Chapter 25
Smallholder Adaptation to Climate Change in Semi-arid Areas of Tanzania: Experiences from Iramba and Meatu Districts

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Abstract A study of the impact over the past 30 years of climate variability and change on smallholders' farming systems and adaptation strategies was conducted in three villages of Iramba and Meatu Districts, Tanzania. Both districts involved in the study lie within a semi-arid zone. Crop failure and food insecurity are common characteristics to all three villages in the study. Personal descriptions of climate change and meteorological data confirmed that rainfall patterns have become increasingly inconsistent and unpredictable and that the length of dry spells has increased. Crop growing seasons have been shortened by 1 month or more. The availability of ground water, particularly from rivers, has increasingly become seasonal, compared to the situation in the 1970s and 1980s. These results have all impacted negatively on rain-fed agriculture and livestock production systems and increased the vulnerability of smallholder livelihoods, because of their high dependency on natural resources. Almost 80 % of the households in both study areas were characterized as poor. Households are becoming increasingly vulnerable to multiple factors including drought, price fluctuations, increased population pressure, loss of soil fertility and decreased productivity, scarcity of farm and grazing land, water and fuel wood shortages, loss of 'ngitiri', increased conflicts over pastures, crop and livestock diseases, male out-migration, and increased labor burdens on women. Responses to climate change impacts varied by the socioeconomic condition of households and gender. Coping and adaptation mechanisms to which farmers have resorted include selling labor, land leasing, shifts in crop and livestock systems, use of early maturing, drought and disease resistant varieties, small scale irrigation systems, gardening, increased use of crop residues as animal feed, diversification to off farm activities, and petty trade.

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25.1 Introduction

One third of the land area in Tanzania is located in the semi-arid agro-ecological zone, in which mean annual rainfalls fluctuate between 400 and 900 mm. Semi-arid agro-ecological zones are characterized by erratic and low mean annual rainfall. Drought, inadequate soil moisture, soil infertility, higher day time temperatures, and evaporation rates that exceed precipitation rates are also common in these areas (Senkondo et al. 2004; Vette 2009; Mongi et al. 2010). Agriculture and agro-pastoralism are major farming systems, and 95 % of the agriculture is rain fed. According to IPCC (2007) and Sarr (2012), semi-arid areas are most affected by climate change.

Many studies on climate variability and climate change in Sub-Saharan Africa, and in Tanzania more specifically, have been undertaken (Galvin et al. 2001; Paavola 2008; Lema and Majule 2009; Mongi et al. 2010; Swai et al. 2012; Juana et al. 2013; Legesse et al. 2013). Lyimo and Kangalawe (2010) analyzed rainfall variability for the period between 1974 and 2005 in semi-arid areas of Shinyanga Rural District in Tanzania and reported no significant decrease over time. Lema and Majule (2009) reported decreasing measured rainfall and increasing temperature for the period between 1922 and 2007 in Manyoni, another semi-arid area in Tanzania.

Climate change is, however, not just an environmental issue. It is also a human issue because it impacts livelihoods and numerous communities are threatened by it. While the exact nature and extent of climate change impacts on temperature and rainfall distribution patterns remain uncertain, it is the poor and vulnerable who will be the most susceptible to them. This is especially true for households who rely largely or totally on rain-fed agriculture and natural resources for their livelihoods. Production uncertainty associated with between and within season rainfall variability remains a fundamental livelihood constraint for many communities, and climate change is likely to increase their vulnerability due to increases in rainfall variability and uncertainty.

Small scale farmers in semi-arid areas have developed coping and adaptation strategies to deal with climate variability and associated climatic extremes. These strategies introduce flexibility in agricultural practices and regimes for access to natural resources. They focus on diversity and draw upon social networks for implementation. Increasing climate risk is affecting those strategies and the effects are particularly dramatic when they are added to existing stresses on production systems, such as price volatility for inputs and commodities, population pressure, land scarcity, and social and political conflict. Social, economic, and environmental factors define the situation people confront. Thus, they affect vulnerability levels and capacity to adapt. Smallholder subsistence farming is predominantly a woman's task (FAO 1996) and rural women farmers are affected differently than male farmers.

They respond differently to climate change, depending on culture and socio economic group. The gender and socio economic dimensions of adaptation to climate change impacts and the capacity to adapt has, however, not been significantly addressed, and women are rarely involved as important agents and active participants in adaptation activities (Nombo et al. 2013).[1]

In this article we address relationships between farmers' perception of climate change over the last 30 years, related variables measured using meteorological data, the impact of the climate change on farming systems and food security, and small scale farmers' adaptation strategies. We conclude with some policy guidelines for adaptation to climate change in semi-arid areas of Tanzania based on our analyses.

25.2 Study Area

The study was conducted in Meatu District in Simiyu Region.[2] Mean annual rainfall in Meatu varies between 400 and 900 mm in the district southern and northern zones. Being farmers and agro-pastoralists, the Sukumas began migrating to and settling in the area in 1966. Meatu is regarded as the poorest district in Simiyu region. More than 40 % of the population live below the basic need poverty line. Eighty-seven percent of the Meatu population is employed in the agriculture sector. Two villages were selected for the study, namely, Mwamanimba located in the southern zone, and Mshwata located in the northern zone. In Mwamanimba, farmers pursue a sorghum/cotton crop production system. They also practice agro-pastoralism, and rely on income from livestock. Farmers in Mwashata, in the highest rainfall zone, are more dependent on agriculture and mainly on crop production. A maize/cotton crop production system predominates. The dominant ethnic group in both villages is Sukuma. Members of this group constitute 95 % of the Mwamanimba population and 75 % of the Mshwata population.

Iramba District, on the other hand, is divided into three major agro-ecological zones, namely, the Western Great East African Rift Valley, the Central highland, and the Eastern zone. The former zone is relatively drier (Iramba District Council 2009). Generally, the district receives a mean annual rainfall of between 500 and 850 mm. The village selected for the study, Kidaru, lies in the Western zone and the major crop production system is millet/sorghum. The main ethnic group in this region is Nyiramba.

[1] In this paper, we report on the research findings for a project entitled, "A gendered analysis of climate change impact and adaptation on dry-land farming systems and natural resources management" which began in 2011 as a part of the more comprehensive NORAD-funded program at Sokoine University of Agriculture. The main objective of this study was to determine gender differentiated impacts of climate change on rural livelihoods in semi-arid areas of Tanzania and small scale farmers' adaptation strategies.

[2] Before 2011/12 the district was part of (Shinyanga Region), and in Iramba District in Singida Region.

In both districts the rainfall regime is mainly unimodal, and 80 % of the population are agro-pastoralists depending on crop production and livestock as their main economic activity for food and income. The seasons are determined by rainfall, being divided into a 'wet/rainy' season that runs from November to May, with a dry spell in February and heavier rains falling from March to May, and a 'dry' season that runs generally June to October/November. Both districts involved in the study lie within a semi-arid zone, and climate variability and unpredictability have a major impact on people's livelihoods. Crop failure and food insecurity are common characteristics to all three villages in the study.

25.3 Methodology

Climate variability and change were assessed using quantitative data and qualitative information. Rainfall meteorological data from 1994 to 2011 was collected from Tanzania Meteorological Agency (TMA). In Iramba, the data were from Kiomboi administrative station, while in Meatu the data were an average from two stations, one situated at Mwandoya and the second one situated at Mwanhuzi. The analysis of meteorological data focused on trends of mean monthly rainfall within the November–April growing period. The study measured changes in rainfall patterns by comparing their deviation from the seasonal mean.

Farmers' perceptions were obtained through focus group discussions (FGDs) and key informant interviews were conducted. The composition of the sample for this study is found in Table 25.1.

Using a structured questionnaire, the study used a household survey to collect additional quantitative data on farmers' perception of climate variability and change. Systematic random sampling was used to select 388 households (HH) as shown in Table 25.2

Table 25.1 Information on FGDs and participants involved

Village name	Number of FGDs conducted	Number of male participants	Number of female participants	Mean age (years)	Maximum age (years)	Minimum age (years)
Kidaru	3	6	9	44	60	25
Mwashata	2	10	14	42	63	29
Mwamanimba	2	13	11	49	68	31
Total	7	29	34			

Table 25.2 Households involved in the survey

Village name	Total number of households	Selected households	Selected households (%)	Women involved (%)
Kidaru	444	142	32	42
Mwashata	462	145	31	30
Mwamanimba	315	101	32	43
Total	1,201	388	32	39

A 1–5 point scale was used to measure perception of climate variability and change. The variables measured were: (i) frequency of floods, (ii) rainfall unevenness, (iii) rainfall predictability, (iv) strength of winds, (v) daytime temperatures, and (vi) nighttime temperatures. Others were: (vii) frequency of droughts, (viii) prevalence of crop diseases, (ix) prevalence of livestock diseases, and (x) prevalence of crop insect pests. Farmers' perceptions and meteorological data on rainfall patterns and trends of bad years were compared.

Trends of bad years were assessed using a timeline approach. The variables of interest were change in rainfall pattern (onset and end), change in the February dry spell, change in length of the dry season, changes water levels of ponds, lakes, etc., change in amount of rainfall and trends of bad years. In addition historical timelines and resource mapping were accumulated based on interviews with groups consisting of different gender and age.

The household survey was used to collect data on the impact of climate change on farming systems, management of natural resources, household food and nutrition security, and small scale farmer coping and adaptation strategies. Although the main aim was to examine the influence of climate change on farming systems, other drivers for the changes were also explored.

The number of months of adequate household food provisioning (MAHFP) was used to measure the level of food security. MAHFP scores are a measure of the number of months during the previous year a household, or group of households, was able to obtain adequate food resources to maintain normal health and activity (Bilinsky 2010).

25.4 Results

25.4.1 Climate Change in Meatu and Iramba Districts – Farmers' Perception

During the focus group discussions, farmers explained that the rain stopped falling in February for 2–4 weeks even in a good year. They also noted that during other months of the year, rainfall would fluctuate consistently, but would never stop for longer than 1 week at a time.

Farmers' perceptions regarding changes in rainfall patterns from the 1970s to the present are found in Tables 25.3 and 25.4. Data in Table 25.3 suggest a change in the onset of rainfall from September/October to November/December, and the end of rainfall from May/June to April/May, shortening the growing period in the villages of Meatu by approximately 2 months.

Data in Table 25.4 suggest that the dry spell, occurring earlier in February, has expanded in each of the villages. According to the farmers, the length of the dry period in the 1970s lasted from June/July to September/October; now it lasts from May to November/December, indicating a longer dry season.

Table 25.3 Change in onset and end of rainfall

	1970		2013	
Village	Onset	End	Onset	End
Kidaru	November/ December	May/June	November/ December/January	March/April/May
Mwashata	September/ October	May/July	November/December	April/May
Mwamanimba	September/ October	May/June	December	April/May

Table 25.4 Change in February dry spell and dry season

	Dry spell		Dry season	
Village	1970	2013	1970	2013
Kidaru	1 month	More than 1 month	June–October	May–December
Mwashata	8 days	2 weeks to 1 month	July–September	May–December
Mwamanimba	8 days	1 month	June–October	May–November

The results from the household survey show that the frequency of droughts and rain fall unpredictability has greatly increased (Table 25.5). Respondents also confirmed that day and night temperatures have increased since the 1970s.

The results from the survey also indicated that the amount of rainfall has decreased, and frequency of bad years has increased, particularly since 2000. River flows of water have increasingly become seasonal.

25.4.2 Meteorological Data

Below, meteorological data are used to assess past and current rainfalls patterns for the two districts studied. Data for monthly rainfall 2009–2011 was only available for Meatu district. Data in Tables 25.6 and 25.7 represent monthly and seasonal means of mm rainfall measured from November to April for the period 1994–2011. The data do not show a clear trend of decreasing rainfall during the period, but indicate reduced rainfall in January compared to the past. The result was in line with people's perceptions, which suggested that the dry spell that used to occur in February had extended to January, and that the growing season had decreased. A study conducted by Mongi et al. (2010), which analyzed meteorological data at the regional level in Tabora,[3] Tanzania, for a 35-year period (1973–2008), also reports that the duration and frequency of the February dry spell has increased with implications for crop production and food security.

[3] This borders Singida and Shinyanga regions and some parts of the Tabora Region are found in semi-arid zone.

Table 25.5 Perceived climate variability and change compared to the situation in the past 30 years in percentages (n = 388)

Perceived climate change variables	Percentage responses					Descriptive statistics
	Greatly decreased	Moderately decreased	No change	Moderately increased	Greatly increased	Median score
Frequency of flood	22	11	60	6	2	3
Rainfall unevenness	13	18	5	33	32	4
Rainfall unpredictability	10	12	4	28	47	4
Greater wind velocity	11	13	15	29	32	4
Higher day temperature	3	11	4	37	46	4
Higher night temperature	3	10	7	41	40	4
Crop disease prevalence	5	13	10	36	35	4
Livestock disease prevalence	8	16	11	39	27	4
Insect crop pests prevalence	8	16	8	37	31	4

Scores: Greatly decreased (1 score); Moderately decreased (2 scores); No change (3 scores); Moderately increased (4 scores); and Greatly increased (5 scores)

Meteorological data from Iramba shows that rainfall in December and April was declining during the period between 1994 and 2008 (Table 25.7). A decrease of rainfall in April implies early cessation compared to the situation in the past. Decrease of rainfall in December indicates that rainfall has become insufficient during a critical growing period.

Meteorological data for Meatu and Iramba indicate that standard deviations were high, implying that rainfall patterns were inconsistent in each month during growing seasons.

People's perceptions of a changing climate suggested that the amount of rainfall had decreased during growing seasons compared to the situation in the 1970s. In addition, there had been an increase in the frequency of droughts, expansion of the dry spell, shortening of the growing seasons by 1 month or more, as well as rainfall unpredictability. The meteorological data confirm people's perceptions (Kabote et al. 2013). The correlation between local views and meteorological climate trends is also documented in other studies (West et al. 2008; Gill 1991).

The shortening of the growing season implies that smallholder farmers must change crop and livestock production systems to address the impact. Insufficient and inconsistent rainfall patterns have serious implications on the decisions of farmers and agro-pastoralists regarding the cropping calendar and types of crop varieties to be adopted.

Table 25.6 Measured rainfall variability during growing seasons in Meatu District

	November		December		January		February		March		April	
Period	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev
1994–1998	132.9	90.9	141.0	106.5	168.4	113.1	124.1	88.4	102.1	42.8	130.5	23.2
1999–2003	64.6	31.5	77.6	15.1	108.9	46.3	74.9	34.9	138.2	62.1	88.5	69.6
2004–2008	108.4	83.5	135.0	42.1	101.2	53.2	102.1	48.0	133.3	92.5	84.3	43.5
2009–2011	62.5	20.2	175.0	16.8	48.0	36.4	139.9	49.1	136.0	23.8	96.3	76.9

Table 25.7 Measured rainfall variability during growing seasons in Iramba District

	November		December		January		February		March		April	
Period	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev
1994–1998	71.0	68.9	195.6	197.6	140.2	68.1	158.8	49.5	151.8	112.8	120.8	56.1
1999–2003	123.6	84.8	139.1	54.0	192.4	97.2	60.1	26.4	202.2	57.1	87.6	45.3
2004–2008	67.3	50.6	112.9	59.3	149.9	65.7	134.7	57.5	135.3	100.4	66.6	69.1
2009–2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA not available

25.4.3 Food Security and Wealth Status

Food insecurity in Meatu and Iramba districts is a serious problem. Food aid has been distributed to the villages by the district authorities every year since 2000. Food security update for Tanzania in May 2011, projected that the Shinyanga region would be in the 'Stressed' Acute Food Insecurity Phase in the months from May to September 2011. It also stated that food prices in 2011 had remained above the 5 year average due to insufficient rainfall affecting crop production, as well as high transportation costs of both inputs and outputs due to rising fuel prices (FEWS NET 2011).

Wealth inequalities affect access to resources and the ability to respond to changes brought about by climate change and other stresses. This study was designed to ensure that the concerns, with respect to climate change impacts and adaptations, of all community members from different socio-economic groups were taken into account.

Key informants used their local classification to define poor, less poor, and rich households in the three villages. Their definitions of the different wealth groups took into consideration issues such as a household food security, asset ownership (in particular livestock), land access, ability to hire labor, and quality of housing. Indicators were developed and the households included in the survey were defined accordingly. The association between livestock keeping and wealth status was significant ($p < 0.05$). Most rich households had more livestock than poor and less poor households. Differences of income and poverty can be traced to differences in cattle ownership across households. Very few households kept cash as savings; rather cattle were the most important form of savings.

The percentage of households in the different wealth groups is shown in Table 25.8.

The study showed a high degree of poverty, less poor and poor households exceeded 80 % in all villages. The observed percentages of poor households were high when compared to levels reported for other rural areas of Tanzania. According to Tanzania Country Report on the Millennium Development Goals (2011), about 33.6 % of Tanzanians fall below the basic needs poverty line and 17 % below the food poverty line.

The respondents were asked to remember how many months of the past 12 the households had insufficient food access. The Monthly Adequate Household Food Provisioning (MAHFP) scores (Bilinsky and Swindale 2010) are presented in Table 25.9. The measurement ranges from 0 to 12. Households in Mwshata,

Table 25.8 Wealth status of households (HH) in the study villages

	Location		
Wealth status	Mwamanimba	Mwashata	Kidaru
% Poor HH	59.7	43.0	48.4
% Less poor HH	22.8	49.6	36.6
% Rich HH	17.5	7.4	15.0

Table 25.9 Months of adequate food provisioning (MAHFP)

MAHFP		
	Agricultural production system	Agro-pastoral production system
Wealth group	Mwshata	Mwamanimba
Poor	7.6	9.6
Medium	8.1	9.9
Rich	9.8	10.4
Average	8.5	10

depending mainly on crop production, were more food insecure than households in Mwamanimba, where livestock keeping was more widespread. Households practicing agro-pastoralism had on average, 1.5 months more adequate food provisioning than households mainly practicing agriculture. The poorest households showed the lowest number of months with adequate food provisioning, 7.6 months during the year. The rest of the months the households suffered from inadequate food provisioning. The most food insecure months are from December to March with a significant peak in January–February.

In the agro-pastoral village, Mwamaninmba, all wealth groups had access to a varying and higher number of livestock, and were less dependent on crop production for ensuring food security. Owning livestock may signify increased adaptive capacity since cattle can be sold to purchase food during food insecure months. This might explain the higher food security score in the agro-pastoral production system despite frequent droughts.

25.4.4 Crop and Livestock System Under Pressure

The main staple crops differed in the three villages studied, due to different farming systems and rainfall patterns in the villages, as shown in Table 25.10. The table indicates a strong association between types of crops grown and location. Kidaru and Mwamanimba had the lowest amount of rainfall (400–500 mm), and drought resistant crops, such as millet (*Pennisetum glaucum L.*) and sorghum (*Sorghum bicolor L.*), were the main staple crops. Mwshata received higher annual rainfall and maize (*Zea mays L.*) was the main staple crop in the village. However, farmers still cultivated a diverse range of crops and practiced intercropping. Traditional wild and cultivated vegetables were key food and/or medical crops. They were either consumed raw or dried depending on the season. Dried vegetables were combined in various ways, and stored dried vegetables were expected to last for an entire season of at least 6–7 months. Twenty-three important traditional, wild and modern vegetable species were identified as important components of the local diet (Ang and Synnevåg 2012). Wild vegetables included jute mallow (*Chorcorus olitorius L.*), wild amaranth (*Amaranthus spp.*), spider plant (*Cleome gynandra L.*) and wild traditional cucumber (*Cucumis anguria L.*), which are all resistant to

Table 25.10 Percentage of farmers who produced major crops grown during the 2012/2013 growing season

Type of crop	Variable	Kidaru (n = 142)	Mwamanimba (n = 101)	Mwashata (n = 145)	Chi-square	P-value	Phi-value
Maize	Grown	37	85	96	135.934	0.000	0.592
	Not grown	63	15	4			
Sorghum	Grown	38	65	9	85.400	0.000	0.469
	Not grown	62	35	91			
Sweet potatoes	Grown	16	78	72	123.430	0.000	0.564
	Not grown	84	22	28			
Bulrush millet	Grown	74	4	3	214.359	0.000	0.743
	Not grown	26	96	97			
Cotton	Grown	4	93	69	218.394	0.000	0.750
	Not grown	96	7	31			
Sunflower	Grown	65	19	35	56.081	0.000	0.380
	Not grown	35	81	65			

drought and often used as famine crops. Sweet potato (*Ipomoea batatas L.*) was also mentioned to be an important crop during food shortage periods, normally occurring during February and March just before the harvesting period. Cotton (*Gossypium arboreum*) was the main cash crop in Mshwata and Mwamanimba, while sunflower (*Helianthus annuus*) was the main cash crop in Kidaru. Sunflower also became a cash crop in Mwashata and Mwamanimba between 2008 and 2010, due to price fluctuations and low market prices for cotton at that time.

Drought and irregular rainfall had a huge negative impact on harvest and household food security within and between years, and it was not surprising that this was the main challenge for adequate food access for all villages included in the study. Food security had, according to 70 % of farmers, decreased due to longer dry periods characterized by inadequate access to food and reduced and more irregular food intake. Several wild species, commonly used in the diet in the southern zone of Meatu, began to decline from the 1990s as rainfall patterns became more irregular. These plants were among the first to be harvested after the dry season, serving as important food inputs during the hunger gap. The increasing scarcity of wild food plants was a concern for the interviewed households. Also the increased time it took for women to gather the wild plants concerned the respondents. Decreasing groundwater and increased water scarcity were also reported, as rivers in the area had become increasingly seasonal since the 1970s, making irrigated farming and vegetable growing for improved income generation difficult.

Excessive droughts had also increased the distance, duration, and frequency of movement of animals since the 1970s, also with major implications for food security. Livestock keepers in the agro-pastoral village of Mwamanimba indicated that they had to move their herds to neighboring areas and even to far regions in search of pastures during the dry season. Although the practice has been commonly used for decades, the increased frequency of prolonged and excessive drought required that livestock keepers and herders, mainly men and boys, were away for longer periods to seek pasture and water. In the past, livestock keepers were away for between 1 and 2 months, returning when the rainy season began. Now they often moved for several months and sometimes did not return in the case of two consecutive dry seasons. This had major implications for women, children, and elders left behind in the village, as their working burden increased substantially. In Kidaru and Mwashata, where households were mostly dependent on agriculture, seasonal movement of animals occurred during the growing season to give room for crop production, from January to July. Growing populations and agricultural expansion were the main drivers for the seasonal movement of the animals. During the July–December dry season, animals returned to feed on agricultural residues.

During the dry seasons, the distressed sale of animals at very low prices is a common occurrence. Animal deaths have increased compared to the situation in the 1970s, mainly due to decreased pasture and increased livestock diseases. Lack of agro-vet shops in the villages has enhanced the problem. Insufficient knowledge about livestock diseases and pests among livestock keepers is also problematic.

Drought and irregular rainfall also had a negative impact on river flows becoming seasonal, thus increasing water scarcity for humans and animals, even during wet seasons. Since the 1980s, prolonged droughts had prompted agro-pastoralists to dig trenches in low lands and along the rivers in search of water for the animals. The depths of these watering trenches have increased over time.[4]

Lack of farm implements was also mentioned as a challenge. According to the FGDs, slight changes in the use of agricultural implements had occurred, and the use of oxen in land preparation was increasing. However, due to population growth, *insufficient land* was rated as a more important challenge than farming technologies. Population increase was associated with migration in search of land for both crop cultivation and animal pasturing. In the 1970s, the Sukuma tribe dominated both villages in Meatu district. However, as a consequence of migration, a number of ethnic groups are now found in the area. It was also observed that the farmers are currently cultivating more farm land than before due to declining soil fertility and low productivity. They were compensating for these factors by expanding the area cultivated rather than intensifying their production. Increased farm size has implications for the workload of women, as they perform important on-farm activities.

[4] Mattee and Shem (2006), also reported presence of water trenches for animals in semi-arid northern Tanzania.

Striga and birds were identified by interviewees as important problems. Participants in FGDs reported that the intensity of insects, diseases, and birds attacking farm crops had increased compared to the past. They also reported that disease identification and how to manage crop-related pests and diseases is a challenge.

Distance to markets and bad roads were also mentioned as a major challenge for selling their crops and for buying food and agricultural inputs, particularly during the rainy season. In order to increase food security, most crops were sold during the harvest period when the prices were low. During the December–April food shortage period, each year prices were higher causing households to sell their assets, including livestock, in order to purchase food stuffs.

25.4.5 Farmers' Adaptation Strategies

Because of the shorter growing period, combined with increased length of the February dry spell and higher unpredictability and irregularity of rainfall, small scale farmers had adopted crop varieties that could be harvested within a shorter growing period. Changes had occurred in terms of varieties cultivated now compared to the past. For instance in Kidaru, early sorghum and millet varieties were introduced in the village during 1990s following the failure of long-term sorghum varieties. Similarly, participants in Mwamanimba village reported a change from long-term sorghum varieties to short-term sorghum varieties. In Mshwata, a change from long-term to short-term maize varieties was reported. As indicated in Table 25.11, 66 % of the rich households had adopted improved maize varieties. Improved varieties of sorghum were not regarded as drought resistant and local varieties were preferred.

Table 25.11 Percentage responses on adoption of improved varieties (n = 388)

Type of crop	Variable	Wealth status			Chi-square	P-value	Cramer's V – value
		Poor (n = 192)	Less poor (n = 152)	Rich (n =44)			
Maize	Adopted	46	49	66	8.637	0.071	0.105
	Not adopted	24	24	25			
	Partly adopted	30	27	9			
Sorghum	Adopted	24	20	27	9.374	0.052	0.110
	Not adopted	46	53	64			
	Partly adopted	30	27	9			

Adopted: Improved seeds bought every year
Partly adopted: Improved seeds bought some of the years

Results from FGDs in Kidaru village showed that farmers were making use of both improved and local maize and sorghum varieties, and kept seeds for a range of varieties to ensure flexibility and enhance stability of yields. On average 25 % of the farmers had adopted improved seeds. Farmers usually procured seeds from other farmers. Farmers also procured seeds from the District Agricultural and Livestock Development Department and from private agro-dealers, mainly based at the district headquarters. Farmers indicated that the main reasons for not adopting improved seeds were unavailability and high price.

Farmers practiced intercropping to enhance effective utilization of labor and land, and to minimize risk of crop failure.

Small-scale irrigation farming systems and water harvesting had emerged as a way to overcome increased frequency of drought. The main water sources during the dry season were dry river canals. Holes were dug in river channels during the evening. Overnight water rose through the sand layers to the surface for collection in the morning. Water was used for personal as well as irrigation purposes. Women and girls were responsible for collecting water. Small scale rain water collection systems were developed by some farmers to harvest water in the wet season and also for tapping into groundwater sources. It was also reported that there were about 20 small water pumps in the villages. Results from the focus group discussions showed that a few farmers practiced gardening of modern vegetable crops, such as tomatoes and lady fingers for income generation, by using small-scale traditional irrigation mainly along River Ndurumo in Kidaru village and River Simiyu in Mwashata village. This strategy ensured food availability. Some farmers in Mwamanimba and Kidaru village had started practicing irrigated farming along the river valleys using generator driven water pumps Examples of water and soil conservation strategies by mulching and ridges were reported.

Regarding agricultural technologies, focus group discussions showed that 75 % of the informants in Mwamanimba and Mwashata villages used the ox-plough for land tilling. The other 25 % probably use a hand hoe, axe, and bush knife. In Kidaru village, however, less than 25 % of the informants reported use of the ox-plough. Some changes were noted in comparing practices. In the 1970s, most farmers depended on a hand hoe, axe, and bush knife to till the land. An important labor exchange system was noted. Farmers without oxen provided labor to the farmers with oxen, in exchange for assistance in tilling their farm land using the ox-ploughs.

Climate change, human population growth and agricultural expansion had consequences for agro-pastoral livelihoods. In the 1970s, animals grazed anywhere in the village. Due to dwindling sizes of these grazing areas, the situation changed in the 1990s. Adaptation mechanisms included changes in increased duration of seasonal movement and migration of animals, purchase of grazing areas, and grazing crop residues in the household plots. Crop residues after harvesting have increasingly become an important source of feed. Currently, livestock keepers have to pay other farmers for animal feed in the form of crop residues (maize stove, sorghum and millet remains, and beans straws etc.).

Before the 1970s, the communities in Meatu District used to set aside a reserve land known as “ngitiri” for grazing which was used during the dry season as a

fodder/grazing reserve. Two types of *ngitri* existed, namely, enclosures owned by individuals or families, and communal enclosures owned and managed in common. Both were originally developed by the Sukuma people in response to acute animal feed shortages caused by droughts. The system is now facing a number of constraints, mainly declining land availability, increasing land insecurity, and resource use conflicts. They have weakened traditional adaptation strategies. Data suggest that it is no longer feasible to set aside areas for pasture as ngitiris, because the demand for agricultural land is too high in the villages of this study. Grazing lands also decreased due to the creation and expansion of the game reserves. Game reserve policies prohibit grazing in the Maswa Game Reserve Thus, conflicts and killings have been reported between agro-pastoralists and conservation authorities in Mwamanimba and Mwashata. One of the male FGD participants in Mwamanimba described the situation as follows '. . .grazing animals in the Maswa Game Reserve is part of life. . .this will continue forever unless pasture and water scarcity problems are addressed. . .'

To reduce vulnerability, some farmers have searched for casual jobs to generate income to meet some of their needs. They have diversified their livelihood options to include off-farm activities and petty trade. Engagement in non-agricultural activities has become a popular way of coping with reduced agricultural production. Men have been engaged in brick making and selling of cash crops such as sunflower seeds. Women have reportedly been engaged in petty trade, such as selling food and vegetables from their own gardens, as well as fish, porridge, and local brew.

25.5 Summary and Conclusion

The three remote rural villages that we studied are located in Meatu and Iramba district in Northern Tanzania. They are in a semi-arid environment, characterized by irregular and unpredictable rainfall, and substantial household food insecurity. Small scale rain fed agriculture and agro-pastoralism were the main source of livelihoods. Flexibility and physical mobility were traditionally important strategies to overcome impact caused by climate variability in the villages. Small scale farmers developed local coping and adaptation strategies dependent on access to economic, social, and natural resources, the local context and culture. However, they are now confronted with growing competition for resources such as land, water and pasture, and local coping and adaptation strategies are weakened, thereby threatening livelihoods. Human population, land scarcity, related expansion of agricultural land, declining soil fertility, shrinking pastures, and increasing levels of land use conflicts were reported. Data were collected from focus group discussions with male and female farmers, household surveys, and secondary meteorological sources. Results of our analyses indicate that (1) the onset and end of rainfall during the growing period has become more erratic and unpredictable since the 1970s, (2) the February dry spell has become longer, and (3) that the growing season has been shortened by a month or two dependent on location. Droughts have

become more common. Farmers reported that the dry season is becoming more prolonged and that less water is available for domestic purposes, livestock, and irrigation. Farmers' perceptions of climate change are confirmed by secondary meteorological data. Climate change is causing additional pressure on crop and livestock production systems, threatening livelihoods of an already vulnerable and food insecure rural population.

Data from the study suggest that poverty and food insecurity are prevalent in all the three villages. In fact the percentage of less poor and poor households exceeded 80 % in all villages. Wealth differences were correlated to ownership of assets, in particular livestock, land, and ability to hire labor. The poorest households had adequate food provisioning for only 7.6 months during the year, and households depending mainly on crop production had a higher degree of food insecurity than agro-pastoral households. Drought and irregular rainfall had a huge negative impact on harvest and household food security within and between years. Seventy percent of the farmers reported a decline in household food security. Longer dry periods have resulted in reduced access to food and less and more irregular food intake. Several wild species, commonly used in the diet in the southern zone of Meatu, have begun to decline. These plants were among the first to be harvested after the dry season, serving as important food inputs during the hunger gap. The increasing scarcity of wild food plants was a concern for the interviewed households. Excessive droughts have also increased the distance, duration, and frequency of movement of animals compared to the 1970s. Increased seasonal and permanent migration has serious implications for women left with responsibilities for managing both household and farming activities. Their working burden has increased and gender roles are changing. Reductions in available pasture lands have resulted in increased grazing of livestock in a neighboring Game Reserve which has been a frequent source of conflict in villages in Meatu district. Loss of ngitiris, reserved land for grazing during the dry periods, were reported.

Adaptation strategies have included a clear shift to early varieties of maize, sorghum, and millet. Diversification of crops and varieties are practiced to promote flexibility. Small-scale irrigation systems and water harvesting have occurred and have resulted in increased access to water for crops and livestock as well as for domestic purposes. Diversification of crops, keeping a range of local and improved varieties, intercropping, and income generation from vegetable gardening along the riverbeds have become common practices, particularly among agricultural households. Adaptation mechanisms introduced by agro-pastoralists include changes in seasonal movement and migration of animals, and the purchase of grazing areas and paying for feeding livestock on crop residues from household plots. Crop residues after the harvesting period had increasingly become an important source of feed. Diversification to off-farm activities like petty trade has become an important strategy to reduce vulnerability. Wealth inequalities among households are directly related to access to resources and the ability to adapt to changes brought about by climate change and other stresses. Poor households have been most affected by the changes and have had less resources and adaptive capacity. Climate changes has affected men and women differently, and caused changes in gender roles and

responsibilities. Socio-economic and gender considerations must be taken into account when climate change and adaptation responses are planned and implemented at national and local levels.

25.6 Suggested Policy Recommendations for Adaptation to Climate Change in Semi-arid Areas

- Climate change threatens livelihoods, food and water supplies by reducing the ecological base on which they depend. Integrated long term development plans, actions, and programs for semi-arid areas at a national and local level need to include actions for improved adaptation to climate change. Climate change adaptation must be mainstreamed into development programs.
- Integrating the views of the people most affected by droughts is crucial if we are to understand the impacts of climate change and their ability to adapt.
- Integrated adaptation and development programs must bring together activities to improve resilience, environmental sustainability, and food- and livelihood security
- Climate change has resulted in additional pressure being put on an already vulnerable rural population. Integrated adaptation and development programs need to consider population increases, agricultural expansion, land scarcity, competing land use, price fluctuations and policies, and access to infrastructure and markets.
- Adaptation processes need to be seen in a holistic manner. They need to consider local actors and local knowledge, climate risk, vulnerability and adaptive capacity, and take into account environmental, technological, cultural, institutional, and political considerations. Improved technology alone will not reduce the impact of climate change on farming systems and people's livelihoods.
- Access and rights to natural, economic, and social resources are crucial for successful adaptation to climate change impacts
- Poor small scale farmers have few adaptation options, and low adaptive capacity. To reduce vulnerability, it is important to build local adaptive capacity. There is a lack of institutional capacity and human capital needed to adapt to the changes.
- Actions for improved adaptation to climate change need to build on knowledge about the diversity and differences in and between local farming systems and natural resource management strategies.
- Social, economic, and environmental factors decide the situation people are in – and thus decide vulnerability and capacity to adapt. Vulnerability varies between socioeconomic groups and individuals.
- Climate change impacts are not gender neutral, and may influence male and female farmers differently depending on gender roles and responsibilities. Adaptation strategies to improve livelihoods must be gender sensitive. Gender considerations must be mainstreamed into adaptation and development strategies and actions.

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