cohabiting	0	0	0.2	0.1
Divorced	2.6	4.4	11.2	4.3
Separated	1.1	1.7	1.2	1.3
Widowed	11	14.1	11.2	12

Numbers in parentheses are standard errors.

3.2 Wealth Ranking Indicators from Farmer Participatory Exercises

3.2.1 The Southern Region

In the Southern Region, the farmer wealth ranking participatory exercises revealed that the main indicators of wealth included animals such as cattle and goats (in the lower wealth categories chickens were also considered), total farm land and area of land cultivated, method of cultivation and for the richer categories, number of vehicles owned.

The very poor in this region are those who did not own any cattle, goats or chickens. They usually use hand hoes to cultivate about 0.25 hectares of land per season and do not possess any vehicles. Close to this group were the poor who own on average 0 - 2 heads of cattle, 1 -3 goats, 10 – 20 chickens and they also use a hand hoe to cultivate about 0.5 hectares of land. The rich households in the Southern region boasted of 20 – 30 herds of cattle, with more than 30 goats, more than 30 chickens, use oxen for cultivation of about 10 – 15 hectares of land and they owned a motor vehicle or 2. The very rich households had more than 50 of each of the livestocks; cattle, goats, chickens and up to 5 vehicles including either a tractor, light truck or a family car. They cultivated more than 15 hectares of land using either oxen or a tractor or a combination of the two.

3.2.2 The Eastern Region

In the Eastern region, the number of cattle, goats, chickens, farm size, cultivated area, whether household hired or sold labour, ability to take children to school, were all mentioned as indicators of wealth. In this region, the very poor had no cattle, goats or chickens and they used hand hoes in cultivating less than 0.25 hectares of land. These usually hired out labour and lived in grass thatched huts and cannot afford assets such as bicycles, radios, television sets or Knap sack sprayers. They cannot afford medical services and are in most cases unable to send their children to school. The poor have characteristics similar to the very poor but some of them can afford to send their children to at least primary level of education, and they had at least up to 10 of each of the following animals and poultry; goats, pigs and chickens. Despite using hand hoes like the very poor, the poor cultivated between 0.25 – 0.75 hectares of land. The rich in the Eastern region had 5 herds of cattle or less, 10 – 19 goats and/or pigs and more than 10 chickens. Most of them hired labour and were able to send their children to school, in addition to having a bicycle, a radio and a television set. The radio and television set are usually powered with car batteries and a solar panel in some instances. They cultivated between 0.75 and 1.5 hectares of land. The very rich owned an iron roofed house with 5 – 40 herds of cattle, more than 10 of each of the following; goats, pigs, chickens and have ox-drawn implements. Further, they owned a hammer mill and a motor vehicle or two. The very rich were also able to send their children to school.

3.2.3 The Northern Region

Unlike the Southern and Eastern regions, the Northern region does not use cattle as one of the measures of wealth indicators. This is because only very few farmers own cattle. Goats and some pigs are owned but in few numbers. The very poor in the Northern region comprised of people who had very small (less than a quarter of a hectare) of farm fields. These people ate only one meal per day during the hunger months (Oct, Nov, Dec, Jan, Feb) and at least two meals after harvest. They could not afford to buy new clothes and usually wore torn clothes. This group of people always made their labour available to others through piece works. In some cases they leave in houses that look deserted. They cannot afford a TV or a Radio. The second category was the poor. This group could afford at least two meals per day in the hunger months. This group farms on about half or 0.5 hectares of land, some within the group can afford a radio and had a few chickens. They were able to buy clothes for their family members. They had some sort of assets which they can point at. The third category was the moderately rich or middle class. They are a few that belong to this group. This group comes from both the poor class and very rich classes. Most of them had a house with a tin roof. They do not sell their labour to other households. They farmed about 1 – 2 hectares of land. They had some goats and chickens. The last category is the super-rich who were very few in the communities and typically possessed a hammer mill and sometimes had a car or cars (tractor/family bus/Open light truck) in addition to the other assets mentioned earlier.

Generally, participatory ranking of households into wealth categories by the farmers themselves, though useful can sometimes produce conflicting results. Although this study did not allow the farmer groups to place each and every known household into a wealth category, indications were that this was not going to be an easy task. This was evidenced by the fact that even agreeing on which indicator should fall in which category was problematic. A distinct boundary between the different wealth groups such as the very rich and the rich could not be consensually determined. The farmers were however very useful in providing indicators which when combined with those from literature, some quantitative manipulations such as that used in this study (PCA), could help towards ranking the households on some form of a wealth ranking scale.

3.2.4 Wealth Indicators Used in PCA

The preceding discussion shows that rural households use various indicators to categorize themselves into wealth categories. The indicators can be different across regions and can also produce inconsistent results in so far as placing a household in a given category, is concerned. For instance a household can be endowed in one or two of the assets that would make it suitable to be in a rich category only to be poorly endowed in other assets hence making the placement of this household problematic. Several authors (Grandin, 1988; Crowley, 1997; Sharrock et al., 1994) suggest that farmers themselves (or key informants) can be allowed to place each of them in wealth categories. Though this would produce reasonably acceptable outcomes, the most obvious problems expected includes failure to obtain a consensus on households who dispute to be placed in certain categories they believe they don't belong to.

The farmer participatory exercises helped to identify important wealth indicators according to farmers own perspectives. These included; animals such as cattle, goats, pigs and chickens, farm size, bicycles, TVs, radios, motor vehicles etc. To present a more objective wealth categorization, the indicators or assets identified by farmers together with those that are important but usually taken for granted such as access to information, group membership and access to credit were used in PCA to rank the sampled households. The mean values of assets used in the analysis are shown in Table 2 while the proportions of households owning some of these assets are shown in Table 3. Results from the structured interviews augmented the PRA findings that generally only few households own cattle (to some extent goats and pigs) and ox drawn related implements in the Northern part of the country (Table 3). The use of draught power was therefore more pronounced in the Southern region followed by the Eastern region. More households in the Northern region however hired more labour than their counter parts from both Southern and Eastern regions.

Table 2. Average number of assets used for wealth ranking in the PCA

……	Southern (N= 272)	Northern (N= 362)	Eastern (N=597)	Whole sample (N=l 1231)
Household hired labour (1=yes, 0= no)	0.16 (0.022)	0.27 (0.023)	0.12 (0.013)	0.17 (0.011)
Household used animal labour (1=yes, 0= no)	0.66 (0.029)	0.01 (0.006)	0.41 (0.020)	0.35 (0.014)
Farm size	3.15 (0.218)	2.47 (0.240)	3.18 (0.116)	2.97 (0.103)
Area planted in hectares	1.81 (0.0999)	1.074 (0.064)	1.97 (0.678)	1.67 (0.053)
Number of ox ploughs	1.44 (0.030)	0.04 (0.014)	0.69 (0.044)	0.53 (0.028)
Household has ox cart (1=yes, 0= no)	0.22 (0.25)	0.02 (0.007)	0.23 (0.020)	0.15 (0.010)
Household has wheel barrow (1=yes, 0= no)	0.11 (0.045)	0.08 (0.015)	0.05 (0.009)	0.07 (0.007)
Number of bicycles	0.78 (0.050)	0.86 (0.043)	0.94 (0.035)	0.88 (0.024)
Household has knack sprayer (1=yes, 0= no)	0.25 (0.026)	0.05 (0.012)	0.12 (0.013)	0.13 (0.010)
Household has solar panel (1=yes, 0= no)	0.26 (0.027)	0.23 (0.022)	0.18 (0.016)	0.21 (0.012)
Number of cell phones	1.10 (0.081)	1.04 (0.059)	0.74 (0.037)	0.91 (0.031)
Number of radios	0.72 (0.047)	0.73 (0.036)	0.69 (0.029)	0.71 (0.020)
Number of tvs	0.24 (0.030)	0.33 (0.035)	0.19 (0.018)	0.22 (0.013)
Number of car batteries	0.21 (0.030)	0.29 (0.034)	0.15 (0.016)	0.21 (0.014)
Number of homes	1.18 (0.053)	0.98 (0.040)	1.10 (0.034)	1.08 (0.023)
Number of cattle*	8.43 (0.989)	7.60 (2.684)	6.15 (0.375)	6.89 (0.409)
Number of goats*	10.92 (1.345)	5.15 (0.456)	6.53 (0.607)	7.30 (0.438)
Number of pigs*	4.94 (0.972)	3.08 (0.551)	6.36 (0.410)	5.94 (0.356)
Number of chickens*	13.38 (0.859)	13.38 (0.961)	11.71 (0.570)	12.56 (0.434)
Access to information (1=yes, 0= no)	0.95 (0.013)	0.87 (0.018)	0.87 (0.014)	0.89 (0.009)
Group membership (1=yes, 0= no)	0.37 (0.029)	0.56 (0.026)	0.43 (0.002)	0.45 (0.014)
Household member size	6.33 (0.150)	6.63 (0.129)	5.80 (0.096)	6.08 (0.069)
Access to credit (1=yes, 0= no)	0.09 (0.17)	0.01 (0.004)	0.25 (0.018)	0.14 (0.010)

*Average does not include those who do not own the asset.
Numbers in parentheses are standard errors.

Table 3. Proportional distribution of assets by households (%)

	Region			Whole sample
	Southern	Northern	Eastern	
Ox plough	65.9	1.9	41.9	33.3
Ox cart	21.7	1.9	20.8	15.4
Wheel barrow	11.4	7.7	5.0	7.2
Bicycle	58.8	63.8	69.5	65.5
Knack sprayer	24.6	5.2	12.2	12.9
Solar panel	26.1	22.7	18.1	21.2
Cell phone	62.5	62.4	51.9	57.4
Radio	59.6	62.7	58.3	60.0
Television set	16.5	22.4	17.4	19.6
Car battery	17.6	22.7	14.4	17.5
Cattle	50.0	2.8	46.6	35.4
Goat	43.8	22.7	34.0	35.1
Pigs	11.4	5.5	33.2	23.3
Chickens	63.4	60.5	64.3	62.2
N	272	362	597	1231

3.3 Household Adoption of Climate Change Adaptation Strategies

Rural households engage in various livelihood strategies to earn a living. The main economic activity among the rural households of Zambia is farming or agriculture. When these livelihood strategies are threatened, the households usually attempt to find a way to ensure a sustained welfare. The surveyed households were asked to indicate what modifications or adaptations they have made to their livelihood strategies as a result of the negative effects of climate change. The various adaptation strategies and the proportion of households adopting them are shown in Table 4. Most of the strategies are agricultural in nature perhaps reflecting the fact that farming is the major enterprise in most rural parts of the country. Going by the overall results, changing crop varieties, changing planting dates and crop diversification were cited as major strategies by more than 20% of the households. Switching crops (crop rotation), planting of fertiliser trees and implementing some form of conservation farming (minimum tillage through potholing and ripping) were cited as major strategies by between 11 and 20% of the farmers. There were regional variations in the uptake of these adaptation strategies (Table 4).

Table 4. Proportion of households adopting climate change adaptation strategies

	Region			Whole sample
	Southern	Northern	Eastern	
Minimum tillage	12.1	5.5	15.4	11.8
Fertilizer tree planting	15.8	9.1	13.2	12.6
Changing planting dates	15.4	29.3	48.7	35.7
Crop rotation	6.6	6.6	32.7	19.4
Change crop varieties	22.8	37.6	53.1	41.8
Crop diversification	21.3	32.9	18.6	23.4
N	272	362	597	1231

3.4 Wealth Ranking of Households

Despite the regional differences in a few assets the categorisation of households into poorly and well-endowed groups produced similar estimates. Sixty one percent of households in the Southern and Northern regions were in relative terms poorly endowed. In the Eastern region 60.3% of the households were poorly endowed. Pooling the data together and repeating the wealth ranking estimation showed that 61.6% of the households were poorly endowed, relative to the communities' measure of wealth (Figure 1).
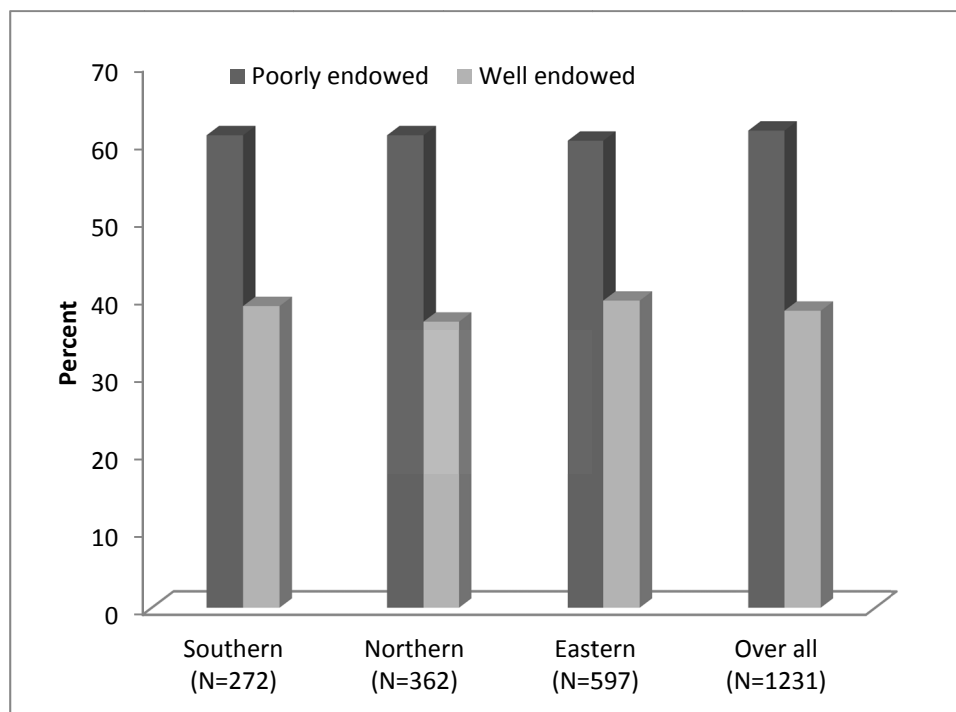
Figure 1. Household assets endowment by regions

3.5 Chi-square Estimates on the Association of Wealth and Adoption of Climate Change Adaptation Strategies

3.5.1 The Southern Region

In the southern region, more well-endowed households than the poorly endowed were associated with minimum tillage ($P= 0.05$), fertiliser tree planting ($P= 0.002$), crop rotation ($P= 0.000$) and changing crop varieties ($P= 0.052$) (Table 5).

Table 5. Household wealth and adopting adaptation strategies in the Southern Region

Adaptation strategy	% households adopting strategy		Pearson Chi-Square	
	Poorly endowed	Well endowed	Value	Asymp. Sig (2 sided)
Minimum tillage	9.0	17.0	3.831	0.050
Fertiliser tree planting	10.2	24.5	9.922	0.002
Change in crop planting dates	15.7	15.1	0.016	0.899
Crop rotation	1.8	14.2	15.950	0.000
Changing crop varieties	19.9	27.4	2.056	0.052
Crop diversification	22.3	19.8	0.237	0.627

3.5.2 The Eastern Region

In the eastern region, more households in the well-endowed category than the poorly endowed category were associated with the adoption of minimum tillage ($P = 0.000$), fertiliser planting trees ($P = 0.059$), crop rotation ($P= 0.003$), changing crop varieties ($P= 0.011$) and use of livestock supplements ($P= 0.024$) (Table 6).

Table 6. Household wealth and adopting adaptation strategies in the Eastern Region

	% households adopting strategy		Pearson Chi-Square	
Adaptation strategy	Poorly endowed	Well endowed	Value	Asymp. Sig (2 sided)
Minimum tillage	7.5	27.4	43.530	0.000
Fertiliser tree planting	11.1	16.5	3.555	0.059
Change in crop planting dates	48.6	48.9	0.006	0.936
Crop rotation	28.1	39.7	8.754	0.003
Changing crop varieties	48.9	59.5	6.454	0.011
Crop diversification	16.9	21.1	1.628	0.202

3.5.3 Northern Region

In the northern region, more households in the well-endowed category than the poorly endowed category were associated with the adoption of minimum tillage ($P= 0.097$), fertiliser planting trees ($P = 0.002$), crop rotation ($P= 0.014$) and changing crop varieties ($P= 0.074$) (Table 7).

Table 7. Household wealth and adopting adaptation strategies in the Northern Region

	% households adopting strategy		Pearson Chi-Square	
Adaptation strategy	Poorly endowed	Well endowed	Value	Asymp. Sig (2 sided)
Minimum tillage	4.5	7.1	1.087	0.097
Fertiliser tree planting	5.4	14.9	9.305	0.002
Change in crop planting dates	28.1	31.2	0.413	0.521
Crop rotation	4.1	10.6	5.995	0.014
Changing crop varieties	33.9	43.3	3.192	0.074
Crop diversification	30.8	36.2	1.138	0.286

3.6 Probit Estimates of the Relationship between Wealth and Adoption of Climate Change Adaptation Strategies

The well-endowed households were almost 10% likely to adopt minimum tillage than their poorly endowed counter parts. Minimum tillage requires some investment in accessing manure and human labour, among others. In addition households who were aware of the consequence of climate change were 6% more probable of adopting minimum tillage. Compared to the Northern region, households from the Eastern and Southern regions had around 9% likelihood of adopting minimum tillage (Table 8).

Table 8. Probit estimates of determinants of adoption of Minimum tillage

Variables	Coefficient	Std. Err	Z	P>IZI	Marginal Effects (dy/dx)
Wealth (1 well-off, 0 otherwise)	0.502	0.106	4.750	0.000	0.095
Sex (1 male, 0 otherwise)	0.179	0.211	0.850	0.396	0.029
Monogamously married (1 yes, 0 otherwise)	0.225	0.176	1.280	0.200	0.369
Education (1 primary, 0 otherwise)	-0.012	0.078	-0.015	0.878	-0.002
Age (years)	0.005	0.003	1.440	0.150	0.001
Access to conservation farming advise (1 yes, 0 otherwise)	0.043	0.107	0.410	0.683	0.007
Distance to town (km)	-0.004	0.002	-1.550	0.121	-0.001
Climate Change awareness (1 yes, 0 otherwise)	0.400	0.133	3.010	0.003	0.061
Eastern Region (1 yes, 0 otherwise)	0.485	0.137	3.530	0.000	0.086
Southern Region (1 yes, 0 otherwise)	0.455	0.163	2.800	0.005	0.093
Constant	-2.568	0.316	-8.130	0.000	
Number of obs*	1184				
LR Chi^2 (10)	74.130				
Prob>Chi^2	0.000				
Pseudo R^2	0.085				
Log likelihood	-399.204				

*Some observations dropped during analysis.

Belonging to the well-endowed category increased the probability of adoption of fertiliser trees by 7.1%. Adoption of fertiliser trees requires some investment in the form of both financial and human capital. Land, tree seeds, hiring of labour etc are some of the items requiring financial outlay. The fertiliser trees are labour intensive hence family labour in addition to hired labour would increase the probability of adopting the technologies. Climate change awareness, being domiciled in Eastern and Southern regions increased the probability of adoption of fertility trees by 7.5%, 4.2% and 6.1%, respectively (Table 9). There was no relationship between household wealth status and changing of planting dates by the farmers (Table 10).

Table 9. Probit estimates of determinants of adoption of fertilizer trees

	Coefficient	Std. Err	Z	P>IZI	Marginal Effects (*dy/dx*)
Wealth (1 well-off, 0 otherwise)	0.347	0.102	3.390	0.001	0.071
Sex (1 male, 0 otherwise)	0.326	0.199	1.640	0.101	0.056
Monogamously married (1 yes, 0 otherwise)	-0.057	0.162	-0.350	0.727	-0.011
Education (1 primary, 0 otherwise)	0.104	0.075	1.390	0.166	0.020
Age (years)	0.000	0.003	-0.030	0.979	0.000
Access to conservation farming advise (1 yes, 0 otherwise)	0.074	0.103	0.720	0.473	0.014
Distance to town (km)	-0.001	0.002	-0.520	0.600	-0.001
Climate Change awareness (1 yes, 0 otherwise)	0.446	0.131	3.410	0.001	0.075
Eastern Region (1 yes, 0 otherwise)	0.217	0.126	1.720	0.085	0.042
Southern Region (1 yes, 0 otherwise)	0.286	0.144	1.990	0.047	0.061
Constant	-2.200	0.301	-7.300	0.000	
Number of obs*	1184				
LR Chi2 (10)	47.120				
Prob>Chi2	0.000				
Pseudo R2	0.092				
Log likelihood	-432.169				

*Some observations dropped during analysis.

Table 10. Probit estimates of determinants of farmers changing planting dates

	Coefficient	Std. Err	Z	P>IZI	Marginal Effects (*dy/dx*)
Wealth (1 well-off, 0 otherwise)	0.008	0.085	0.090	0.927	0.003
Sex (1 male, 0 otherwise)	0.402	0.156	2.580	0.010	0.139
Monogamously Married (1 yes, 0 otherwise)	-0.132	0.138	-0.960	0.337	-0.049
Education (1 primary, 0 otherwise)	-0.095	0.062	-1.530	0.126	-0.035
Age (years)	0.002	0.003	0.730	0.468	0.001
Access to conservation farming advise (1 yes, 0 otherwise)	0.039	0.082	0.480	0.632	0.014
Distance to town (km)	-0.001	0.001	-0.220	0.826	-0.001
Climate Change awareness (1 yes, 0 otherwise)	-0.042	0.094	-0.450	0.652	-0.016
Eastern Region (1 yes, 0 otherwise)	0.469	0.097	4.820	0.000	0.171
Southern Region (1 yes, 0 otherwise)	-0.535	0.126	-4.240	0.000	-0.182
Constant	-0.703	0.224	-3.130	0.002	
Number of obs*	1184				
LR Chi2 (10)	116.480				
Prob>Chi2	0.000				
Pseudo R2	0.075				
Log likelihood	-714.689				

*Some observations dropped during analysis.

The well-endowed households were 10.6% more likely than poorly endowed households, to practice crop rotation due to climate change. To have a variety of crops to rotate, a farmer need to have capital to invest in such crops. Climate change awareness increased the likelihood of practising crop rotation by 5.2%. Households in Eastern region were more likely to practice crop rotation than their counter parts in Northern region (Table 11).

Table 11. Probit estimates of determinants of adoption crop rotation

	Coefficient	Std. Err	Z	P>IZI	Marginal Effects (*dy/dx*)
Wealth (1 well-off, 0 otherwise)	0.422	0.097	4.34	0.000	0.106
Sex (1 male, 0 otherwise)	0.139	0.181	0.77	0.444	0.032
Monogamously Married (1 yes, 0 otherwise)	0.016	0.158	0.10	0.922	0.004
Education (1 primary, 0 otherwise)	-0.111	0.071	-1.56	0.118	-0.026
Age (years)	-0.002	0.003	-0.54	0.590	-0.000
Access to conservation farming advise (1 yes, 0 otherwise)	0.143	0.098	1.47	0.142	0.034
Distance to town (km)	0.001	0.002	0.61	0.540	0.000
Climate Change awareness (1 yes, 0 otherwise)	0.233	0.112	2.08	0.038	0.052
Eastern Region (1 yes, 0 otherwise)	1.019	0.130	7.85	0.000	0.245
Southern Region (1 yes, 0 otherwise)	-0.112	0.171	-0.66	0.512	-0.026
Constant	-1.879	0.281	-6.68	0.000	
Number of obs*	1184				
LR Chi2 (10)	170.23				
Prob>Chi2	0.000				
Pseudo R2	0.143				
Log likelihood					

*Some observations dropped during analysis.

The probability of changing crop varieties due to climate change by the well-endowed households was higher by 5.5%. Changing crop varieties needs financial capital to do so. This is especially true in Zambia where most of the major crops being planted are improved varieties being sold by multinational seed companies. In addition, male headed households, those who were not monogamously married, and households coming from the Eastern and Southern Region, had a high probability of changing crop varieties (Table 12). Wealth status did not have an influence in households' decision to diversify into other crop production activities (Table 13).

Table 12. Probit estimates of determinants of farmers changing crop varieties

	Coefficient	Std. Err	Z	P>IZI	Marginal Effects (*dy/dx*)
Wealth (1 well-off, 0 otherwise)	0.140	0.083	1.690	0.091	0.055
Sex (1 male, 0 otherwise)	0.460	0.151	3.040	0.002	0.170
Monogamously Married (1 yes, 0 otherwise)	-0.312	0.133	-2.340	0.020	-0.123
Education (1 primary, 0 otherwise)	0.019	0.060	0.320	0.750	0.007
Age (years)	0.000	0.003	0.090	0.929	0.000
Access to conservation farming advise (1 yes, 0 otherwise)	0.139	0.079	1.750	0.080	0.054
Distance to town (km)	-0.002	0.002	-1.110	0.267	-0.001
Climate Change awareness (1 yes, 0 otherwise)	0.125	0.092	1.360	0.173	0.048
Eastern Region (1 yes, 0 otherwise)	0.379	0.095	3.980	0.000	0.147
Southern Region (1 yes, 0 otherwise)	-0.468	0.118	-3.950	0.000	-0.174
Constant	-0.669	0.219	-3.050	0.002	
Number of obs*	1184				
LR Chi2 (10)	98.690				
Prob>Chi2	0.000				
Pseudo R2	0.061				
Log likelihood	-755.374				

*Some observations dropped during analysis.

Table 13. Probit estimates of determinants of farmers diversifying crops

	Coefficient	Std. Err	Z	P>IZI	Marginal Effects (*dy/dx*)
Wealth (1 well-off, 0 otherwise)	0.031	0.089	0.340	0.734	0.009
Sex (1 male, 0 otherwise)	0.259	0.167	1.550	0.121	0.072
Monogamously Married (1 yes, 0 otherwise)	-0.039	0.145	-0.270	0.790	-0.012
Education (1 primary, 0 otherwise)	0.078	0.066	1.180	0.239	0.023
Age (years)	0.007	0.003	2.440	0.014	0.002
Access to conservation farming advise (1 yes, 0 otherwise)	0.161	0.088	1.830	0.068	0.047
Distance to town (km)	-0.003	0.002	-0.950	0.051	-0.001
Climate Change awareness (1 yes, 0 otherwise)	0.352	0.108	3.270	0.001	0.097
Eastern Region (1 yes, 0 otherwise)	-0.451	0.101	-4.450	0.000	-0.134
Southern Region (1 yes, 0 otherwise)	-0.291	0.120	-2.420	0.016	-0.081
Constant	-1.354	0.241	-5.610	0.000	
Number of obs	1184				
LR Chi2 (10)	57.200				
Prob>Chi2	0.000				
Pseudo R2	0.095				
Log likelihood	-614.319				

4. Conclusion

The use of indicators from several sources other than only from the farmers provided a holistic picture of what comprises household wealth. This study has shown that from a farmers stand point of view, belonging to groups, access to credit or information or simply social or institutional capital is rarely valued as wealth in rural communities of Zambia. It is the physical, tangible, assets such as farm and animal herd size that counts. The use of farmer participatory wealth exercises in identifying indicators, structured questionnaires in soliciting for information on whether households possessed the assets and in what quantities and PCA in analysing the wealth status of each households within the communities produced an objective wealth ranking measure that helped to place farmers into either the well or poorly endowed groups.

Generally, wealth of households was associated with adoption of most of the climate change adaptation strategies considered in this study except change in crop planting dates and crop diversification. More well-endowed households had adopted minimum tillage, fertiliser trees, crop rotation and changing crop varieties. Most if not all of these strategies require some level of resource investment hence only those households who can afford such resources are likely to adopt them. Subsidising the relatively poor endowed households may encourage adoption of these strategies among this category of farmers.

Although warranting further investigation, intuition would suggest that the value of the strategy in immediately providing food security and its relative cost to the other strategies affected the levels of adoption of these strategies. For instance regardless of the wealth status of the farmers, changing crop varieties, changing planting dates and crop diversification were cited as major strategies by most of the households. This was followed by crop rotation, fertiliser tree uptake and minimum tillage, in this order. Changing crop varieties, changing planting dates and crop diversification would immediately provide the much needed food. On the other hand strategies such as crop rotation, soil fertility enhancing trees and minimum tillage ensure the long term sustainability of the production system and might be associated with delayed benefits.

The adoption of some of the strategies also show regional biasedness perhaps reflecting the way the extension system in the country has discouraged the uptake of certain practices in certain areas. For example, conservation farming comprising minimum tillage and planting in potholes, or ripped trenches has been discouraged in agro-ecological region III of Zambia that receive more 1000 mm of rainfall annually (Langmead, 2015). Results from this study are consistent with this message. For the Northern region whose vast areas falls in region III, very few households from both the well and poorly endowed categories embraced minimum tillage as a climate change adaptation strategy.

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