



# Climate Variability: Attributes and Indicators of Adaptive Capacity in Semi-Arid Tharaka Sub-County, Kenya

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## Abstract

This study assessed the state of adaptive capacity in four agro-ecological zones of Tharaka sub-county, Kenya. The study utilized two data sets: household survey and key informants. A total of 326 household respondents across four agro-ecological zones; and 24 key informants from public and private sectors were sampled. A chi-square test was used to test the independence of attributes of adaptive capacity-flexibility and access to resources. It was established that the state of adaptive capacity is reflected in households' cropping and livelihood diversification; and cultivation of drought tolerant crops. Institutions are also involved in support programs such as distribution of relief food and planting seeds, infrastructural support of irrigation and rainwater harvesting. There is need for climate science, practitioners and community interaction to scaled-up communication of best optimal adaptation practices that are risk averse to climate variability.

## Subject Areas

Atmospheric Sciences, Environmental Sciences

## Keywords

Adaptive Capacity, Climate Variability, Semi-Arid, Kenya

## 1. Introduction

There is growing evidence that global climate is changing [1] [2] and subsequently re-shaping the world. A changing and variable climate has combined with non-climatic factors to create vulnerability [1]. According to [3] Africa is

especially vulnerable to climatic changes and variability. This vulnerability has been attributed to dependency on climate-sensitive economic sectors, widespread poverty, limited funding of institutions, poor infrastructure, high illiteracy rates, over-exploitation of natural resources and tribal conflicts [4]. These factors have contributed to the continent's low adaptive capacity. In spite of the low adaptive capacity of Africa, communities and governments have developed adaptation strategies to cope with climate variability and extreme events [5] [6] [7]. Some literature to support current climate change adaptation efforts by local communities and institutions (public and private) would suffice.

[7] discussed the importance of science-practitioner communication and the role of regional institutions and policy in addressing vulnerability in southern Africa. These views are echoed by [5] (Malawi and Kenya), [8] [9] (Ontario-Canada), [10] (US and Mexico) and [11] (in Brazil). In these studies, the role of institutions in supporting adaptation through technology transfer is underscored. Besides institutional level-support, there exist location specific studies on ongoing adaptation strategies. [12] discussed seed fair as a drought recovery strategy in semi arid Kenya districts within the Tana Basin. In South Africa, rainwater harvesting techniques are the most popular risk management and adaptation strategy used [13]. In Central Rift Valley of Ethiopia, farmers apply different strategies such as sell of livestock, migration, change of crops and agricultural practices and reliance on food relief [14]. These studies demonstrate that there is variation in climate change adaptation strategies. These variations may be an outcome of cultural or economic setting of a community or the development agenda of the supporting agency.

Against this background, the present study sought to examine smallholder agro-pastoralists' ability to draw on available skills, resources and experience to respond to climate variability in Tharaka sub-County. The study further examined institution-led efforts in supporting adaptation to climate variability. Study finds are expected to contribute to Kenya's National Climate Change Response Strategy (NCCRS) [15] and the Climate Change Act 2016 [16] on Tharaka's social vulnerability to climate change. In general, the study provides a perspective on the state of adaptive capacity in Kenya's arid and semi-arid lands (ASALs).

## 2. Methodology

### 2.1. Study Area

Tharaka sub-county is found in Tharaka Nithi County and covers an area of 1569.5 km<sup>2</sup> and a population of 175, 905 [17]. The sub-county has four agro-ecological zones (AEZs), namely; Lower Midland (LM)4, Lower Midland (LM)5, Intermediate Lowland Zone (IL)5 and Intermediate Lowland Zone (IL)6 [18]. Tharaka has a bi-modal rainfall-MAM "long rains" and OND "short rains". Annual rainfall amount range from 1100 mm (in the wetter LM4) to less than 800 mm (in the drier IL6) in Tharaka sub-county [19]. On the other hand, Temperatures range from 21°C to 25°C [20]. Derived from these AEZs are three main livelihood zones, namely; rain-fed cropping, mixed farming and marginal

mixed farming [21]. As a semi- arid sub-county, rainfall is highly variable causing wide fluctuations in agricultural production and has profound impacts on the ecology, economy and social welfare of the people. The choice of the sub-county was based on an understanding that as a semi-arid area, climate variability is a major source of vulnerability. Thus there is need to establish the state of existing climate change adaptation strategies.

## 2.2. Sample Size and Data Collection

Household survey data and interviews of key informants was collected from four main agro-ecological zones in Tharaka sub-county-LM4, LM5, IL5 and IL6. A total of 326 respondents were interviewed across the four study sites (**Figure 1**) in the year 2010. In each study site, 5% of the households were selected for interview (**Table 1**). Simple random sampling [22] was used to select respondents in each location-giving all household members a chance to be interviewed. A total of twenty-four key informants were purposively selected and interviewed; nineteen from the government and the five from private sector entities. These were drawn from agriculture, livestock, water, public health and administration sectors. Information from key informants was used to validate household survey data-particularly the role of institutions in supporting adaptation to climate change.

Data collection was carried in three stages. First, it involved a reconnaissance survey and consultation with the Arid and Semi-arid Department at Marimanti. Reconnaissance provided an understanding of the administrative units, general physiography and communication network of the sub-county. This provided critical information on planning for data collection. The second phase entailed pre-testing and administration of a structured questionnaire and interview schedule. Pre-testing of these tools was done to check the reliability and validity of the questions.

## 2.3. Data Analysis

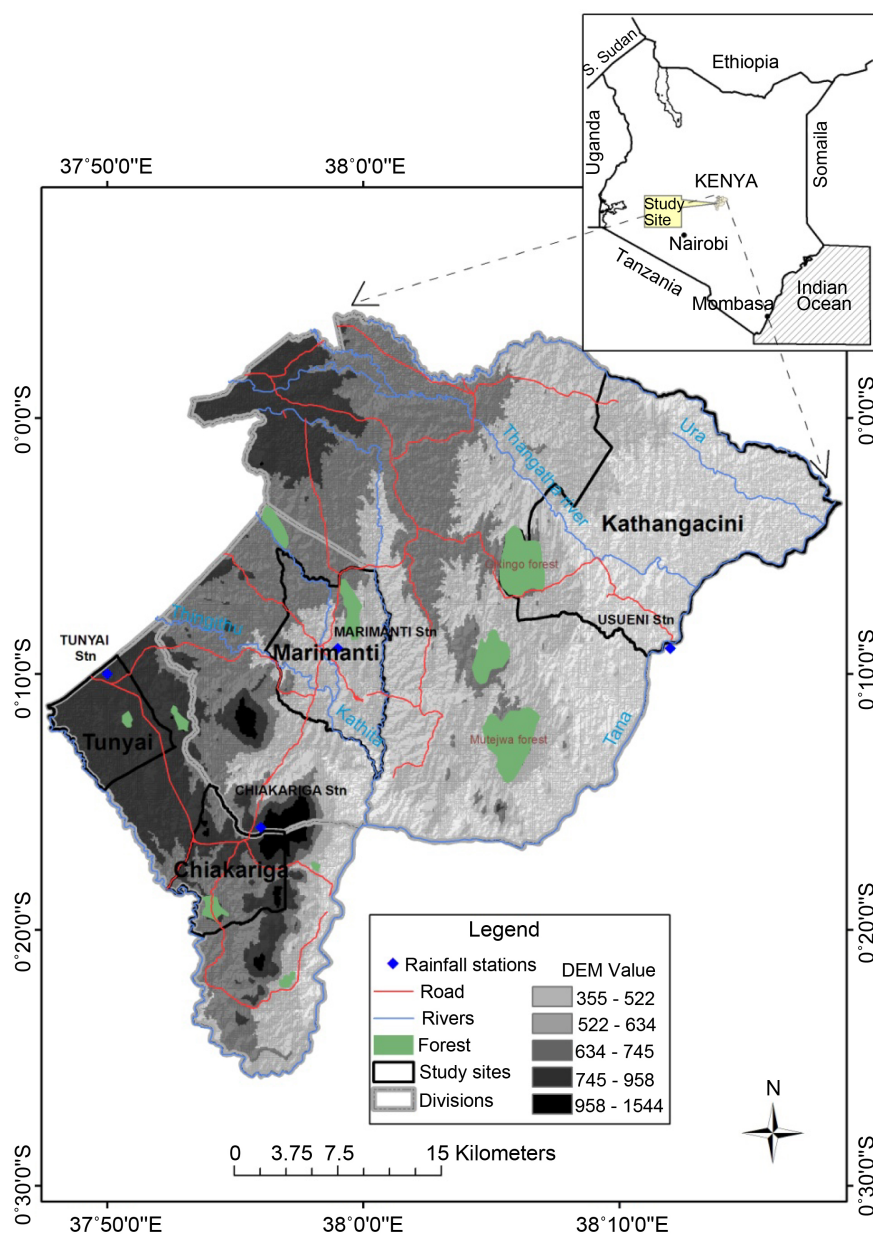
The variables analyzed from the data collected were flexibility of and resource access by agro-pastoralist households in Tharaka sub-county as presented in **Table 2**. The two variables are regarded as the attributes of adaptive capacity [8]. Chi-square ( $X^2$ ) is a non-parametric test used to test the independence of attributes. To apply  $X^2$ , requirements were observed as discussed by [23].  $X^2$  was used to establish the difference between number of livelihoods and study sites.

## 3. Results and Discussion

### 3.1. Flexibility

#### 3.1.1. Cropping Diversity

Cultivation of a variety of crop is a way of diversifying risk. In Tharaka, 65% and 56% of the respondents had more than one crop for OND and MAM seasons



**Figure 1.** A Map of Tharaka sub-county showing study sites.

**Table 1.** Sample population by study sites and gender.

<i>Location</i>	<i>Sub-location</i>	<i>Male</i>	<i>Female</i>	<i>Sub-total</i>	<i>Total</i>
Kathangacini	Kathangacini	27	24	51	58
	Rwanthanju	4	3	7	
Marimanti	Marimanti	20	20	40	92
	Kithigiri	26	26	52	
Tunyai	Tunyai	24	13	37	78
	Tubui	30	11	41	
Chiakariga	Materi	23	6	29	98
	Chiakariga	51	18	69	
<b>Total</b>		<b>205</b>	<b>121</b>		<b>326</b>

**Table 2.** Attributes and indicators of adaptive capacity.

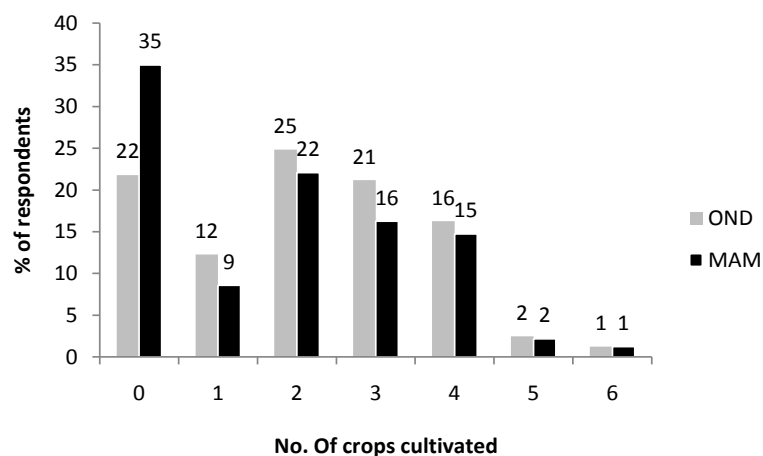
Attributes	Indicators
<i>1. Flexibility</i>	
Diversity of agricultural	Number of crops planted
Income and livelihood options	Diversity of income sources (agriculture, livestock, off farm and non-farm)
<i>2. Resource access</i>	
Access to financial resource	Formal and informal credit
Participation in social and support programs	Emergency welfare programs
	Technology transfer, technical assistance

Adopted and modified from [24].

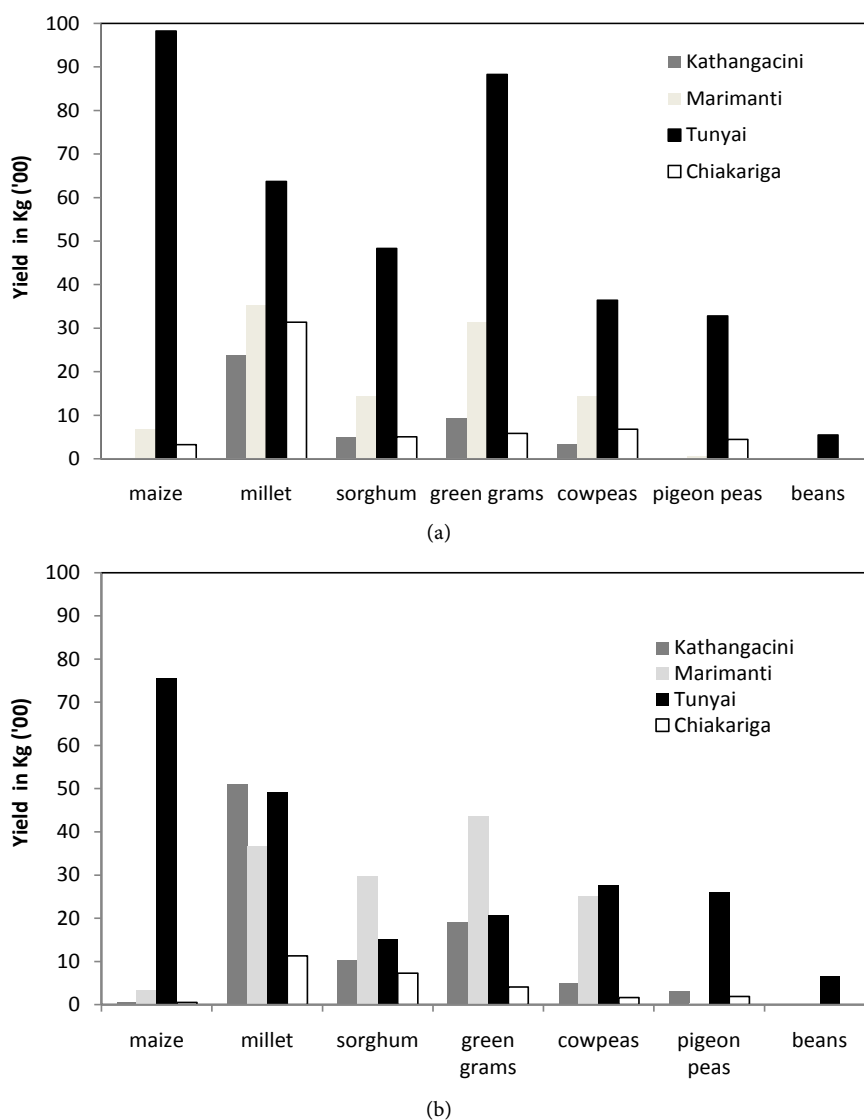
respectively (**Figure 2**). During the OND season, majority of the households at AEZ IL6 and IL5 planted three cultivars while their counterparts in LM4 and LM5 had two cultivars. During MAM season, the number of households cultivating more than one crop reduced, with majority (35%) not planting any crop. In a rural-based economy where crop farming is a lead livelihood, failure to engage in farming is a statement of socio-economic factors (not necessarily rainfall) being a hindrance. High cost of farm inputs (especially seeds and fertilizers) potentially limits engagement in crop farming.

The specific crops cultivated in Tharaka sub-county were green grams, millet, sorghum, cowpeas, pigeon peas, maize and beans. A comparison of cultivated acreage by seasons shows that there is a marked difference-with MAM recording the least acreage across all crops (**Table 3(a)** and **Table 3(b)**). Millet and green grams are the most cultivated with a total acreage of 315 acres and 286 acres during OND and 239 acres and 228 acres during MAM, respectively. While beans and pigeon peas are the least cultivated in both seasons. It is also significant to note that maize and beans require more moisture and are mainly grown in LM 4 (Tunyai) where annual rainfall is slightly over 1000 mm [19].

Although households cultivate more than one crop, yields remain low (**Figure 3(a)** and **Figure 3(b)**). A comparison of total yield by study sites show OND recorded higher yield than MAM for nearly all the crops. When analyzed by sites, Marimanti recorded the highest yields in millet, sorghum, green grams and cowpeas during MAM than OND. Kathangacini too recorded higher yields for green grams during MAM than OND. Low food production remains an enduring concern in sub-Saharan Africa [25]. This has triggered institution-led agricultural modernization that has entailed technological and market fixes-with a focus on maize [5]. Unfortunately, these efforts have narrowed options for small-holder farmers and undermined crop diversification. Cultivation of drought tolerant crops such as millet, sorghum, green grams and cowpeas is an indication households are practicing livelihood strategies that are climate resilient. These findings are supported by [26] who established that ASAL communities were already engaged in climate resilient farming activities and therefore less likely to



**Figure 2.** Number of crops grown by seasons-October-November-December (OND) and March-April-May (MAM).



**Figure 3.** Total crop yield of the main crops cultivated in Tharaka sub-county during (a) OND and (b) MAM.

**Table 3.** Cropping diversity and acreage by study sites for (a) OND and (b) MAM.

(a)							
Site	Crop acreage						
	Maize	Millet	Sorghum	Green grams	Cowpeas	Pigeon peas	Beans
Kathangacini	5	115	41	100	55	8	0
Marimanti	27	78	52	102.5	44	7	1
Tunyai	82.95	56	31	54	65	44	17
Chiakariga	8.2	66	37.5	29.5	25	10	0
<b>Total acreage</b>	<b>123.15</b>	<b>315</b>	<b>161.5</b>	<b>286</b>	<b>189</b>	<b>69</b>	<b>18</b>
(b)							
Site	Crop acreage						
	Maize	Millet	Sorghum	Green grams	Cowpeas	Pigeon peas	Beans
Kathangacini	3	92	41	89	50	8	0
Marimanti	16	43	37	62	37	2	1
Tunyai	67	48	19	46	54	49	16
Chiakariga	2	56	40.5	31	25	6	0
<b>Total acreage</b>	<b>88</b>	<b>239</b>	<b>137.5</b>	<b>228</b>	<b>166</b>	<b>65</b>	<b>17</b>

engage in adaptation. In view of the findings, adaptive capacity can be strengthened with efforts directed towards increased productivity and facilitating marketing of farm produce. This will contribute to improved food security and overall wellbeing of the Tharaka people. Although this study did not go into the agronomy of crop varieties in Tharaka, cultivation of non-native crops such as pearl millet (matures in 55 days), N-26 green gram (matures in 45 - 50 days) and sorghum varieties demonstrates that farmers have mixed agricultural science with their knowledge of agro-ecological zones. Preference for non-native cultivars is evidence of fruitful co-production of knowledge between farmers and extension workers and development agencies-similarly reported by [27] (in Zambia) and [28] (in Namibia).

Allocation of more arable land to crop farming and cultivation of more cultivars during OND than MAM rain seasons suggests farmers' preference for the former. Indeed in Eastern Kenya, OND is the main growing season. OND rain season has been found to be reliable than MAM rain season [29] [30]. But the relatively high crop yield at Marimanti (IL5) during MAM highlight the significance of the season. The significance of MAM is further given credence in a study by [19] who established that there is no significant difference between MAM and OND rainfall amount in AEZ IL5. To practitioners and farmers, it calls for a re-evaluation of the current emphasis on OND rainfall season especially in IL5. These results should however be treated with caution given that crop yield were based on one season. But they offer a fertile ground for further investigations on the link between seasonal rainfall and crop yield over time.

### 3.1.2. Livelihoods Diversification

Households were asked to mention livelihood support strategies they engaged in

during the past 12 months. Sale of livestock (55%), crops (15%) and forest & non-wood forest products (8%) were the main livelihood support strategies in Tharaka sub-county. Sale of goats, cattle and poultry, were the main sources of income from livestock. Cowpeas and green grams were the most sold crops at household level. A small section of the sampled households (N = 27) engaged in sale of charcoal and handicrafts. At least 18% (N = 60) of the respondents engaged in on-farm-wage employment, while 8% joined social programs as a food security measure. The high percentage of respondents who sold livestock is further supported by a high proportion and diversity of livestock ownership. Cattle, sheep, goats and poultry are owned by 55%, 34%, 64% and 72% of households sampled. But a sizeable (27%) group of respondents had no livestock. Livestock is important in an agro-pastoral system of the semi-arid Tharaka-found to increase resilience of vulnerable people especially in light of a projected decline of crop production under climate change [31]. But livestock keeping as a lead livelihood in Tharaka will have to content with diseases and prolonged drought.

Result in **Table 4** shows the number of livelihoods in the last 12 months. Fifty percent of the respondents had 3 - 4 and 5 - 6 livelihood options in Tharaka. At least 18% claimed not to have been involved in a livelihood strategy. It is not clear whether this group (without livelihood) is the most stable and therefore did not dispose some assets or engaged in alternative sources of income. Chi-square test ( $p = 0.05$ ) showed that there is a significant relationship between number of livelihoods and study sites. It is concluded that households in relatively high potential agro-ecological zones (LM4 and LM5) have more livelihood options than their counterparts in marginal agro-ecological zones (IL5 and IL6). Diversity in livelihoods was an indication of stability and therefore less vulnerable to climate variability. The fewer livelihood options at Marimanti (agro-ecological zoned IL5) can be attributed to the growing urbanization-a precursor for unemployment.

Although households in Tharaka had more than one livelihood, their reliance on rainfall dependent livelihoods-livestock and crop produce, make them vulnerable to climate variability, especially drought. It would therefore be prudent to prioritize building livelihoods that will enable households cope better with current climate variability. Livelihood diversification, particularly involvement

**Table 4.** Number of livelihoods at household level by study sites (N = 326).

<i>No. of livelihoods</i>	<i>Site</i>				<i>Total</i>
	Kathangacini	Marimanti	Tunyai	Chiakariga	
None	8 (14%)	31 (34%)	14 (18%)	5 (5%)	58 (18%)
1 - 2	11 (19%)	28 (30%)	16 (20.5%)	23 (23%)	78 (24%)
3 - 4	16 (28%)	22 (24%)	25 (32%)	34 (35%)	97 (30%)
5 - 6	14 (24%)	6 (7%)	16 (20.5%)	30 (31%)	66 (20%)
7 - 8	9 (15%)	5 (5%)	7 (9%)	6 (6%)	27 (8%)
<b>Total (N)</b>	<b>58</b>	<b>92</b>	<b>78</b>	<b>98</b>	<b>326 (100%)</b>



in non-farming income sources was reported in [32]. There is a need for diversification of livelihoods to reduce over-reliance on crops and livestock. In Tharaka, venturing into non-wood forest products such as gum arabic & resin, bee keeping and handicrafts would complement existing livelihood options. But there is also need to refocus use of remote sensing technology (e.g. normalized difference vegetation index data) in monitoring livestock diseases in Kenya's ASALs [33]. The focus on livestock is motivated by an understanding that it's a lead livelihood in Tharaka sub-County.

### **3.2. Resource Base**

#### **3.2.1. Access to Credit**

Access to formal credit is almost non-existent among smallholder farmers in Tharaka sub-county. The most common source of credit was where members make monthly contribution to one another on rotational basis-locally referred to as *Merry-go-round*. Limited access to credit can be explained by three factors. To smallholder farmers of semi-arid Tharaka, borrowing money for farming does not make economic sense as chances of crop failure are much higher than success. Secondly majority of the farmers are poor and therefore lack collateral, including land title deeds. Third, the sub-county had no operational bank by the time of study. For residents who had bank account, they travel long distances on all-weather roads to Meru or Chuka towns in neighbouring sub-counties. The construction of Kathwana-Chiakariga and Marimanti-Mitunguu roads is expected to open up the sub-county. It is hoped that major banks will open branches and other essential services will be established in the sub-county. There is need for formulation and implementation of pro-poor policies which should include provision of short term production credit as was found in Ghana [34]. Often, access to credit makes it possible to make climate change adaptation decisions. A case in point was in Ethiopia where access to credit had a positive and significant impact on the likelihood of adopting soil conservation, change of planting dates and use of irrigation [35]. In Kenya, there are several efforts by the Ministry of Agriculture and other development agencies in providing credit and farm inputs to farmers. Unfortunately, these efforts are emphasized in high and medium potential areas than in semi-arid lands.

#### **3.2.2. Institutional-Level Support Programs**

There are several social programs in Tharaka sub-county that aim at reducing household vulnerability to climate variability. Households in Tharaka are dependent on relief food (52%) and seed distribution (28.2%). Other support programs reported in the sub-county were water supply and installation of irrigation equipment. When these support programs were compared by study sites, relief food was most mentioned in Chiakariga (70.4%), Kathangacini (64%) and Marimanti (54%). Only 19% of the respondents in Tunyai had benefited from relief. The same pattern applied to seed distribution where 41%, 42%, 34% and 6% of the respondents at Kathangacini, Marimanti, Chiakariga and Tunyai respectively had benefited. Ninety percent and 70% of the respondents who re-

ceived relief food and seeds respectively attributed it to prolonged drought. Water supply, installation of irrigation equipment, participation in training and technology transfer were mainly mentioned in Tunyai with a few cases reported in Marimanti. The focus of these development programs in Tunyai-agro-ecological zone LM4, can be attributed to agricultural potential. Irrigation has been found to be highly beneficial in reducing poverty among the poor and in providing employment opportunities which diversify income base [36]. [26] found investment in irrigation a desired investment among farmers of ASAL Kenya – well ahead of other adaptation options such as agro-forestry and change of crop cultivars. Given the agro-pastoral system preferred in Tharaka [37], promotion of irrigation can reduce vulnerability caused by erratic rainfall.

The Kenyan government was acknowledged by respondents for playing a role in food relief and seed distribution. The specific Kenyan government agencies involved in support programmes were agricultural extension service providers, Kenya Agricultural and Livestock Organization (KALRO) and the Ministries of Livestock and Special Programmes. The extension is involved in the technology transfer programs in agriculture and natural resource management. KALRO is involved in farm trials of drought tolerant cultivars and promotion of their adoption. The Ministries of Livestock and Special Programs encourage households to sell-off their livestock before drought to avoid losses. Non-governmental organizations found to be promoting adaptation to climate change in Tharaka were the Catholic Diocese of Meru, Plan International, United Nations Development Programme (UNDP) and World Food Programme (WFP). These organizations were widely quoted as helping in the installation of water storage facilities, distribution of relief food and farm inputs, and promotion of natural resource conservation (water and soil). Although practitioners observed that use of seasonal climate forecast would improve resource and planning (especially in mitigating the effect of climate variability), none indicated its use. Lack of interest can be attributed to inaccuracy arising from large scale of prediction [38]. But practitioners need to tap into the improved rating of seasonal climate forecast by households where 74% rated it as *somewhat accurate*. Application of forecasts in the drought prone Tharaka sub-county would help farmers reduce risk and losses, and enable them plan for alternative livelihoods.

It was however not clear whether researchers (or research institutions) are involved in support programs, notably technology transfer and training in natural resources programs. Either, there is less research supporting communities in Tharaka, or researchers are embedded in NGO and government as channels of dialogue and engagement. To improve science-practitioner interaction, [7] suggests the need to find out what a practitioner does and what decisions are pending (rather than asking what kind of information he/she needs). In Tharaka, science-practitioner interaction is favoured by a majority of practitioners.

## 4. Conclusion

This study sought to establish the state of adaptive capacity in semi-arid Tharaka

sub-county. Diversity of livelihoods, two growing season (MAM and OND), and cultivation of drought tolerant crops (millet, green grams, sorghum and cowpeas) are indicators of adaptive capacity, a demonstration of the communities' in-built adaptation to climate variability. In Tharaka, there was a mismatch between land allocation and crop yields for the two growing seasons-MAM and OND. Although farmers have an outright preference for OND rainfall season, analysis of crop yield shows that there is an untapped opportunity in the MAM rainfall season. Farmers in agro-ecological zones IL5 (Marimanti) and IL6 (Kathangacini)-the driest agro-ecological zones, can benefit from MAM rainfall season by allocating more farmland to cowpeas, green grams and millet. To support adaptation, institutions are engaged in support programs that are both short term (seed distribution, food relief) and medium term (irrigation, installation of small-scale irrigation infrastructure and rain water harvesting). Acknowledging the vital role of short term strategies in reducing vulnerability to impact of extreme climatic events, it is the promotion of rainwater harvesting techniques and use of climate forecast in agricultural planning and resource management that are key to risk reduction. Since communities in semi-arid are growing drought tolerant crops, efforts by non-governmental organizations and government agencies need to be directed towards increasing productivity and market access of farm produce. Much more success can be realized if the existing communication gap between climate science, practitioners and community can be addressed.

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