4thICAAAE 2013 SEPTEMBER 22-25, Hammamet Tunisia
4th International Conference of the African Association of Agricultural Economists
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Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia

Exploring use of livestock wealth and social capital by pastoral and agro-households in ASALs as insurance against climate change and variability risks: A case study of Samburu District in Kenya

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Abstract

We explore households coping and adaptation strategies to climate change and variability in Arid and Semi-Arid Lands (ASALs) using data collected from 500 households across Samburu District; Kenya. We hypothesised that as we move from wet to dry areas, households' accumulate livestock wealth, structural and cognitive social capital as insurance against risks and shocks associated with climate change and variability. In testing the hypotheses, for robustness we used two approaches: simple regression and generalized linear model. Results from both approaches supported hypotheses that households accumulate livestock wealth and structural social capital as insurance against risks as we move from wet to dryer areas. Results from simple regression analysis showed that rain do not matter for cognitive social capital for all households as we move from wet to dryer areas. However, results from generalized linear model indicated that rain matters for cognitive social capital for the poor and financially integrated but not the rich households. The accumulation of cognitive social capital was therefore not generalizable but was rather contingent on household endowments. To improve households coping and adaptation abilities, it is therefore desirable to promote measures aimed at enhancing livestock wealth and structural social capital as form of insurance for household in Arid and Semi-Arid lands. The results also showed that measures aimed at enhancing cognitive social capital can help poor households as a social insurance safety net to cope and adapt to risks associated with climate change and variability.

Key words: climate change, variability, Insurance, Social capital, Cognitive, Structural, Livestock, Kenya.

1. Introduction

For centuries now, to varying degree, households communities and nations have had to cope with or adapt to climate change and variability related risks and shocks (O'Connor and Kiker, 2004). This is particularly so for households whose main source of livelihoods is farming. Predictions from climate modeling research indicates that negative effects arising from climate change and variability in terms of frequency and intensity are likely to be felt more in Africa (Desanker and Magadza, 2001; Davies *et al.*, 2009; Intergovernmental Panel on Climate Change (IPCC), 2001a). This is because in Africa majority of households are poor and relies mainly on rain fed agriculture making them vulnerable to climate related risks (ADB et al., 2003; Fafchaps, 2004; Goulden, 2005; Stern, 2006).

Poverty in Sub-Saharan Africa (SSA) is prevalent in rural areas, where majority households depend on agriculture for food and income. Agriculture accounts for about 30% of SSA gross domestic product (GDP) (Delgado *et al.*, 1999; Thornton *et al.*, 2006). Agricultural sector is highly susceptible to disturbances associated with climate change and variability, particularly in Arid and Semi-Arid Lands (ASALs)(Kikar, 2000). Approximately 41% of ASALs in SSA are situated in East and Southern Africa and are mainly occupied by livestock keeping households; pastoralists and agro-pastoralists (Ogle, 1996; Tessema, 2012). Pastoralism is a production system, which involves livestock mobility and use of natural pastures (Butt *et al.*, 2009; Tessema, 2012). Pastoralists are households whose way of life, socio-cultural norms, values and indigenous knowledge revolves around livestock keeping and transhumance in order to utilize natural pastures (Cohen, 1974, P. 126; Koocheki and Gliessman, 2005; Ayatunde *et al.*, 2011). On the other hand, agro-pastoralists are households who incorporates crop faming alongside livestock keeping and transhumance (Swift *et al.*, 1996; Tessema, 2012).

In Kenya, ASALs occupy approximately 87% of the total area and supports; more than 30% of the total human population, the entire camel population, 50% cattle, 70% sheep and goats (SRA, 2003; Government of Kenya, 2004; Otuoma, 2004). These areas are characterized by low and unreliable rainfall ranging between 400 to 700 mm (Otuoma, 2004). Consequently, pastures are greatly reduced especially during droughts resulting to high livestock mortalities and low crop yields (World Bank, 2005; Shanguhyia, 2008; Alinovi *et al.*, 2010). Droughts are thus, the most relevant climate related shocks that households have had to cope and adapt (Goulden, 2005; Vogel, 2005; Silvestri *et al.*, 2012b). Coping refers to the use of endowments and entitlements by households to ensure survival after the shocks (Howden *et al.*, 2007; Agrawal, 2008). Adaptation, though crafted in part by coping strategies, is a long term set of action taken maintain the ability to deal and recover from current and future stress and shocks while maintaining assets and capabilities (Campbell, 1999; Valvidia *et al.*, 2003; Nelson *et al.*, 2007). However, it is worth noting that coping and adaptations strategies take place at different temporal and spatial scales (Agrawal, 2008).

1.1 A review of coping and adaptation strategies to climate change and variability in ASALs

In ASALs, adaption strategies adopted by households are based on three pillars of pastoral livelihood systems which include; natural resources, livestock keeping and organised use of communal resources (Broekhijsen, 2010). Essentially, five coping strategies, namely; 1) food sharing, 2) increased asset sales 3) diversification, 4) reliance on food aid, and 5) local institutions have been observed to gain prominence (Paxson, 1992; Besley, 1995).Food sharing is based on the uncorrelated covariant risks over wide geographical areas, such that households shares their harvest with those affected, hoping that next time they will get assisted too (Campbell, 1984, 1999). Increased asset sales is practiced for welfare gains in order to cover households basic needs when faced with risks and shocks (Naess *et al.*, 2010; Tessema, 2012, P. 28).

Diversification helps to exploit alternative livelihood resources not affected by the climate change and variability related shocks (Galaty and Johnson, 1990). It ranges from production of different products, herding different livestock species to other activities such as brewing, charcoal burning and sale of traditional herbs (Bollig, 2006; Cousins *et al.*, 2007; Broekhijsen, 2010). Diversification is reliable to an extent that benefits flowing from various resources are subject to uncorrelated covariant risks (Ellis, 2000; Young and Lipton, 2006). Nevertheless, diversification is not attributed to a single cause, but rather a combination of increased market integration, changes in land use policies and increased climatic uncertainty (Abule *et al.*, 2005; Cousins *et al.*, 2007; Naess *et al.*, 2010). Reliance on food aid has become common, particularly in areas accessible to support programs. However, reliance on food aid is risky in that if unavailable, households have nothing to depend on (Notenbaert *et al.*, 2012).

Local institutions hereby refers to various forms of community based, social or grass-root associations that are found within communities, but which sometimes are not "visible" as formal institutions such as development agencies. They can also be referred to as the "informal rules of the game"(North, 1990; Nugent, 2001) formed for the purpose of managing common resources (Ostrom, 1990; Pretty and Ward, 2000) and can be based on kinship, caste, religious beliefs, community relations, family ties or social entrustment (Binswanger and Mcintire, 1987). As a coping strategy, local institutions provide support which ensures households livelihood are safeguarded and enhanced (Tompkins and Adger, 2004; Broekhijsen, 2010). For example, since an agro-pastoral households cannot farm and take advantage of transhumance at the same time, they entrust their livestock to other mobile pastoralists (see for example Moritz, 2008).

1.2 *Theoretical underpinning*

This study is based on the roles of endowments and privileges for coping and adaptation framework (Sen, 1981). According to Sen (1981) famines observed in Bengal in the 1940s were not due to lack of food but, rather exhaustion of endowments and privileges. Relevant asset endowments for households coping with and adapting to climate change and variability are physical, human, natural, financial, and social capital (see Box A in Figure 1) (Smithers and Smit, 1997; Adams *et al.*, 1998; Eriksen *et al.*, 2005). Entitlements shape households ability to cope and adapt (Valvidia and Gilles, 2003; Valvidia *et al.*, 2003; Adger *et al.*, 2007). Chambers and Cornway (1992) argue that vulnerable households have neither enough assets nor capabilities to gain access to them and as such cannot cope with crises. One important strategy which is useful for decreasing vulnerability is accumulation of livelihood assets (Ellis, 2000). In their paper, Binswanger and McIntire (1987), notes that as we move from wet to dry areas climate change and variability related risks tend to increase. To counteract these risks households are thus likely to rely heavily on livestock wealth unlike areas of higher agricultural potential.

Furthermore, in their paper Binswanger and McIntire (1987) notes that in ASALs high covariance in activities also implies high covariance in risks. The main consequence of geographical isolation, covariant risks and moral hazard is absence of insurance for crop and livestock. Since collateral option are extremely limited in land abundant areas such as ASALs, market-credit link cannot serve as important collateral substitute as demonstrated by Binswanger and McIntire (1987). Consequently, households tend to look for alternative ways for self-insurance through social capital such as extended families (Stern, 2006; Stern, 2008; Davies *et al.*, 2009). The livelihood framework describes social capital as being derived from social ties or networks which requires investment in order to derive current and future benefits. In column B of Figure1, the livelihood framework shows how access to assets are modified by social capital. We use livelihood framework to study how household respond to risks, shocks and stresses (see column C of Figure 1) associated with climate change and variability in ASALs. Objectives of this study were to explore households coping and adaptation strategies to climate change and variability in ASALs in Kenya. Attention was devoted in exploring whether indeed households accumulate livestock wealth and social capital as insurance strategies to climate change and variability related risk as we move from wet to dry areas. We used sampled data collected through structured interviews, field measurement and direct observation information. We took a research approach informed by application of livelihood framework (Chambers, 1995) for household level data collection and econometric approach for data analysis. The specific research questions were; (i) Do households accumulate livestock wealth as an insurance against risks and stress associated with climate change and variability as we move from wet to dryers areas? (ii) Do households accumulate structural and cognitive social capital (CSC) as insurance against risks and stress associated with climate change and variability as we move from wet to dry areas? (iv) Do accumulation of livestock wealth, structural and cognitive social capital as insurance against risk associated with climate change and variability for the two orthogonal gradients: environmental dryness and market access gradients, varies? (v) How does market access and household livelihood variables affect livestock wealth, CSC and structural social capital (SSC)? In this study, we hypothesized that households tend to accumulate livestock wealth, structural and cognitive social capital as insurance against risks associated with climate change and variability as we move from wet to dry areas.

2. Methodology

2.1 Study area

The study was conducted in Samburu District: an arid and semi-arid district in Rift Valley Province of Kenya. The district is situated between 00^0 36 and 20^0 40 N and 36^0 20 and 38^0 10 E, covers an area of 21,000 km^2 and has a population density of 11 Persons km^{-2} (Government of Kenya, 2009b). The climate is hot and dry with mean monthly temperature varying between a minimum of 24°C in July and a maximum of 33°C in December (Government of Kenya, 2005). The rainfall is highly variable, with an annual rainfall ranging between 250 and 700 mm in the plains, and between 750 and 1250 mm in highland areas. The rainfall distribution is bimodal with the long rains occurring between March and May, and short rains between July and August in the north and October and November in the east. The altitude ranges between 1,000 m on the plains to 2,752 masl in the highlands (Government of Kenya, 2005). The district is characterized by strongly contrasting landforms at various altitudes and very different rock types (mainly gneisses and granites). Soil types vary with altitude and steepness of the terrain. Sandy clay loam soils are common on the plains, while thick humus rich topsoil's are common at higher altitude, where forests are still intact (Touber, 1989). Vegetation are dominated by Acacia woodlands namely; *Acacia tortilis, Acacia recifiens* and *Boscia corriace* and sparse grasslands. The district is ranked the second poorest in Kenya (Government of Kenya, 2009a). Pastoralism is the main economic activity, with about 80% of the households being livestock keepers (Kadohira *et al.*, 1997; Government of Kenya, 2005). The main livestock kept include goats, sheep, cattle and camels. Cash for buying maize which is the main staple food is derived mainly from livestock sales. However, wage labor (mainly livestock herding) to supplement household income is also common.

2.2 Sample selection

Field survey was conducted from February to May 2012 across 500 households, who were sampled randomly from five locations namely; Barsaloi *(block I)*, Swari *(block II)*, Londunokwe *(block III)*, Maralal *(block IV)* and Wamba *(block V)* as shown in figure 2. Household selection was done through multi-stage cluster sampling. To take into account environmental dryness and market access gradients, the five locations were selected purposively (first stage cluster sampling)(Scheaffer *et al.*, 1979; Nyariki, 2009). In second stage, three sub-locations were selected from each location. In the third stage, 10 villages were randomly selected from the three sub-locations, to end up with a total of 50 villages. In the fourth stage, 10 households were randomly selected from village sampling frames, that had been developed with the assistance of Chiefs (Nyariki, 2009). Finally, the interviews were conducted using structured questionnaires with the help five trained local enumerators.

Figure 2 (about here)

2.3. Data collection and measurement

2.3.1 Human

We collected comprehensive data on five type of capital that constitute household livelihoods.Table 1A summarize human capital variables. To measure the 'household size', the respondents was asked to list all household members who live (i.e. sleep in the same home), share production and consumption (i.e., eat from the same food pot) activities. Information on the household size was then used to compute 'human dependence ratio' (HDR). That is, the proportion of household members aged below 15 and above 65 years of age to the total household size (Babu and Sanya, 2009). 'Household size' was measured in terms of adult equivalent (AE).The values used for AE were; 1 if a household member was aged between 15 and 65 years, 0.5 if a member was aged between 6 and 14 years or older than 65 years and 0.25 if age of household member was less than 5 years.

Household age was measured by asking respondents how long household heads had lived since birth (or year of birth). Level of education was measured by asking respondents number of years that household heads had spent on education. Data for gender was collected by assigning dummy variable of 1 if household head was male. Experience in farming was measured by asking number of years that household heads had been involved in farming. We used a dummy variable 1 for households with at least one chronically ill member during the last 12 months. Households that had utilised hired labour during the last 12 month were assigned a dummy variable of 1.

Table 1 (about here)

2.3.2 Natural

Table 1B summarises natural capital variables. The 'cultivable farm area' was measured by pacing the boundaries of each of the households' fields. To assess 'resource use constraints' we asked two questions for the following resources: forest, water and pastures. The two question asked were ; i) whether households pay to access the natural resource and ii) whether there are rules regulating access and use of the natural resources. Responses were assigned a dummy value of 1 for yes and 0 for no. The responses were average into a single value for 'natural resource use constraint'. The variable 'resource use frequency' was computed by summing number of times household had used the natural resource per week. The frequency totals were then normalised to a 0-1 scale. We include the 'natural resources constraint' because drought and poor livestock prices may make households to pursue alternative income generating activities such as charcoal burning (Abule *et al.*, 2005).

2.3.3 Financial

Table 1C summarizes financial capital variables. Access to credit was measured by assigning a dummy variable of 1 to those who reported to have had access to credit during the last 12 months. Financial saving was measured by assigning a dummy variable of 1 to households who had saved money during the last 12 months. Crop, communal and livestock incomes were calculated using revenues from crop, communal products, livestock and value of consumed products as shown in equation (1), (2) and (3).

Total net crop income

$$T\_cinc_i = Csale + VcP - Crcost_i \quad (1)$$

Where:

T_cinc_i is total annual crop income for household i

$Csale$ is annual income from crops

VcP is annual monetary value of consumed crop produce

$Crcost_i$ is annual direct cost of production for household i

Communal income

$$T\_COMinc_i = CPsale + VcCP - CPcost_i \quad (2)$$

Where:

T_COMinc_i is total income from communal products for household i

$CPsale$ is annual income from sale communal products (such as charcoal, poles and timber)

$VcCP$ is annual monetary value of consumed communal product (such as wild fruits and vegetables)

$CPcost_i$ is annual direct cost related to harvesting of communal products for household i

Total livestock income

$$T\_linc_i = Lsale + Lprod + VlP - Lcost_i \quad (3)$$

Where:

T_linc_i is total annual livestock income for household i

$Lsale$ is annual income from livestock sales

$Lprod$ is annual income from sales of livestock products

VlP is annual monetary value of consumed livestock products

$Lcost_i$ is annual direct cost of livestock production for household i

2.3.4. Physical and social capital

The physical capital variable is summarised in Table 1D. The value of households assets was generated by summing up the value (using the current market price) all items and farm implement for each household. Table 1E summarizes the indicators of social capital variables. To measure ‘cognitive social capital’ (CSC) the respondents were asked whether they trust fellow villagers or not. A dummy variable of 1 was assigned to those who responded yes. ‘Membership to community groups’ was measured by counting community groups which households head were members. To measure 'degree of participation in community group meetings' household were asked to rate their degree of participation on a 0-4 (low to high) point scale. The 'participation in group activities' was measured by assigning a dummy variable 1 for participation in activities such as election of leaders, campaigns and conflict resolutions. These dummy values were then averaged for each household so that a value of 1 indicated full participation in all group activities and 0 no participation at all.

2.3.5 Market access and climate variables

Table 2 summarizes market access variables (X_i). The distances from each homestead to the; tarmac road, motorable road, local market and urban market were all measured in km by the researcher. However, the distances from homestead to the livestock market were calculated using ArcGIS software. A dummy variable 1 was assigned to household with mobile phones. In this study we used rain as proxy for environment dryness (south to north as shown in Figure 2). This is because rain has been regarded as the most important climate parameter affecting household livelihoods and consequently their activities (Vogel, 2000; Assan *et al.*, 2009). Moreover, past research have shown that as the rain decreases; the variability in output increases, number of possible activities that households can engage into decreases, and covariance risks in those activities increase, while vice versa is true for high rainfall areas, implying that semi-arid tropic are more risky (Binswanger and Mcintire, 1987). The rainfall data is from (Hijmans *et al.*, 2005) and is based on WorldClim – Global climate data (WC-GCD) database. The WC-GCD data are computed from monthly temperature and rainfall from local rain station gauge measures and then corroborated against satellite data of cloud cover and precipitation to generate more biologically meaningful variables. WC-GCD provides set of climate layers on global scales with a spatial resolution of about a km (Hijmans *et al.*, 2005). We used rainfall data covering a period of 50 years (1950-2000) to calculate the average annual rainfall for 1x1 km pixel for households under study.

Table 2 (about here)

2.4 Empirical strategy

2.4.1 Computation of livestock wealth indices (LWI)

The livestock wealth index (LWI) was computed using three components: the 'monetary value of livestock' that households had at the time of survey, 'net income from livestock sales' and 'net income from sale livestock products.' Each of these component were computed via a balanced weighted average to contributes equally to the overall livestock wealth index (Sullivan, 2002). The three components variables were then standardized as an index using equation (4) below that was originally adapted from human development index (HDI) to calculate life expectancy index, which is the ratio of the difference of the actual life expectancy and pre-selected minimum and maximum life expectancy (United Nation Development Program (UNDP), 2007 as cited in Hahn's et al., (2009).

$$\left(G_i = \frac{S_i - S_{min}}{S_{max} - S_{min}}\right) \qquad (4)$$

Where:

G_i is an index for each of the components for household i

s_i is the original value for each of the components for household i

s_{min} and $s_{\max}$ are the minimum and maximum values for each of the component

After the components were standardized, they were then averaged using equation (5) to compute livestock wealth index (LWI)

$$\mathrm{LWI}_i = \frac{\sum_{i=1}^{n}(G_i)}{n} \quad (5)$$

Where:

LWI_i is the livestock wealth index for household i

2.4.2 Computation of structural social capital (SSC)

The social capital index (I) was computed using three variables: 'membership to community groups', 'degree of participation in group meetings' and 'participation in group activities'. These variables were then standardized as an index using equation (6) below.

$$\left(R_i = \frac{P_i - P_{min}}{P_{max} - P_{min}}\right) \quad (6)$$

Where:

R_i is index for each of the four variables constituting SSC for household i,

P_i stand original value for the four variables constituting SSC for household i,

P_{min} and P_{max} are the minimum and maximum values for each of the four components constituting SSC

After standardization, the three variables were then averaged using equation (7) to compute SSC index for household i,

$$\mathrm{SCC}_i = \frac{\sum_{i=1}^{n}(R_i)}{n} \quad (7)$$

2.5 Data analysis

We adopted two approaches in data analysis for robustness: simple regression and general linear model approach

2.5.1 Simple regression approach (SRA)

We used SRA to test the hypotheses whether households accumulate; livestock wealth, cognitive social capital (CSC), structural social capital (SSC) and social capital (as linear combination of CSC and SSC) as environmental dryness increases (see Fig. 2), while controlling for market access variables and household characteristics. We start the analysis by using the whole sample ($n = 500$). Then to increase robustness of the analysis, we test the hypotheses using sub-sample households in block I, II and IV ($n = 300$). At this stage, we exclude households in sampling block III and V because they were closer to urban centers: Maralal and Wamba towns (see Fig. 2). That is, block III and V are different from blocks I, II and IV by other parameters (market) apart from rainfall. Finally we test the hypotheses using sub-sample ($n = 300$) households in blocks III, IV and V falling along the market access gradient (Fig.2). We therefore run three independent regressions using a SRA model specified in equation 8 below

$$Y_i = \propto + \delta_1 rain + \delta_2 X_i + \delta_3 C_i + \varepsilon_i \quad (8)$$

Where:

Y_i stand for dependent variables (LWI, CSC and SSC) for household i

X_i represents vector for market access control variables for household i

C_i represents vector for livelihood variables for household i, and

ε_i stands for error term associated with household i

2.5.2 General linear model (GLM)

Using the GLM approach, instead of controlling for household characteristics, we used agglomerative hierarchical analysis to reduce dimensionality of SLF capital variables (Fig. 1) summarized in Table 2.1 by clustering households into homogenous groups (HGs). The clusters aimed at maximizing between and minimizing within cluster variances as shown in Figure 3. To identify ideal HGs for use in testing our hypotheses, the means for all 16 variables were compared starting at a random rescaled distances (RD) of 11, then 14 and finally at 18 (Fig. 3), where we had (7), (5) and (3) HGs. At RD of 11 we found that HG2, HG3, HG4 and HG5 were clustered around human capital variables (Table 4). At RD of 14, we found that the main disaggregating variables for HG2, HG3 and HG4 were still human capital variables (Table 5). This motivated us to probe further. At RD of 14, we found that none of the three HGs was clustered around human capital variables per se (Table 6). Figure 4 shows the distribution of households in the three HG's as we move from dyer to wetter areas. The three HG's namely (the rich, the poor and the financially integrated households were thus considered as a good basis for testing our hypotheses using equation (5) below.

$$Y_i = \propto + \delta_1 D_1 + \delta_2 D_2 + \delta_3 I_{r1} + \delta_4 I_{r2} + \delta_5 X_i + \delta_6 R_i + \varepsilon_i \quad (5)$$

Where:

Y_i is the dependent variables (LWI, CSC and SSC) for household i

$\delta_1 to \delta_6$ are the parameter estimates,

D_1 is the dummy variable equal 1 for the HG1, and 0 otherwise

D_1 is the dummy variable equal 1 for the HG2, and 0 otherwise

I_{r1} is the interaction terms for rain and HG1

I_{r2} is the interaction terms for rain and HG2

X_i represents vector for market access control variables,

R_i is the mean annual rainfall for household i for the 50 years period, while

ε_i stands for error term.

Table 3, 4, 5 and 6 (about here)

Figure 3 and 4 (about here)

3. Results

3.1 Result based on SRA

Table 7 present our finding on LWI hypothesis. The results in columns (1) to (6) of Table 7 show that livestock wealth significantly (P<0.1) increases as the rain decreases (i.e., as we move from wetter to dryer areas) when across all households. The results are thus consistent with our hypothesis that, as we move from wet to dryer areas, households tend to accumulate more livestock wealth as insurance against risks associated with climate change and variability. Column (1) to (6) shows that distances to the motorable roads and livestock market had a positive and significant (P<0.05) correlation with livestock wealth, implying that households close to motorable road and livestock market had low livestock wealth. The results in column (1), (3) and (5), shows that mobile phones had positive and significantly (P<0.001) associated with livestock wealth across all households. But when we control for households characteristics, mobiles phones are no longer significant for households in south-north gradient (see column (4)). This implies that most of the effects for mobile phones were originating from households along market access gradient (see column (6)). The remaining results in Table 7 show the following;

(i) Total value of household assets had a positive and significant (P<0.05) association with livestock wealth as the environment get dryer;

(ii) Household gender had a negative and significant (P<0.1) correlation with livestock wealth, implying that livestock wealth was lower among female headed households as the environment got dryer. However, most of this influence were from households along market access gradient (see column (6)),

(iii) 'Financial savings' had a positive and significant (P<0.05) correlation with livestock wealth, implying that households who had saved money during the last 12 months and those who practiced cropping had higher livestock wealth. However most of the influence were emanating from households along the market access gradient;

For household along the market access gradient, results in column (6) shows that 'cultivable farm size' had positive while 'natural resource use constraint' had negative but significant (P<0.05) correlation with livestock wealth. This implied that along the market access gradient; households whose farm size were large, also had higher livestock wealth; and livestock wealth was more among households with low 'natural resource use constraint'

Table 7 (about here)

Table 8 present our finding on CSC hypothesis. The results in columns (2), (4) and (6) of Table 8 shows that when we control for both market access variables and households livelihood variables the CSC does not increase as the environment becomes dryer. Consequently, we reject null hypothesis that as we move from wetter to dryer areas households tend to accumulate more CSC as insurance against risks associated with climate change and variability. Further, the result in column (2) of Table 8 also shows that;

(i) Distance to tarmac roads and ownership of mobile phones had negative and significant (P<0.1) association with CSC, implying that households far from the tarmac roads and those who own mobile phones had low CSC. However, most of the influence by tarmac roads on CSC were originating from households along market access gradient (see column 6), while most influence by ownership of mobile phones was emanating from households mainly along the environment dryness gradient (see column 4);

(ii) Distance to livestock markets, household gender, use of hired labor and 'natural resource use constraint' had a positive and significant (P<0.05) influence on CSC for all households, implying that households: close to livestock market, headed by female, that does not use hired labor and those with low 'natural resource constraint' had low CSC. Nevertheless, most of the influence on CSC by 'natural resource use constraint' was originating mainly from households along the market access gradient (see column 6);

(iii) Crop and communal incomes had a negative and significant (P<0.05) association with CSC, implying CSC was low for households with high crop and communal products based income.

The results in column (4) of table 8 shows that distance to the livestock market had a positive and significant (P<0.05) association with CSC only for households along the south-north gradient. This imply that along the south-north gradient, households close to the livestock market as expected had low CSC.

Table 8 (about here)

Table 9 present results on SSC hypothesis. The results in column (1) to (6) shows that when we control market access and household livelihood variables, SSC increases as the environment becomes dryer. This finding is consistent with our study hypothesis, that as we move from wet to dry areas households tend to accumulate SSC as implicit insurance against risks. The remaining results in column (2) of Table 9 also that: (i) Distance to tarmac roads was negative and significantly (P<0.001) correlated with SSC across all households, implying that SSC was higher for households close to tarmac roads. (ii) Mobile phones had a positive and significant (P<0.05) correlation with SSC, implying that households with mobile phones had a higher SSC. Most this influence, however, was emanating from households along market access gradient (see column 6). (iii) Household size and access to credit had a positive and significant (P<0.05) association with SSC, implying that households that were large in size and who had accessed credit during the last 12 months had more SSC. However most of these influences were originating mainly from households along the market access gradient (see column 6). (iv) Age of the household head had a negative and significant (P<0.01) correlation with SSC, implying that aged households had low SSC. Most of this influence, however, originates from households along the south-north gradient. (v) Years lived in village by households head had a positive and significant (P<0.05) correlation with SSC, implying that households who had lived long in village had as expected higher SSC. Most of this association, however, was originating from households along south-north gradient.

In addition, results in column (4) showed that for households along the south-north gradient: Distances to motorable road was negatively but significantly (P<0.001) correlated with SSC, implying that households near motorable roads had more SSC; human dependence ratio (HDR) had a positive and significant (P<0.1) correlation with SSC, implying that households whose HDR was large had a high SSC and as expected, ‘cultivable farm size’ had a negative and significant (P<0.1) association with SSC, implying that households with small farm sizes had higher SSC.

Table 9 (about here)

3.2 Result based on GLM

The results in columns (1) and (2) in Table 10 showed that households have fewer livestock where environment is wet; and HG2 were particularly poorly endowed with livestock (in wet and dry areas alike). Since none of the interaction effect (group x rain) was significant, we have no evidence for group specific responses to dry environment. However, the results in general indicate that people have more livestock when the environment is more hostile (dryer), which is consistent with the study hypothesis. These results are thus consistent with study hypothesis that livestock wealth increases as we move from wet to dryer areas for all households.
In an attempt to go beyond significance of the results and interpret what the magnitude of the coefficient implies, we included results in column 3 of Table 10. The results in columns (2) and (3) shows that when rain increases by one unit holding other factors constant, then:

(i) Livestock wealth for HG1 decreases by 0.00019 (i.e., -0.00025+0.00006), which is equivalent to a decrease in livestock wealth equivalent to Kshs. 378.77 (i.e.-806.2506+427.4803). Since, the cost of tropical livestock unit (TLU) in Samburu at the time of survey was on average Kshs. 24000. The results suggest that an increase in rain by 1 unit leads to a decrease in cattle by 0.015 (-378.7703/24000) TLU which is equivalent to a decrease of 1.5% (i.e., 0.015*100).
(ii) Livestock wealth for HG2 decreases by 0.00007 (i.e., -0.00025+0.00018), which is equivalent to decrease of Kshs. 61.46 in livestock wealth (i.e.,-806.2506+744.7914). This implies a decrease in cattle by about 0.0025 TLU (i.e., -61.4592/24000) which is also equivalent to a decrease of 0.25%.

(iii) Livestock wealth for HG3 decreases by 0.00025, which is equivalent to a decline in livestock wealth equivalent to Kshs 806.2506 or 0.033TLU (i.e., 805.25/24000). This is equivalent to a decrease of 3.3%.

These indicate that a households moving from HG3 to HG1 would lose 12.37 TLUs (i.e., 23.16-10.79) or livestock wealth equivalent to Kshs. 292,977 (partial derivative of LW with respect to HG1 or ∂LW/∂HG1). While, if a household moves from HG3 to HG2, they would lose 20.87 TLUs (i.e., 23.16-2.29) which is equivalent to Kshs 501,459.9 (i.e., ∂LW/∂HG2).

Table 10 (about here)

The results in Table 11 shows that people in the wet environment have lower CSC, and compared to HG3, we find that HG1 (the farmers) have low CSC. There is no difference (in terms of CSC/trust) between the poor households (HG2) and the mature/financially integrated households (HG3). However, when we move from wet to dry environment, we find that HG1 is characterised by lower CSC (relative to HG3). Nevertheless, because the magnitude of interaction terms (HG1 x rain) is of the same magnitude as the rain levels variables (i.e., since when we add them up it equals zero (-.0017+.0018=0.0001)), implying that there is no effect of rain on CSC for HG1. The remaining effects in Table 11 show two things: First, for HG1 the CSC is lower in the rainy area. Second, that HG2 has lower CSC than HG3. Therefore, results in Table 11 suggest that when rain increases by one unit, at *ceteris paribus*, then:

(i) the CSC for households in HG1 decreases by 0.00 (i.e., -0.0017+0.0018). That is, CSC does not change for HG1, even when the rain increases, implying that rain does not matter for CSC for households in HG1.
(ii) the CSC for households in HG2 decreases by 0.05% i.e., {(-0.0017+0.0012=-0.0005)*100}
(iii) the CSC for household in HG3 decreases by 0.17% (i.e., -0.0017*100)

Therefore we can say that households moving from HG3 to HG1, would lose equivalent to 0.92 (i.e., ∂CSC/∂HG1 =-0.9195) or 67% of CSC (i.e., 0.92/1.37*100). Similarly, households moving from HG3 to GH2 would lose about 0.77 or 56% of CSC.

The possible reason why rain matters for HG1 could be because majority were in the south where crop and communal resources were the main source of income (Table 6A and 6C). Moreover, the results in Table 8 showed that crop and communal income had negative correlation with CSC. Results Table 6A and 6C, suggest that rain matter for CSC for HG2 and HG3 because these groups had low crop and communal incomes; both of which were negatively associated with CSC. Although results in Table 6A, shows 'natural resource use constraint' was significantly high for HG3, we could say that since 'natural resource use constraint' was based on presence or absence of rules and regulation and whether households paid cash to access the resource. It is possible that HG3 (the financially mature) could pay to harvesting communal resources, while those in HG2 (the poor) had no means to pay to harvest communal resources.

Table 11 (about here)

The result column 1 of Table 12 shows that when we control for market access variables, the hypothesis that SSC increases as the environment becomes dryer is not supported. However, when we consider separately variables that constituted SSC; 'membership to organisations', 'participation in group meetings' and 'participation in group activities', as the dependent variables. The results in columns (3) of Table 12, shows that when we control for market access variables, then; (i) all households have low 'participation in group meetings' in wet areas, (ii) there is no difference (in terms of participation in community meeting) between HG1 and HG2 compared to HG3, and (iii) there is no group level and interaction (group x rain). Therefore we can say that if rain increases by one unit, at *ceteris paribus*, then: (i) 'Participation in group meetings' for HG1 decrease by 35% i.e., {(-0.0040-1.3975= -1.4015)/4*100}. NB: dividing by 4 since our participation was scaled from 0 to 4. (ii) 'Participation in group meeting' for HG2 decrease by 30% i.e., {(-0.0040-1. 1911=-1.1951)/4*100}. (iii) 'Participation in group meeting' for HG3 decrease by 0.1% i.e., {(-0.0040)/4*100}.

The results in column (3) in Table 12 shows the level of 'participation in group meetings' were equal to 1.31 {6.6629-1.3975+0.0020)/4} for HG1, 1.37 {(6.6629-1.1911-0.0014)/4} for HG2 and 1.67 for HG3. This implied that moving from HG3 to HG1, a household would lose 'participation in group meetings' equivalent to 35% {(i.e., (∂Participation in group meetings/∂HG1 = - 1.3955)/4*100}. A household moving from group 3 to group 2, would lose 'participation in group meetings' equivalent to 30% {i.e., (∂participation in group meetings/∂HG2 = - 1.1911)/4*100}

Table 12 (about here)

Table 13 present results on social capital (as a linear combination of CSC and SSC). The results in column (2) shows that when we control for market access variables, households in wet areas have low social capital, and compared to HG3 we find that HG1 had low social capital. There is no difference in social capital between HG2 and HG3, and as we move from wet to dry areas we find that HG1 is characterized by low social capital, relative to HG3. However, we also observe no effect of rain on social capital for HG1, because the magnitude of interaction terms (HG1 x rain) are of the same magnitude as the rain levels variables (i.e., when we add them up, the sum equals zero (-0.0025 + 0.0023 = 0.0002). The remaining effect in Table 13 is as follows: (i) for HG3, social capital was lower in the rainy areas, and (ii) HG1 has lower social capital than HG3. The result for HG3 and HG2 are consistent with the hypothesis that as we move from wet to dry areas households tend to accumulate more social capital as an implicit form of insurance against risk. The results also shows that distance to the tarmac roads enters the model with a negative sign but significant ($P<0.001$) implying households away from tarmac roads have more social capital as the environment becomes hostile. However, both 'distances to the local market' and 'mobile phones' had positive and significant ($P<0.05$) correlation with social capital, implying that households close to local and livestock markets had lower social capital as the environment becomes more hostile.

Table 13 (about here)

3.3 What does the SRA and GLM approaches tell us?

In summary, results from both approaches shows consistency on the hypotheses that; households accumulate livestock wealth as we move from wetter to dryer areas and households accumulate SSC as we move from wetter to dryer areas. However, we see some variation for the hypothesis that households accumulate more CSC as we move from wetter to dryer areas. Results from SRA shows that rain do not matter for CSC as we move from wetter to dry areas, while results from GLM shows that rain matter for CSC for HG2 and HG3 as we move from wetter to dryer areas, but not for households in HG1.

The use of the two approaches in this study was thus important in that they unraveled some information, which otherwise would not have been picked out, if we had used one of the two approaches. For instance, although the results from approach 1 shows that CSC does a not increase as the environment get hostile, it does, however point out important variables that explain variation in CSC as we move from wetter to dry areas. This variables and their association with CSC, provide some answers as to why rain matters for trust for households HG2 and HG3 but not for HG1

4. Discussion

Although much has been written about climate change and variability in the past, uncertainty still remains about when and where its effects will be felt more (Kabubo-Mariara, 2009). Nevertheless, some consensus in recent literature point to climate change and variability effects as likely to be felt more in Africa (Desanker and Magadza, 2001; IPCC, 2007). It is therefore important to understand how households cope and adapt with risks and shocks associated with climate change and variability, for the purpose of redesigning and developing options that are flexible, that can enable households be better well placed to adapt to future climate change and variability (Notenbaert *et al.*, 2012). Moreover, any attempt to enhance our understanding of how households are responding to the present climate change and variability challenges is a prerequisite to the identification of key strategies that could be improved or facilitated for households to cope and adapt better in the future (Adger, 2003b; Heltberg *et al.*, 2008a, 2008b; Nelson *et al.*, 2010a).

In this study, we extend the knowledge on the generalizability of accumulation of livestock wealth, structural and social capital as coping strategies against risks associated with climate change and variability as we move from wetter to dryer areas. To do so we tested hypotheses that households accumulate livestock wealth, SSC and CSC as an insurance against risk associated with climate change and variability, using two approaches: SRA and GLM. Consistently, support our null hypothesis that as the climate risk increases households tend to accumulate more livestock wealth for use as buffer to shocks and risks associated with climate change and variability in ASALs. This result resonates with other findings, in Ethiopia, Kenya, Tanzania, Mozambique and Swaziland that attributes livestock as a form of saving (Doran *et al.*, 1979; Janke, 1982; Ayalew *et al.*, 2003; Ouma *et al.*, 2004; Ng'ang'a, 2011) and as a form of insurance (Binswanger and Mcintire, 1987; Bosman *et al.*, 1997), which households in sub-Saharan Africa turn to when faced with risks that threaten their livelihoods. Similarly, other studies elsewhere have shown that in addition to accumulation of livestock as a store of wealth, they also perform important economic function for instance; diversification (Binswanger and Mcintire, 1987), maintaining the social economic status of the households (see for example Jarvis, 1980; Schilizzi and Boulier, 1997; Moll, 2005; Siegmund-Schultze *et al.*, 2007; Agrawal, 2008). We extend earlier work by demonstrating that in ASALs as we move from wetter to more hostile environment households accumulate livestock wealth as a coping and adaptation strategy for addressing risks associated with climate change and variability.

Consistently, results from SRA and GLM approaches support the hypothesis that households accumulate SSC as the environment becomes more hostile as insurance as we move from wetter to dryer areas. Therefore, the concept that as climate risk increases households accumulates more SSC is generalizable in ASAL context. This finding is not exceptional; other studies for example by Goulden, (2005) in lakesides areas of Uganda, found that SSC offered households networking capability between friends and neighbor in communities, thereby enhancing resilience and ability to cope and adapt to climate impacts and other shocks. In our study, although, 'membership to organizations' and 'participation in groups activities' were expected to increase as the environment becomes hostile, the results (Table 12) showed the contrary. The most probable explanation for lack significant association of 'membership to organizations' as we move from wetter to dry areas could be due lack of variation in numbers of organizations for majority of households. However, our findings on households 'participation in group activities' contrast earlier findings by Tompkins and Adger (2004) who found that 'participation in groups activities' in Trinidad and Tobago made it easier for households to undertake communal pooling of resources, as an attempt to diffuse risk and shocks associated with climate change and variability. Though puzzling at first sight, our finding may not be in conflict with their results.

The increase in 'participation in group meetings' as rain decreases could be because households associate meetings (which involves discussions, deliberations, agreements and understanding the importance of a particular course of actions to the needs of affected households) as a first step toward addressing challenges such as those associated climate change and variability. 'Participication in group activities' usually follows group meetings. Across the studied households 'participation in community group meetings' was important compared to 'participation in group activities' as we move from wetter to dryer areas (Table 13). This could be due to three things; (i) some of the activities agreed on were not beneficial to across all households who were members of the community groups, (ii) some households were free riding on others, by attending meeting to agree on course of actions and then failing to avail themselves for the activities, (iii) that households felt their contribution during community meeting was more valued (and therefore were obliged to attend), but alienated during execution of the agreed activities (hence keeping away), and (iv) that some households considered community group meetings as a strategic opportunity for acquiring new information different issues affecting the community.

This could explain why there was no significant correlation between ‘mobile phones’ and ‘participation in community group meetings’, as opposed to positive and significant (P<0.05) correlation with ‘participation in community group activities’. Implying that decision to attend group meeting as the environment becomes hostile does not depend on whether you have a phone or not (and thus need not be constantly reminded), but is rather contingent on desire to participate out of own volition. Similarly, the results show that ‘mobile phones’ had some positive influence to a household becoming a ‘member of community organizations’ as opposed to those without. This therefore point that, in matters relating to enlightening households on new opportunities or available options for coping with risk and shocks, it would be strategic to provide such information during group meetings. These results resonate with the principles of integrated learning and adaptive management, in that by doing so households would deliberate on own volitions and to understand fully the consequences of a particular decision before fully engaging in translating it into action (Davos, 1998; Brown *et al.*, 2002; Adger, 2003b).

The hypothesis that households tend to accumulate CSC as we move from wetter to dryer areas as an insurance against risks and shocks is not supported across all households when using SRA approach. However, when we test this hypothesis using GLM approach, we find that rain matters for trust for HG2 (the poor) and 3 (financially integrated) only, but not for the HG1 (basically the farmers). For farmers, it is unlikely that the absence of the hypothesized effect was caused by study characteristics (see Table 12), rather we find a possible explanation for this result by comparing the means of the variables that constitute households livelihoods (Table 6). Most people in HG2 and HG3 had high resource constraint, low crop incomes and communal related incomes, but high CSC. This depict that households with alternative coping strategy such as farmers, who when faced with low income, could turn to natural resource harvesting or crop products for food and income generation, did not consider accumulation of CSC as important for coping and adapting to risk associated with climate change and variability. However, for HG2 and HG3 who had low income and high resource constraint, accumulation of CSC was important coping and adaptation strategy.

The availability of alternative income sources may explain the absence of CSC among farmers. The use of crop production as viable risk management strategy has been noted among pastoralist elsewhere (e.g. Campbell, 1984; Smith, 1998; Silvestri *et al.*, 2012a). Although, the reliance on natural resource based income is also a risk reduction strategy, it is often viewed as unsustainable and destructive in that it can accentuate risks associated with climate change and variability (Hogg, 1987, 1998). The accumulation of CSC across households as we move from wetter to dryer areas is thus not generalizable. It rather, is contingent on other alternative source of incomes that may be at the disposal of a household. The results that as households move from HG3 and HG2 to HG1, their

CSC decreases by about 35% and 30% (see column (2) of Table 13) can therefore be attributed to inequitable livelihoods endowment across households, which has been noted elsewhere (see for example Martimore, 1989; Eakin, 2005; Agrawal, 2008) to have a lot of effects on how household choose cope and adapt to climate impacts.

As expected, results from the two approaches showed that; distances to the motorable road and local market and mobiles phones were positive and significantly correlated with livestock wealth (Table 7 and 10). In most ASAL areas of Kenya, to help households cope with risk and shocks during drought, the government and other development organization provide relief aid, which most often benefits households situated close to areas easily accessed by motorable roads. The distribution of relief aid also takes place in a local government administrative office (e.g., Chiefs office) which are mostly situated close to local markets, implying that households situated closer to local markets and areas easily accessible via motorable road, have low motivation for accumulating other forms of insurance, as they expect relief aid. This resonates with past evidences showing that households who often receive relief aid do not adopt appropriate coping and adaptation strategies as opposed to those who do not, hence being more vulnerable (e.g., Blaikie *et al.*, 2004; Harvey and Lind, 2005; Notenbaert *et al.*, 2012). The positive correlation of livestock wealth and mobile phones could be attributed to importance attached to communicating about availability of pasture and water, diseases and livestock theft and market prices (Binswanger and Mcintire, 1987).

The positive and significant correlation between 'distance to the local market' and CSC, could be attributed to the need to pull resources together for the purpose of reducing transaction cost. This could explain why households closer to the local market have lesser CSC. Past studies (Bowles, 1998; Feuer, 2004) have shown that CSC (trust) reduces transaction costs by enabling households to operate without written documents.

The negative correlation between 'distance to the tarmac road' and CSC was contrary to our expectations. In light of evidence provided for the Cambodia, by Feuer (2004), that trust is high for households living close to tarmac roads (especially those depending crop based income), as they can easily verify market information market due to frequency in trade, our finding creates an interesting puzzle in our study. Is it that households far from tarmac roads have low trust because they often depend on income generated through trade, and they lack ways of verifying the information they receive concerning livestock trade? Or is it that closeness to tarmac roads provides households a quick means of verifying whether market information provided is true, and hence spread bad reputation for the dishonesty persons, thereby making households to be honest and therefore trustable? Unfortunately our data does not permit us to explore this further.

Mobiles phones were expected to have a positive association with CSC, however, the results showed the opposite. In light of evidence presented by Feuer (2004), that trust is positively associated with mobile phones, since their usage increases communication wealth especially in relation to market by enhancing cooperation and reducing transaction costs, our results create an interesting question. Were mobile phones owned by wealthier households who are likely to have many alternative strategies to cope with risks and shocks, as opposed to those without phones and hence the low CSC? The results in Table 6, shows that HG1 (the farmers) were the richest (in terms crop and communal income and total value of household assets), but indeed with low CSC compared to those in HG3 at P<0.1 level of significance (see column (2) of Table 11). These results suggest, therefore, that 'mobile phones' were mainly owned by rich households who had alternatives strategies to cope with risks and shocks, hence low CSC.

As hypothesized 'mobile phones' had a positive correlation with SSC, implying that they provided opportunities for repeated interactions with friends and community members. These repeated interactions could be used as an avenue for passing information for example reminders to attend scheduled community meetings. However, 'distance from the tarmac road' was negatively associated with SSC. A plausible reason for this could be that further away from the tarmac roads transaction cost involved in participation in group meeting and activities increases. Unfortunately as we did not collect data on transaction cost associate with SSC we could not explore this further.

5. Conclusions

Livelihood resources are key in determining coping and adaptation strategies that household are likely to choose for insuring themselves from risk and shocks associated with climate change and variability. However, the our understanding of which insuring component of sustainable livelihood framework capitals household choose to utilize in order to cope and adapt climate change and variability associate risks and shocks has not been extensively explored. In this study, we used cross a section data from 500 households in Samburu District, Kenya to explore and enhance our understanding how households use physical capital and social capital as coping and adaptation strategy to risk and shock associated with climate change and variability as we move from wetter environment to more dryer (or hostile) areas of ASALs. Specifically, we explored how livestock wealth component of physical capital, cognitive and SSC component of social capital are utilized as risk coping strategies as we move from wetter to dryer environment.

Our results consistently find that as we move from wetter to dryer areas, households accumulate livestock wealth as a form of insurance against shock and risks associated with climate change and variability. Therefore the concept that, in ASALs households accumulate livestock wealth as the environment becomes more dryer (or hostile) as insurance against risks and shocks particularly those associated with climate change and variability is generalizable in ASALs areas of Kenya. This finding also confirm that indeed that climate has major influence on the decisions made by the households in managing or accumulating their assets for the purpose of coping and adapt to risks, shock and stresses associated with climate change and variability. To the extent that this finding overlap with earlier work in the use of livestock wealth for insurance against risk and shocks for example (Doran *et al.*, 1979; Janke, 1982; Binswanger and Mcintire, 1987; Rosenzweig and Wolpin, 1993; Bosman *et al.*, 1997; Ouma *et al.*, 2004) for Swaziland, Mozambique, Semi-Arid tropics, India, West Africa and Kenya respectively, our results are consistent with the existing evidence.

This paper also explored the use of cognitive and SSC as coping strategies as we move from wetter to more dryer environment using households with varying level of resource endowment (i.e., the three HGs). The results lend support to hypothesis that that CSC increases as we move from wetter to dryer environment for medium and poor households, but not for the rich farmers (i.e., most endowed). Thus we can say that the use of CSC as a coping strategy varies depending on the level of resource endowment of the households we move from wetter to more hostile environment.

Our data lend no support for hypothesis that SSC increases as we move from wetter to dryer environment across all households. However, upon the three variables that constituted SSC : 'membership to organizations', 'participation in meetings' and 'participation in group activities' the results shows that only 'participation in group meetings' was significant and with the expected negative sign. That is, participation in community meeting increases as the environment becomes more hostile across all households which is consistent with the principle of adaptive management that as environment becomes more hostile, households are more likely to be more consultative and to discuss issues at length, often during community group meeting in order to understand consequences or the likely outcomes of the decision taken.

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