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# Drought impacts and related risk management by smallholder farmers in developing countries: evidence from Awash River Basin, Ethiopia

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## Forschung zur Entwicklungsökonomie und -politik
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**Discussion papers in this series are intended to stimulate discussion among researchers, practitioners and policy makers. The papers mostly reflect work in progress. This paper has been reviewed externally by Dr Gezahegn Ayele (Ethiopian Development Research Institute (EDRI)) and Dr. Stefan Schwarze (Georg-August-University Göttingen) whom we thank for their comments.**

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# Abstract

Climate risk studies have largely neglected household coping and adaptation strategies. In this paper we analyze drought impacts, drought risk management, and resulting drought resilience in Awash River Basin of Ethiopia based on socio-economic data collected from 43 randomly selected Peasant Associations. We find that severe drought periods have led to a significant depression of crop yields and to widespread death of livestock in the past. Drought periods have drastically increased the proportion of food insecure households and lengthened the duration of food insecurity in the area. Since, with climate change, drought periods are predicted to become more frequent in this region in the future, the problem of food insecurity is likely to become even more severe. Ex-ante adaptation strategies are widely practised in Awash River Basin and include the storage of crop residues as fodder for livestock, the rearing of drought tolerant livestock, mixed cropping, the use of short duration crop varieties, and the adoption of soil and water conservation practices. Ex-post coping strategies utilized to manage the consequences of drought include the sale of assets and the reliance on consumption loans and support offered by informal networks. Therefore, suitable policies are urgently needed to strengthen farmers' capacity to adapt to and cope with drought. Training farmers in the production and conservation of livestock fodder as well as in soil and water conservation practices appear to be key policy options relevant in the area. Moreover, improving farmers' access to climate related information, especially drought forecasts, could improve the timely adoption of effective adaptation measures.

Keywords: Drought, drought risk management, Ethiopia

JEL classification: O13, Q12

# Drought impacts and related risk management by smallholder farmers in developing countries: evidence from Awash River Basin, Ethiopia

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## 1 Introduction

Climate change is a reality that has profound impacts on key development sectors of agriculture, water, energy, transport, and health (Case, 2006). Rainfall variability and other climatic risks account for a significant share of agricultural production risk (World Bank, 2001; FAO, 2008). Climate risks like droughts and floods have impacts on food security and livelihoods of smallholder farmers in developing countries primarily via crop, fodder and biomass losses (IFAD, 2009; FAO, 2008). Boko *et al*. (2007) project that by 2020 yields from Africa's rain-fed agriculture could be reduced by up to 50% due to climate change. This development is worrisome for Africa, a region already having the highest proportion of people living in extreme poverty and the lowest level of agricultural productivity (Hellmuth *et al.,* 2007).

Dinar *et al.* (2008) note that concerns about climate change impacts on agriculture in Africa have increased considering the linkage of agriculture to economic growth. Currently, there are few economic studies that explore the link between rainfall variability and agricultural production in Sub-Saharan Africa. Most of these studies estimate the economic impacts of climate change on agriculture in developed countries (Deressa, 2006; Mendelsohn *et al.,* 1994). To date not much research has been done to estimate such impacts in Africa (Dinar *et al.,* 2008). In addition, most of these studies focus on simulations at global or regional level neglecting farm household level risk management options. The few household level studies mostly ignore coping and adaptation strategies, hence carrying the connotation of farmers as *"dumb-economic agents"* who do not respond to climate change (Nhemachena and Hassan, 2007: 8). In reality farmers and communities respond to climatic risks by employing various risk management strategies in order to maintain a certain level of welfare (Dinar *et al.*, 2008; World Bank, 2001). Nhemachena and Hassan (2007) emphasize that adaptation ought to be included in climate impact analysis, estimating that this has the potential to reduce food deficits in Africa from 50% to 20%.

Taking these fundamental issues into account, recent climate change studies in Ethiopia have incorporated adaptation (Deressa *et al.,* 2008; Yesuf *et al.,* 2008). However most of the research work on climate change has been done in the Nile basin. Accordingly, little is known about how climate change may affect agriculture in other areas of the country.

Our study employs a climate risk chain framework to analyze drought risk, impacts, and risk management. The framework integrates components from the asset based and social risk management approaches outlined by Heltberg *et al.* (2008) and Siegel and Alwang (1999). Using empirical evidence from a random sample of 43 Peasant Associations[4] (PA) leaders in Awash River Basin of Ethiopia, the objectives of this paper are to (1) explore the history of drought occurrences and their corresponding severities in the study area, (2) quantify the impact of drought on crop and livestock production and food security in the study area, (3) identify coping and adaptation strategies taken by households in rural communities to counteract harmful drought effects, and (4) quantify their degree of resilience against drought. The remainder of the paper is structured as follows: a description of the research area is provided in Section 2; Section 3 develops the analytical framework applied and outlines the methods used in sampling and data collection; our findings are presented and discussed in Section 4; finally, our conclusions and recommendations are summarized in Section 5.

## 2 Description of the research area

The Awash River Basin covers a total area of 110,000 km$^2$, of which 64,000 km$^2$, comprising its Western catchments, drain to the main river or its tributaries. The remaining 46,000 km$^2$, mostly the Eastern catchments, drain to a desert area and do not contribute to the main river course (MOWR, 2007). The climate of the Awash River Basin varies from humid subtropical over central Ethiopia to arid over the Afar lowlands (Dinar *et al.*, 2008). Mean annual rainfall varies from more than 800 mm in the semi humid region, *Weina Dega* where five study districts are located, to less than 500 mm in the dry region, *Kolla* where Boset district lies. The seasonal rainfall distribution within the basin is greatly influenced by the migration of the Inter-Tropical Convergence Zone (ITCZ) (MOWR, 2007). The area is mainly dominated by mixed crop-livestock farming systems. Livestock comprise mainly cattle, sheep and goats (MOWR, 2007). Teff, maize, sorghum and beans are the dominant crops in the area (CSA *et al.*, 2006).

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[4] Peasant Association is the smallest administrative unit in Ethiopia

## 3 Research methodology

To quantify drought impact, drought related risk management, and households' drought resilience we construct three indices as follows: The *Drought Impact Index* was developed from the overall perceived impact of the most severe drought experienced by households in the PA, on a scale from 0 (no impact on crop and livestock production) to 5 (very serious impact on crop and livestock production). This concept was drawn from the work by Keil (2004) in Indonesia. The *Drought Coping Strategy Index (DCSI)*[5] used in this study incorporates both income and consumption smoothing strategies and measures the degree to which households in the PA cope with drought impacts. The strategies are weighted by multiplying the proportion of households utilizing a strategy by the importance attached to the respective strategy by the individual households on a scale from 1 (minor importance) to 4 (great importance). The weighted strategies are then aggregated into one value of DCSI for each PA. The DCSI is specified as follows:

$$DCSI_i = \sum_{i}^{n} w_i Q_i$$

Where:

$DCSI_i$ = Drought coping strategy index for households in $PA_i$
$w_i$ = Importance weight
$Q_i$ = Proportion of household in the PA that practised the coping strategy

A *Drought Resilience Index* (DRI) was constructed in order to measure PA resilience to drought. Following Keil (2004) and Heitzmann *et al.* (2002) the level of drought resilience of a PA is a function of its natural asset base and coping capacity.

To identify appropriate variables, Principal Component Analysis (PCA) was carried out using SPSS software. PCA is a multivariate data reduction technique used to analyze multiple observed variables that yields a relatively small number of components, which account for most of the variance in a set of observed variables (Field, 2009). PCA determines and assigns weights mathematically to capture relative importance of multiple indicators and maximize the variance of the linear composites. According to the Kaiser criterion, a principal component is rated meaningful if it yields an Eigenvalue $\geq 1$, whereby the variables retained

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[5] The DCSI has foundations in the Coping Strategy Index (CSI) developed by CARE and World Food Programme (WFP). The CSI combined both income and consumption strategies into one index to measure household food security and the impact of food aid programmes. The index was used in countries like Uganda, Zimbabwe, Ethiopia and Ghana (Collins, 2004; Maxwell *et al.*, 2003; CARE/WFP, 2003). A detailed procedure of computing CSI is contained in CARE/WFP (2003).

in the analysis should have a component loading ≥ 0.4, hence accounting for at least 16% of the variance within the component (Stevens, 1992 cited by Field, 2009). Conducting the PCA involved a trial and error process to determine, from a set of 10 variables, a combination which yielded the best accuracy performance. From initial PCA results the component matrix was checked and variables with component loadings lower than 0.4 were removed, in accordance with Field (2009). Positive loadings indicate a positive correlation of the variable with relative drought resilience and vice versa. Following Field (2009) variables with communalities lower than 0.7 were removed from the list to increase the appropriateness of the model. Eventually, we use the following four variables that reflect the PA's natural asset base and coping capacity to construct the DRI: *elevation/sub-basin*[6] (natural asset), *livestock feed reliability, water reliability*[7] (natural asset), and the *DCSI* (coping capacity) described above.

The construction of composite linear indexes using PCA is a well-established method that has been applied in numerous studies, such as Henry *et al.* (2003), Sricharoen and Buchenrieder (2005), Zeller *et al*. (2006), and Keil *et al.* (2008). Hereby, a crucial assumption is that the common variance represented by the first principal component (exhibiting the largest Eigenvalue) is in fact determined by the underlying phenomenon the index intends to measure, which in our case is the drought resilience of PAs. The reliability of the first principal component was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. The KMO, calculated from the multiple variables, is the ratio of the squared correlations between variables to the squared partial correlations between variables (Field, 2009). Hence, it is a measure of the compactness of the patterns of correlations between variables, which is a prerequisite for PCA to yield reliable results. The KMO ranges from 0 (very diffuse patterns of correlations) to 1 (very compact patterns of correlations), and Field (2009) recommends accepting KMO values above 0.6.

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[6] *Elevation (Sub-basin)*: Elevation and rainfall are the main criteria for sub-basin classification (c.f Taddese *et al.*, 2001; Halcrow (1989) cited in Wagnew, 2004). In general the uplands receive higher amounts of rainfall than the Upper Valley sub-basin, making them more suitable for crop production.

[7] *Livestock feed and water reliability:* Livestock is an integral part of livelihoods in Ethiopia (Hellmuth *et al.,* 2007). Drought usually affects livestock production via feed and water shortages characterized by grazing inadequacies and drying of water sources (IFAD, 2009). In order to assess drought resilience in terms of the two variables (feed and water availability), relative differences (percentage changes) for each variable between normal and drought year were calculated. PAs exhibiting smaller percentages for each variable are assumed to be more resilient to drought than those with higher percentage changes.

PCA extracts standardized components, i.e., having a mean of zero and a standard deviation of one. Algebraically, the DRI is specified as follows:

$$DRI_i = \sum_{j=1}^{k} \frac{wj\,(x_{ij} - \bar{x})}{s_j}$$

where
$DRI_i$ = Drought Resilience Index
i = PA index (i = 1,…, N)
$w_j$ = vector of weights assigned to individual indicator variables (j =1,…, k)
$x_j$ = vector of indicator variables
$s_j$ = vector of standard deviations of indicator variables

*Sampling procedure and data collection*

A community survey was conducted in May-June 2009 in six districts that lie in Awash River Basin. From a total of 15 districts along the Awash River Basin from Dendi to Boset, six districts were randomly selected. From the sample districts a total of 44 Peasant Associations (Table 1) were randomly selected using the Probability-Proportionate-to-Size (PPS) sampling method. Since the PPS method accounts for differences in the number of PAs between districts in the first stage, this sampling procedure results in a self-weighing sample (Carletto, 1999). From the sample PAs we interviewed the heads of the associations. On average the group consisted of the association chairman, manager and one elderly community member with in-depth knowledge of the area. The survey was conducted with the assistance of two local enumerators who used a carefully tested questionnaire. The composition of the team was such that interviews could be conducted in local languages, which facilitated the communication with the respondents.

**Table 1** The Sampling Frame

| **District** | **Total Pas** | **Number of PAs finally interviewed** |
|---|---|---|
| Adama | 42 | 8 |
| Akaki | 25 | 5 |
| Boset | 33 | 8 |
| Dendi | 53 | 8 |
| ILU | 18 | 8 |
| Lume | 38 | 7 |
| **Total** | **209** | **44** |

Source: Calculated from Secondary Data from Oromia Regional Government

# 4 Results and Discussion

### *4.1 Reference drought periods in Awash River Basin*

Data on the incidence and characteristics of drought periods in the study area are based on respondents' recall, and their respective severities were scored on a scale from 0 (no negative impact on households) to 5 (very severe impact on households). From these profiles, one reference drought period was selected to enable detailed investigations of their impacts and how farmers responded to them. Our decision rule[8] for selecting reference severe droughts yielded the following (mean severity scores in parentheses): Forty nine percent of the severe droughts occurred in 1984 (4.1), 37% in 2002 (4.0), 5% each in 2000 (3.0) and 2007 (2.1), and 2% each in 2001 (3.0) and 2005 (3.0). Although the recall period is very long in the case of the 1984 drought, the respondents citing this event were old enough at the time of the drought to have experienced its consequences themselves.

### *4.2 Impact of Drought*

*Effects of drought on crop and livestock production*

Drought resulted in more diseases, more pests, reduced crop yield due to lack of water, and livestock deaths. Proportions of households[9] in the PA affected by each effect were sought and the severity of each effect was scored on a scale from 1 (not severe effect) to 5 (very severe effect). This provided a measure of extent of coverage and severity of the effect. Mean severity scores exceed the value of 3.0, indicating that drought causes rather serious problems in the research area (Table 2).

**Table 2** Effects of drought on crop and livestock production (multiple responses possible).

| Sector | Drought effect | Share of Pas mentioning effect (%; N = 43) | Mean severity score |
|---|---|---|---|
| Crop production | Reduced yield due to more diseases | 47 | 3.30 |
| | Reduced yield due to more pests | 63 | 3.19 |
| | Reduced yield due to water shortage | 98 | 3.60 |
| Livestock production | Reduced body weight/death due to lack of fodder | 93 | 3.75 |
| | Reduced body weight/death due to lack of water | 77 | 3.85 |
| | Deaths due to more ticks | 49 | 3.38 |
| | Deaths due to more diseases | 49 | 3.81 |

Source: Own data.

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[8] The decision rule was to select one drought with the highest severity score in each PA. In cases of several equal severities, the most recent event (in year 2000 or later) with a severity score equal or greater than 3 were selected because recent drought events could be remembered easily by the respondents. The severity scoring and decision rule were adapted from Keil (2004).

[9] Peasant leaders were asked to provide an estimate of the proportion of households affected by each drought effect in their respective PAs.

*Teff yield performance during drought*

Teff is the staple crop of Ethiopia, with its straw providing a vital source of livestock feed and construction material (CSA *et al.*, 2006). Based on respondent recall we collected yield data of teff for a climatically 'normal' year versus the selected drought year. Table 3 shows that teff yields in the reference drought years amounted to merely 43% of those in reference normal years closest to the drought year, on the average.

**Table 3** Differences in teff yields: normal year compared to selected drought year on identical PAs in Awash River Basin

| **Pair of Average yield (kg)** | **N**[a/] | **Mean yield (kg)** | **Difference (a-b)** | **t-value** |
|---|---|---|---|---|
| In normal (a) and drought year (b) | 41 | 1117<br>480 | 637 | 13.99** |

[a/] Teff yields from 2 PAs were dropped from the analysis because of inconsistent data
** Paired samples t-test significant at 5% level of error probability.
Source: Own data.

*Effects of drought on livestock feed and water availability*

Based on respondent recall we traced livestock feed and water availability scores for two-time periods: normal year before drought and during the drought year (Table 4). Availability of water and feed were scored on a scale from 1 (totally insufficient) to 4 (abundant). Drought significantly reduced both livestock feed and water availability in the study area (Wilcoxon signed rank test significant at P < 0.05).

**Table 4** Differences in livestock feed and water availability between normal and drought year on identical PAs in Awash River Basin

| **Pair of livestock** | **N** | **Mean availability score**[a/] | **Difference** | **Z-value** |
|---|---|---|---|---|
| Feed in normal (a) and drought year (b) | 43 | 3.67<br>1.56 | 1.11 | - 5.44** |
| Water in normal (a) and drought year (b) | 43 | 3.77<br>2.05 | 1.74 | - 5.15** |

[a/] Mean feed and water availability score. Water and feed availability were scored on a scale from 1 (totally insufficient) to 4 (abundant)
** Two related samples (Wilcoxon signed rank) test significant at P < 0.05
Source: Own data.

### *Drought and food insecurity*

Using respondent recall, estimates of the proportions of food insecure households and the duration of food insecurity were derived for two time periods: normal and severe drought year (Table 5).

To test for statistically significant differences, non-parametric procedures were used since the Kolmogorov-Smirnov test rejected the null-hypothesis of normal distributions of these variables. Drought increased the proportion of food insecure households and lengthened the period of food insecurity in Awash River Basin (Wilcoxon signed ranked test significant at $P < 0.05$). This result is in line with numerous other studies finding that drought in Ethiopia is associated with increased food insecurity (e.g., Webb *et al.,* 1992; Hellmuth *et al.,* 2007; Dinar *et al.*, 2008; Yesuf *et al.*, 2008).

**Table 5** Differences in proportions of food insecure households and duration of food insecurity between normal and drought year on identical PAs in Awash River Basin

| **Pair of …** | **N** | **Mean** | **Z-value** |
|---|---|---|---|
| Proportion (%) food insecure in normal (a) and drought year (b) | 34 | 23.63<br>64.09 | - 5.59** |
| Duration (months) of food insecurity in normal (a) and drought year (b) | 34 | 4.34<br>7.49 | - 5.10** |

** Two related samples (Wilcoxon signed rank) test significant at $P < 0.05$
Source: Own data.

### *Drought Impact Index*

The Drought impact indexes were significantly different between the study districts (Kruskal-Wallis test significant at $P < 0.003$) (see Table 6). Following Field (2009) we corrected for family-wise error by dividing α (0.05) by the number of comparisons, to ensure that cumulative type 1 error is below 0.05. Therefore we used 0.003 as our criterion for significance. The number of comparisons was calculated as $C = \frac{k!}{2(k-2)!}$ , where k is the number of experimental groups (6 in our case) and ! is the factorial to yield a total of 15 comparisons. When we look at the duration of the drought periods our results show that the drought in ILU have been longer than in all other districts except for Adama (One-way ANOVA and subsequent *Games-Howell test* significant at $P < 0.05$). Most of the PAs in ILU district made reference to the 1984 drought, whose effects lasted for more than 7 months. This drought and its severe effects constitute the few documented studies in Ethiopia (cf. Webb *et al.* 1992).

**Table 6** Drought impact indexes differentiated by district

| District | N | Mean drought impact index* | Mean drought Duration** |
|---|---|---|---|
| Akaki | 5 | 3.20 | 4.80 $^{a}$ |
| Dendi | 8 | 3.38 | 5.13 $^{a}$ |
| ILU | 7 | 4.43 | 11.29 $^{c}$ |
| Adama | 8 | 3.88 | 8.50 $^{bc}$ |
| Boset | 8 | 3.50 | 7.00 $^{ab}$ |
| Lume | 7 | 3.29 | 5.71 $^{ab}$ |

* Kruskal-Wallis test significant at P < 0.003
* Drought impact index was derived from the overall perceived impact of the most severe drought experienced by households on a scale from 0 (no impact on crop and livestock production) to 5 (very serious impact on crop and livestock production)
** Homogeneous subsets (a, b, c) based on Games – Howell test, $P < 0.05$.
Source: Own data.

### *4.3 Climate risk management*

*Coping strategies*

During drought periods, household relied on various coping strategies. Farmers commonly sold small livestock (goats, sheep and chicken), household utensils (radios, television and furniture), agricultural equipments (plough, sickles) and forestry products (wood, timber and charcoal) to generate income. Despite these coping strategies the majority of households had to reduce food consumption during the drought (Table 7).

**Table 7** Drought coping strategies and their respective mean importance scores (multiple responses possible).

| Strategy | Share of PAs mentioning strategy (%; N = 43) | Estimated proportion of households practicing the strategy (%) | Mean importance score $^{a/}$ |
|---|---|---|---|
| Ate less preferred foods (maize and sorghum) | 95 | 67 | 3.6 |
| Adults restricted consumption | 86 | 66 | 3.1 |
| Household members skipped meals for entire days | 60 | 71 | 3.6 |
| Reduced number of meals eaten per day | 95 | 70 | 3.1 |
| Borrowed food from relatives & friends | 88 | 39 | 2.4 |
| Buy food on credit | 44 | 36 | 1.9 |
| Household members migrate within country to get job | 100 | 28 | 2.5 |
| Livestock and crop sales | 100 | 65 | 3.6 |
| Asset sales[10] | 100 | 39 | 2.4 |
| Earn money from additional sources | 100 | 40 | 2.9 |
| Changed input use in crop production | 72 | 41 | 3.0 |

$^{a/}$ Importance score attached to each strategy ranged from 1 (minor importance) to 4 (great importance).
Source: Own data

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[10] Excluding livestock and crop sales

All PAs claimed to have household members who sought employment, to generate income during drought periods. Of 118 temporary jobs undertaken, 41 were farm related jobs (e.g. weeding, threshing grain) and 77 were off-farm jobs. Households in 15 PAs also generated additional income through dung cake sales. Dung cake is a source of fuel for cooking and heating made by mixing cow dung and teff straw. Dercon (2000) found that crop, livestock and asset sales as well as employment were the major drought coping strategies employed by households in Ethiopia. Hoddinott and Quisumbing (2003) showed that households in Ethiopia engaged in income generating activities to manage rainfall shocks. Fafchamps *et al.* (1998), Siegel and Alwang (1999) also confirmed that smallholder farmers usually utilize farm and off farm income to buffer against weather risks like droughts. Households used less Di ammonium Phosphate (DAP), Urea and pesticides because they could not afford to buy the inputs and feared that fertilizer could burn their crops in the absence of adequate water (Table 8). The results tally with those of Morduch and Sharma (2001), which reported that farmers deferred fertilizer applications until rainfall patterns were clear. Keil (2004) also reported the same trends that farmers in Indonesia reduced fertilizer usage during drought.

**Table 8** Adjustments in use of crop inputs in response to drought in Awash River Basin

| **Type of input** | **Number of PAs[1] with households adjusting input use[2]** | **Number of PAs with households who reduced input use[3]** | **Number of PAs with households who increased input use[3]** |
|---|---|---|---|
| **DAP[4] & Urea** | 31 (100) | 31 (100) | 0 (0) |
| **Organic fertilizer** | 27 (87) | 7 (26) | 20 (74) |
| **Pesticides** | 23 (74) | 22 (96) | 1 (4) |
| **Herbicides** | 5 (16) | 5 (100) | 0 (0) |

[1] PA = Peasant Association

[2] Numbers in parentheses are percentages, relative to all PAs with households that adjusted the use of any input

[3] Numbers in parentheses are percentages, relative to PAs with households that adjusted the use of the respective input.

[4] DAP = Diammonium Phosphate fertilizer

Source: Own data.

*Role of social capital during drought*

Informal networks enabled households to share drought risks by supporting each other, mainly via moral and financial support. These included: 24 religious groups, 9 business groups and 5 groups each for youth, elderly and women (multiple responses possible). Such informal arrangements to deal with risk are common in developing countries, mainly because of weak formal institutions.

From Ethiopia, Carter *et al.* (2004) report that religious associations were prevalent and group members actively supported each other during drought periods, which conforms to our research findings. Other studies, such as Zeller (1998), Zeller and Sharma (2000), Dercon

(2005), Morduch and Sharma (2001) and Futoshi *et al.* (2009), have similarly found that social capital (e.g. social ties and kinship within extended families) is still commonly used by smallholder farmers in developing nations to insure, hedge against, and share risks. In defining social capital, Woolcock and Narayan (2000) linked it to the networks that enable people to act collectively.

### *Drought adaptation strategies in Awash River Basin*

Table 9 summarizes the drought adaptation strategies employed by households in Awash River Basin. Keeping crop residues for feeding livestock in dry periods is common in the area. These results are comparable with those of Benhin (2006), which confirmed that smallholder farmers in South Africa where producing and stocking fodder for feeding livestock in dry periods. Rearing of drought tolerant livestock breeds (*Borena*[11] *breeds*) was confined mostly to the Upper valley sub-basin which is drier.

These results are similar to those found by Dinar *et al.* (2008) who report that farmers were switching to livestock types and breeds adaptable to drought in 11 African countries, including Ethiopia. Nhemachena and Hassan (2007) report similar trends in Southern Africa. Irrigation played a pivotal role in dealing with water shortages associated with drought for some households in 22 PAs. Soil and water conservation techniques, especially infiltration pits and contours ridges to retain runoff and improve water infiltration into the soil, were dominant and practised by households in 32 PAs in the area. Lack of information, credit and water were the dominant constraint affecting household’s drought adaptation efforts in Awash River Basin. These results are consistent and comparable with those of Yesuf *et al.* (2008) who show that lack of information on how to effectively implement the adaptation strategies and lack of credit were the dominant constraints affecting households in the Nile Basin of Ethiopia to adapt to climate variability. Although the study areas were different the results show that lack of information and credit are inherent constraints affecting most farmers in the country.

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[11] Borena Breeds are those that have been bred to adapt to dry areas- adaptable to low plane of nutrition. Borena is named after an area in Ethiopia, which is typically dry.

**Table 9** Proportion of households utilizing crop and livestock adaptation strategies and major constraints to their adoption

| **Drought Adaptation Strategy** | **PAs utilizing strategy** (multiple responses possible) | **Mean proportion (%) of households utilizing strategy** (From PAs utilizing strategy) | ***Major constraints to the adoption of the strategy-from PAs utilizing strategy (%)*** | | |
|---|---|---|---|---|---|
| | | | *Lack of information* | *Lack of water* | *Lack of Credit* |
| Keep crop residues for livestock | 40 | 71.90 | 22.5 | 7.5 | 5.0 |
| Rear adaptable livestock types | 15 | 53.87 | 40.0 | 13.3 | 6.7 |
| Mixed cropping | 18 | 63.06 | 66.7 | 11.1 | 11.1 |
| Harvesting earlier | 35 | 62.57 | 65.7 | 5.7 | 5.7 |
| Planting earlier | 26 | 50.77 | 76.9 | 15.4 | - |
| Planting late | 36 | 58.92 | 69.4 | 16.7 | 8.3 |
| Water harvesting | 17 | 38.76 | 41.2 | 23.5 | 5.9 |
| Planted trees | 26 | 42.81 | 26.9 | 3.8 | 3.8 |
| Changed crop varieties | 17 | 54.12 | 29.4 | 23.5 | 23.5 |
| Soil & Water Conservation | 32 | 45.66 | 46.9 | 9.4 | 6.3 |
| Irrigation | 22 | 30.64 | 40.9 | 18.2 | 4.5 |

Source: Own data.

### *Drought resilience in the study area*

All variables have absolute component loadings > 0.4 (Table 10). The communalities are greater than 0.7 indicating that the proportion of common variance present in each variable is high (Field, 2009). The *KMO* of 0.62 shows that the patterns of correlations between the variables are relatively compact, leading to a sufficiently distinct and reliable first principal component (Field, 2009). *Bartlett's test of sphericity* strongly rejects the null hypothesis that the variables in the population correlation matrix are uncorrelated ($P < 0.001$). The PCA extracted two components with Eigenvalues greater than 1.0 (2.11 and 1.07). The first principal which can be assumed to be the one reflecting drought resilience yields an Eigenvalue of 2.11 and explains 52.69% of the total variance in the data. The minimum value of the first component was -1.55, its maximum value 1.87 and the mean and standard deviation were 0 and 1 respectively.

**Table 10** Summary details of drought resilience indicators

| **Variable** | **Communalities** | **Anti–image correlations** | **Component loading**[1] | **Weight within DRI**[2] |
|---|---|---|---|---|
| DCSI | 0.88 | 0.52 | 0.41 | 0.20 |
| Water change | 0.70 | 0.69 | 0.88 | 0.40 |
| Feed change | 0.79 | 0.61 | 0.81 | 0.40 |
| Elevation | 0.81 | 0.59 | - 0.71 | - 0.40 |

[1] Derived from Component Matrix and [2] from Component Score Coefficient Matrix.
Source: Own data.

*Differences in drought resilience across the survey districts*

The mean drought resilience indices (Table 11) are significantly different between the districts (One Way ANOVA significant at P < 0.05). Pair-wise comparisons reveal that the DRI for the districts in the Uplands sub-basin (Akaki, Dendi and ILU) are significantly higher than those of Adama, Lume and Boset located in the Upper Valley sub-basin (Games-Howell tests significant at P < 0.05). Within the Upper Valley sub basin, the DRI for Adama was higher than Boset. The Upper Valley sub-basin falls within the Rift Valley system which is characterized by drier conditions and frequent droughts.

**Table 11** Mean Drought Resilience Index differentiated by district

| District | Mean DRI * |
|---|---|
| Akaki | 0.65 $^{c}$ |
| Dendi | 0.77 $^{c}$ |
| ILU | 0.81 $^{c}$ |
| Adama | - 0.67 $^{ab}$ |
| Boset | - 1.20 $^{a}$ |
| Lume | - 0.03 $^{b}$ |
| **Total** | 0.00 |

* Homogeneous subsets (a, b, c) based on Games – Howell test, $P < 0.05$.
Source: Own Data.

# 5 Conclusions and recommendations

In Awash River Basin severe drought periods have led to a significant depression of crop yields and to widespread death of livestock in the past. Drought periods have drastically increased the proportion of food insecure households and lengthened the duration of food insecurity in the area. Since, with climate change, drought periods are predicted to become more frequent in this region in the future, the problem of food insecurity is likely to become even more severe.

Ex-ante adaptation strategies are widely practised in Awash River Basin and include the storage of crop residues as fodder for livestock, the rearing of drought tolerant livestock, mixed cropping, the use of short duration crop varieties, and the adoption of soil and water conservation practices. This illustrates that smallholder farmers are clearly not ‘dumb economic agents’ but are highly responsive in their crop and livestock management to the drought risk in the area.

Ex-post coping strategies utilized to manage the consequences of drought include the sale of assets and the reliance on consumption loans and support offered by informal networks. In addition, household members temporarily migrate in search of employment opportunities.

Despite these ex-ante and ex-post drought management efforts, the majority of households have not been able to maintain their usual level of consumption; the skipping of meals even for entire days appears to have been a common consequence of drought. Therefore, suitable policies are urgently needed to strengthen farmers' capacity to adapt to and cope with drought. Training farmers in the production and conservation of livestock fodder as well as in soil and water conservation practices appear to be key policy options relevant in the area. Moreover, improving farmers' access to climate related information, especially drought forecasts, could improve the timely adoption of effective adaptation measures. Finally, formal financial institutions should be strengthened to support farmers' adaptation to riskier climatic conditions in the future and to facilitate consumption smoothing during drought periods.

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