The 2010-2011 Drought Impacts on Cattle Market Integration in the Horn of Africa: A preliminary Evaluation using VAR and Structural Break Analysis

Jean-Claude BIZIMANA
Assistant Research Scientist, Department of Agricultural Economics
Agricultural & Food Policy Center
Texas A&M University
600 John Kimbrough Blvd / Rm 362 AGLS Bldg
2124 TAMU, College Station, TX 77843-2124
Tel: 979-458-9168 / Fax:979-845-3140
Email: bizimanatex@tamu.edu

David A. BESSLER
Regents Professor, Department of Agricultural Economics at Texas A&M University
373 B Agricultural and Life Sciences Building
2124 TAMU, College Station, TX 77843-2124
Phone: (979)-845-3096
Email: d-bessler@tamu.edu

Jay P. ANGERER
Associate Professor, Texas AgriLife Research at Texas A&M University
Blackland Research and Extension Center
720 E. Blackland Road, Temple, TX 76502-9622
Phone: 254-774-6053
Email: jangerer@brc.tamus.edu

***Selected Paper prepared for presentation at the Southern Agricultural Economics Association's 2016 Annual Meeting, San Antonio, Texas, February, 6-9 2016***

## Abstract

Livestock rearing is an important risk reduction strategy for vulnerable communities in developing countries and a major provider of nutrients and traction for crop production. However there is a great concern for pastoral population in the arid and semi-arid zones of East Africa due to recurring drought. Drought leads to the decline in forage and water availability which in return deteriorates the overall livestock health and reduces livestock prices and revenues. This study analyzes the level of price interaction among livestock markets in Ethiopia and Kenya and the impact of the 2010-2011's drought on cattle prices using time series analysis. The results on cattle price dynamics show limited interaction among cattle markets in both countries. The structural break analysis indicates the period around 2010-2011 as a predominant break date for the markets in Ethiopia and Kenya. A lack of market integration in addition to drought prevent cattle herders from using markets as a mitigating mechanism against drought, by selling livestock to destock during drought and buying livestock to restock after drought. In brief, a high level of livestock markets integration can lower the risk of losing animals during a drought.

*Introduction*

Livestock rearing is an important risk reduction strategy for vulnerable communities in developing countries and a major provider of nutrients and traction for crop production (Thorntorn, 2010). Beside the economic importance of livestock as a store of wealth and insurance, livestock also plays a fundamental role in socio-cultural institutions related to marriage and inheritance (Bailey, 1999). However there is a great concern for pastoral population in the arid and semi-arid zones of East Africa due to recurring drought. East African pastoralists face a high and increasing risk due to substantial and seemingly increasing climatic variability (Bailey, 1999; Little et al., 2001; McPeak, 2004; Barrett and Luseno, 2004; AfDB, 2010). This statement is still valid today with regard to the successive occurrence of drought episodes (1990s, 2000-2001, 2005-2006, 2008-2009, 2010-2011 and 2015) in many parts of the Horn of Africa, one of the worst being that of 2010-2011 (Desta and Coppock, 2002; Little et al., 2006; Coppock et al., 2008; IFRC, 2011; Dutra et al., 2013). Also the current food aid needs for Ethiopia due to recent severe drought caused by poor rains (March-September 2015 period) and the El Nino phenomenon has put at risk around 7.5 million people (FEWS NET, 2015; UN-OCHA, 2016 ).

In the livestock sector, drought leads to the decline in forage and water availability which in return deteriorates the overall livestock health conditions (including a loss of weight or emaciation) and translates most of the time into a decline in livestock price and revenues. There is a wide range of risks faced by pastoralists living in the arid and semi-arid lands (ASAL) of East Africa with the most important one being the sudden and unexpected herd losses (McPeak and Barrett, 2001). Thus drought is a serious threat to the livelihood of pastoralists living in dry regions where livestock investments represent both savings and risk management strategy to face climatic or social risks  according to Alary, Corniaux and Gautier (2011, p.1642-43). They deplore however that “livestock sector is often neglected or even forgotten in the Poverty Reduction Strategy Papers (PRSPs) that determine national policies aimed at reducing poverty” (p.1638).

One of several strategies to reduce risk exposure of losing livestock consists of improving livestock marketing especially in the ASALs regions (Arid and Semi-Arid Lands) where very low rates of livestock sales were observed (weak markets) in response to shocks (McPeak and Barrett, 2001). Research findings in the northern Kenyan markets of Marsabit and Moyale have shown in fact a great variability in livestock price and weak spatial correlation in price co-movements. Timely access to market information system is as well very important in mitigating the consequences of drought on livestock and pastoralists’ livelihoods. Thus strengthening the livestock early warning system (LEWS) that provide both weather and price market information to livestock herders, in the East Africa, could help confront natural hazard such as drought.

This paper will attempt to analyze the level of price interaction among livestock markets in both Ethiopia and Kenya and whether the 2010-2011’s drought in the Horn of Africa had an impact on cattle markets in the respective countries. This will be assessed through the analysis of the level of market integration and shock transmission as well as the structural break analysis.

*Literature review*

Frequent and prolonged droughts have caused food insecurity and many other social and economic challenges to the population of East Africa in general and more particularly to the pastoralists who rely completely on livestock rearing (Simel, 2009). Due to food insecurity, pastoralists are at risk when multiple years of drought follow each other and no government efforts or strategic plans is put in place for reconstruction and recovery to restore the pastoralist livelihoods. The occurrence of periodic droughts tends to wipe out asset gains that poor households attain (Little et al., 2006). At a very optimistic post-drought annual growth rate of about 0.3 TLU/year, very poor households would still take about eight to ten years to reach an asset threshold of around 1.0 TLU per capita (an average of 4.5 TLU per household). In this scenario it is very likely that a drought or other shock (for example, family illness) would occur in the intervening years and obliterate asset gains (p.211).

The 2010–2011 drought in the Horn of Africa affected over 13 million people, half of them being children (Ledwith, 2011). One of the main reasons of the famine was the failure of the October to December 2010 "short" rains and the delayed arrival of the April to June 2011 "long" rains which caused crop failures across Somalia, Ethiopia and Kenya (Anderson et al., 2012). As of the recent drought that hit Ethiopia in 2015, the El Nino global climatic event is blamed for ruining the summer rains that came after the failure of the spring rains which have increased the food insecurity, malnutrition and water shortage a high level (UN-OCHA, 2016).

Experts pointed out that the prolonged drought is not the only causes of food insecurity and famine in the Horn of Africa (Ledwith, 2011). Beside the impact of conflict and instability, the issue of low yield from cultivated lands was exacerbating the crisis. Agricultural development that would lead to the increase in per capita crop yield in the pastoralists' regions is one of the key to the lingering problem of drought that most of the climatologists see on the horizon for many years to come.

Despite the fact that the populations living in the Horn of Africa have developed for hundreds of years survival methods and coping mechanisms in the face of severe droughts (migration, stock reduction, emergency wells…), this region has politically, economically and environmentally changed, requiring new strategies (IFRC, 2011). Several recent studies on Northern Kenya and

Southern Ethiopia have focused on the coping strategies used by pastoralists during recent droughts and the longer-term adaptations that underlie them (Morton, 2007; IFRC, 2011).

One of the strategies is the access to livestock markets and early warning systems (Simel, 2009). Research conducted in Northern Kenya markets (Marsabit and Moyale) shows that pastoralists use rarely the market to restock their herds after a shock (McPeak and Barrett, 2001). This suggests that marketing institutions are not playing their role of transforming animal wealth into cash during the crisis period or for self-restocking using savings after the crisis (p.676).

The issue of lack of access to livestock markets has been raised and continues to be raised by pastoralist communities as one of the major contributing factors in livestock deaths during droughts. Increased access to markets will improve pastoralists' terms of trade but as well help to destock in drought periods and restock when rainfall becomes available. Mitigation strategies should address as well the capacity of pastoralist organizations and communities to initiate and develop simple but functional early warning systems within different pastoralist regions and communities (Masih et al. 2014). Long term solutions to the drought issues lie with building community resilience and empower smallholder farmers and pastoralists of the arid lands (IFRC, 2011). Beside the traditional coping mechanism in drought crisis such as mobility and restocking, sustainable approaches comprise building marketing infrastructure and institutions to reduce price volatility, inter-market price differentials and transactions costs (McPeack and Barrett, 2001). Increase and timely access to market and weather forecast information are essential to a long term solution (IFRC, 2011). Drought remains a major disaster causing huge damages to humanity, the environment and the economy, despite making considerable progress on monitoring, forecasting and mitigation of droughts across the world

*Methods*

- *Vector auto-regression*

A possibility of studying the interaction among variables is through econometric analysis of a set of structural equations or as a reduced form vector auto-regression (VAR). The structural equation form is not generally recommended due to possible endogeneity problems (Enders, 2010). Using matrix algebra we can transform the structural form into a standard VAR form or reduced form that is more empirically tractable. The VAR is applied to a vector of prices from m markets at period t ($P_t$) of lag order k; it is represented in compact form as:

$$P_t = A_0 + A_1 P_{t-1} + \ldots + A_k P_{t-k} + e_t \qquad (1)$$

Here $e_t$ is an m-order innovation vector and $A_k$ k=0 …, k is an unknown (to be estimated) (mxm) coefficient matrix.

To capture more on the dynamic properties of a VAR model, innovation accounting techniques can be used. In this paper, the forecast error variance decomposition and the impulse response function were applied to check for these properties[1]. Forecast error variance decomposition informs us on how much change in the future (uncertainty or error variance) of one market price is caused by uncertainty in other markets. We converted the VAR in its vector moving average representation (VMA) to summarize the dynamic price relationships (Swanson and Granger, 1997; Enders, 2010).

[1] To save space we did not present the results on the impulse response function; they are however available upon request

- *Directed Acyclic Graph*

Co-integration methods are important in determining the co-movements of variables but they do not necessarily inform us on the causality between variables. Since the co-integration analysis does not explore the causality between variables, several studies have used the directed acyclic graphs (DAG) method (see works by Bessler and Akleman, 1998; Awokuse and Bessler, 2003; Bessler and Kergna, 2003; Haigh and Bessler, 2004; Vitale and Bessler, 2006) to explain causal relationship between variables in the Agricultural Economics field.

A directed graph is a diagram that represents a causal flow among a set of variables (Vitale and Bessler, 2006). Capital letters such as X1, X 2, . . . ,X n are used to represent variables and lines (also called edges) with arrowheads at one end are used to represent causal flows (e.g. X 1→ X 2 is used to indicate X 1 causes X 2) (Haigh and Bessler, 2004). The graphs with directed edges (for instance the representation X 1 → X 2 is called a directed edge) are of importance since they show the direction of the causal flow as opposed to undirected and bi-directed edges.

- *Structural break analysis*

To find out whether the drought of 2010-2011 in East Africa has had an impact or not on cattle market behavior, we run structural break tests. These tests also called parameter instability test check for any discontinuity in parameter values (Kim et al., 2007). We tested for structural break to check any change of structure that might have happened over the period of study. Several methods that comprise the recursive residual test, Chow test, Box M test and Bai-Perron tests are reported in the literature. However traditional test such as Chow test have nuisance parameter problems when the structural break point is unknown (Kim et al., 2007). This is the reason why the Bai-Perron test (Bai and Perron, 2003), the recursive residuals and the Box M tests methods were used to test for structural break points (we report the Bai-Perron test only). Specifically for the Bai-Perron test, it addresses the important problem of testing multiple structural breaks changes (Jin and Miljkovic, 2009). The procedure allows one to test the null hypothesis of, say, *l* change(s), versus the alternative hypothesis of *l*+1 changes. The latter is particularly useful in that it allows a specific to general modeling strategy to consistently determine the appropriate number of changes in the data.

*Data and Study Area*

To reach our objective, weekly cattle prices were analyzed from July 2007 to July 2012 in Ethiopia and Kenya. Four livestock markets in each country of Ethiopia and Kenya were considered for this study. The choice of the markets depended totally on data availability. All the price data in the two countries were collected mostly during the implementation of the livestock market information system project "LINKS" in East Africa (2003-2010) and afterwards by the implementing institutions in the respective countries. The markets studied are: Addis Ababa-Kararo, Gondar, Abaala and Mekele for Ethiopia and Nairobi-Dagoretti, Chepareria, Emali and Garsen for Kenya. It worth mentioning that we were unable to include markets located in most dry areas (especially in Ethiopia and Kenya) due to a limited data availability. Although prices were collected for various kinds, breeds, ages, and body conditions of cattle, we mainly examined prices of medium adult males. The choice of livestock markets and cattle characteristics (gender, age and body conditions) to include in the study depended strictly on the availability of data.

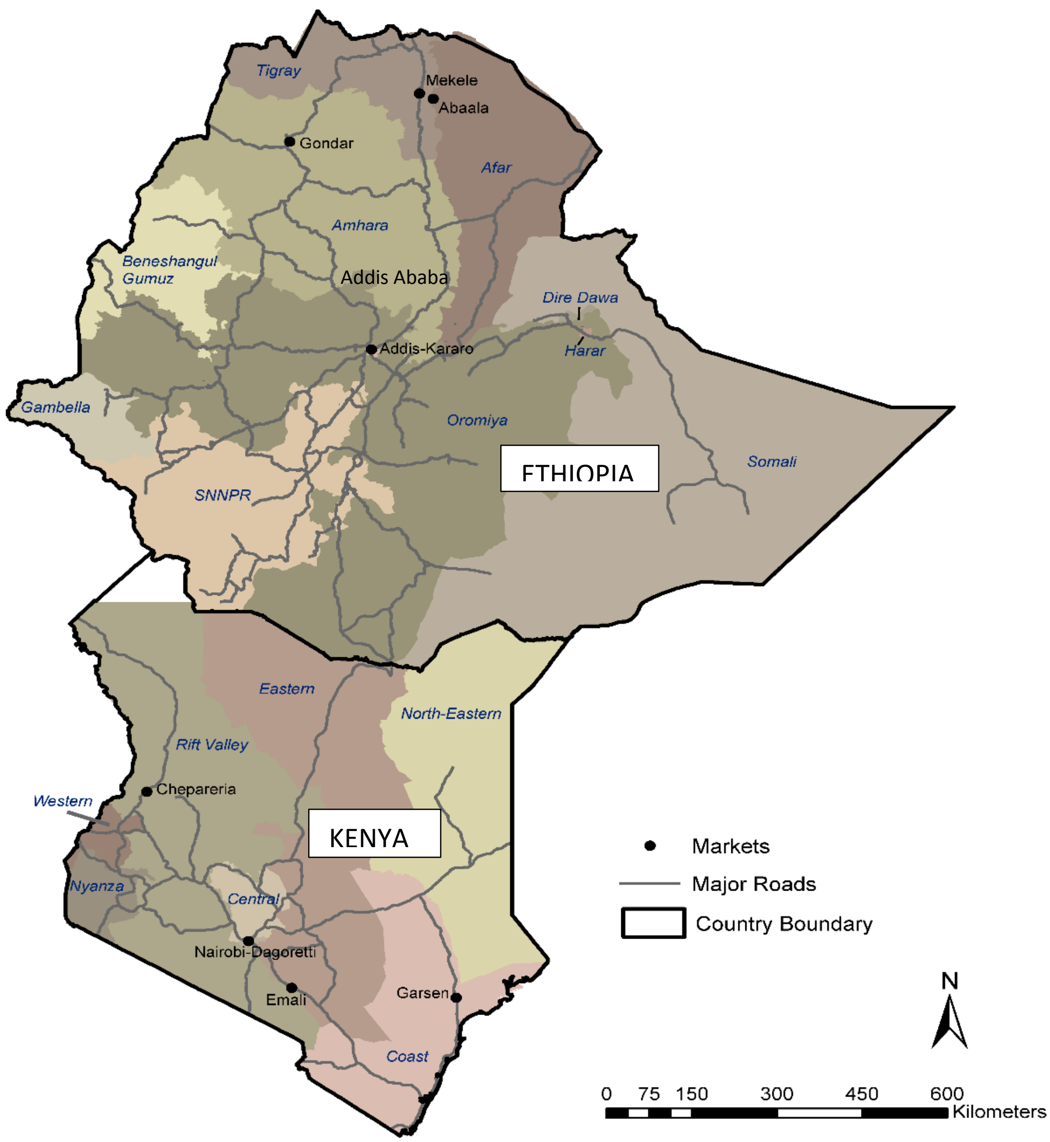



Figure 1. Livestock markets locations in Ethiopia and Kenya

To characterize the drought in our study area (Ethiopia and Kenya), the SPEI (Standardized Precipitation-Evapotranspiration Index) was used. The SPEI is a multi-scalar drought index based on climatic data. It can be used for determining the onset, duration and magnitude of drought conditions with respect to normal conditions in a variety of natural and managed systems such as crops, ecosystems, rivers, water resources, etc. A multi-scaling drought indicator is needed to take into account deficits that affect different usable water sources and to distinguish between different types of drought (Potop et al., 2013). The newly developed SPEI (Vicente-Serrano et al. 2010) is based on monthly precipitation totals and temperature means and follows a simple approach to calculate the PET (Potential Evapo-transpiration) based on a normalisation of the simple water balance (Thornthwaite, 1948). To evaluate the impact of drought on each country, we considered a region index instead of single grid cell. For Ethiopia, the region stretched from Abaala (lat. = 13.37; long. = 39.75) to Chereti (lat. = 5.33; long. = 41.83) while for Kenya the region stretched from Chepareria (lat. = 1.31; long. = 35.20) to Mombassa (lat.= -4.05; long. = 39.66). Various lags are considered for the calculation of SPEI (1- 48 lags) and can be related to different types of droughts in a region (Potop et al. 2013). Short time scales are mainly related to variation in soil moisture content while the long time scales can characterize variation of water resources in soil reservoirs. In our study a 12-month lag was used and the period studied is from July 2007 to July 2012 for Kenya and September 2007 to July 2012 for Ethiopia.

*Preliminary results and discussion*

The evolution of cattle prices over five years at the livestock markets in Ethiopia and Kenya showed a predominant pattern of high variability and an upward trend among price series (Figures 1&2). The unit root test results on levels from the Augmented Dickey-Fuller (ADF) test revealed that all the market prices were non stationary which supports the graph visual analysis. To examine the relationships among the cattle market prices in Ethiopia and Kenya, several approaches (graphical, statistical and econometric) were used. A directed acyclic graph (DAG) was produced from the VAR residuals to explore the contemporaneous correlation among the cattle price innovations (Figures 3&4). The DAG helps evaluate the causal flow in current time among the price series from the VAR model estimation.

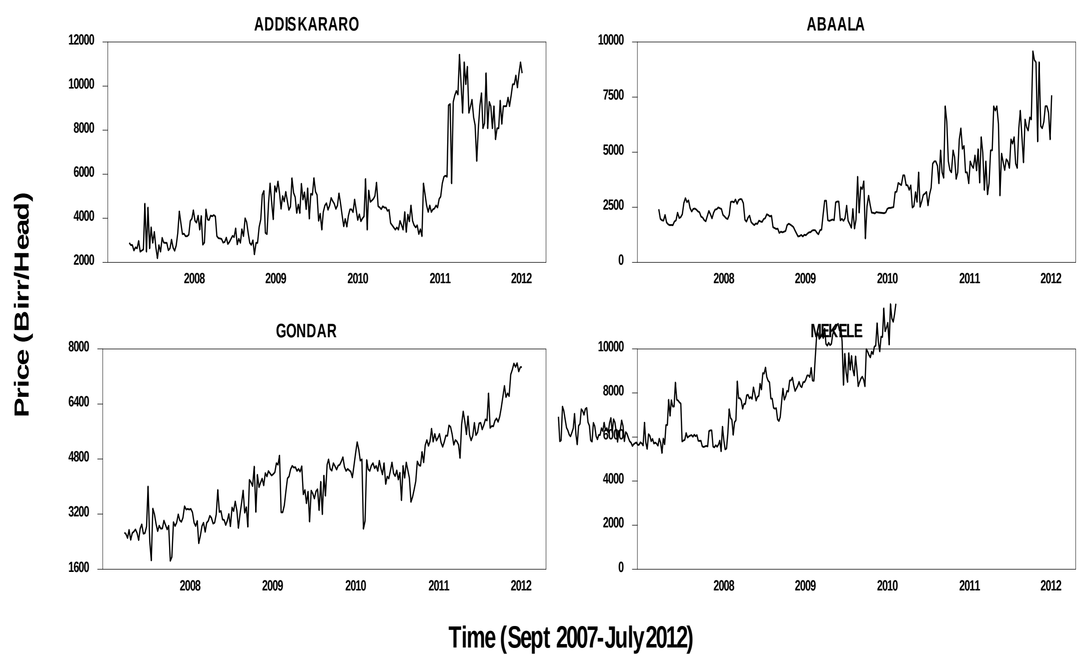



Figure 2. Cattle prices in levels at four livestock markets in Ethiopia, 2007-2012

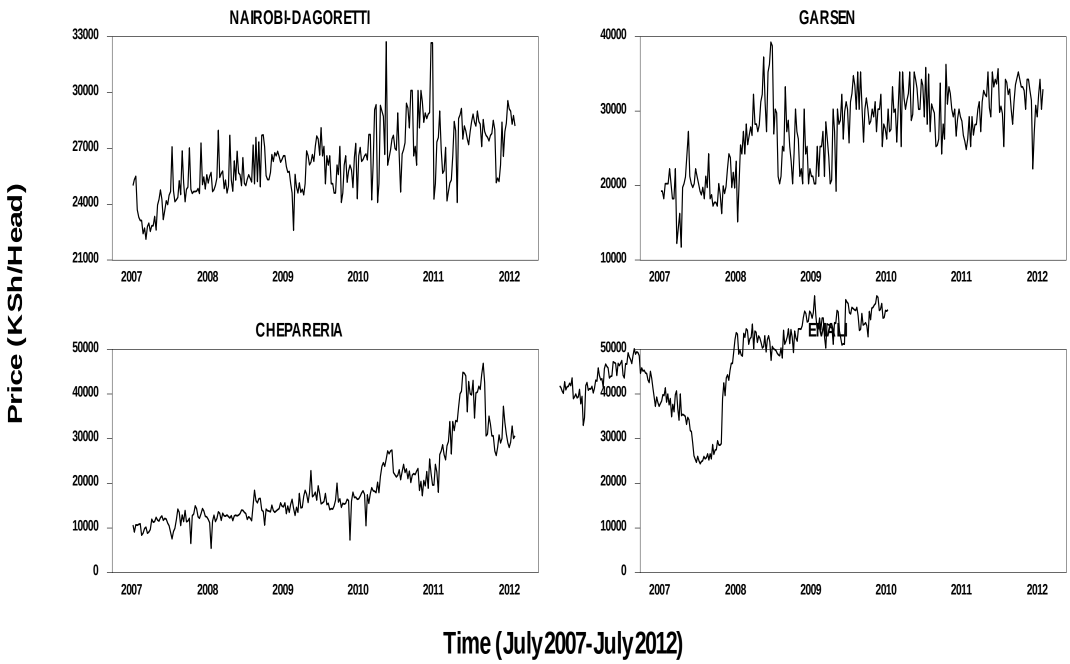



Figure 3. Cattle prices in levels at four livestock markets in Kenya, 2007-2012

Given that the residuals were not normally distributed the LiNGAM algorithm was used in the TETRAD software to produce the DAG. Results of the DAG analysis in both countries indicate that the livestock markets in the capital cities (Addis-Ababa for Ethiopia and Nairobi for Kenya) appeared to send price information signals (innovations) to other markets in current time. The markets of Gondar (in Ethiopia) and Chepareria (in Kenya) seem to send price information as well to other markets while Abaala and Mekele markets (in Ethiopia) and Emali and Garsen markets (in Kenya) are price information receivers.

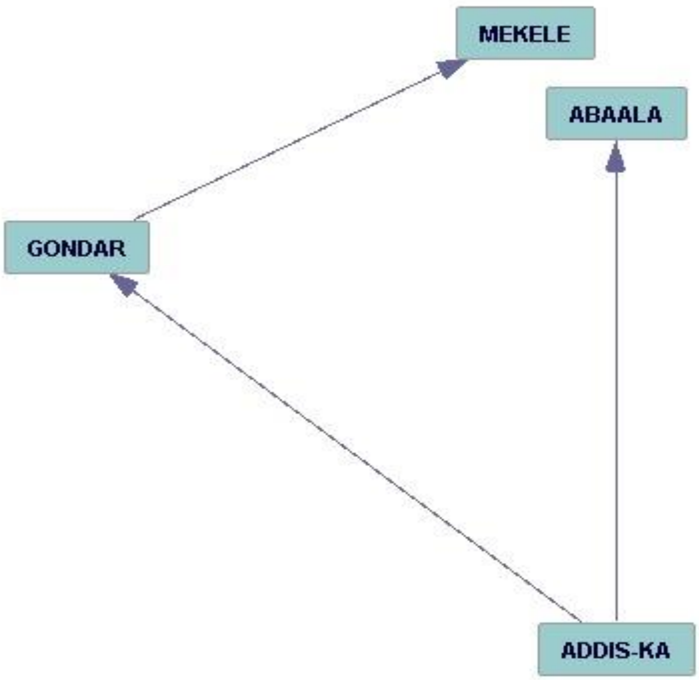



Figure 4. Causal flow found with LiNGAM on innovations from a VAR model on cattle prices from four markets in Ethiopia, 2007-2012

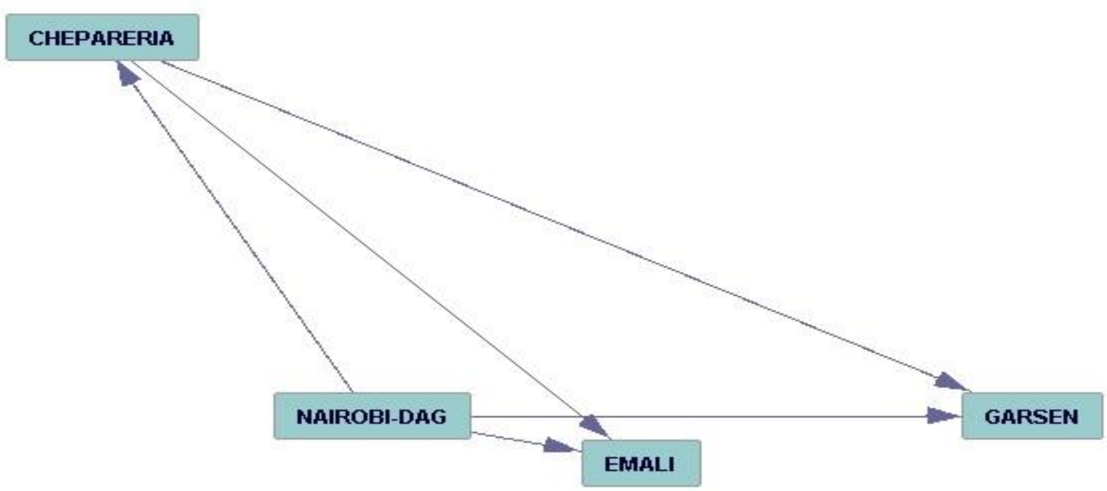



Figure 5. Causal flow found with LiNGAM on innovations from a VAR model on cattle prices from four markets in Kenya, 2007-2012

*Market price dynamics*

The vector auto-regression analysis showed that in general for both countries, the cattle market prices are explained mainly by their lags (1 to 2). The Gondar market in Ethiopia is an exception given that its current price is explained by its lags (1 to 2) and the lags of Addis-kararo markets. The same behavior is observed for Mekele market which is explained by its lags and the lagged price of Abaala market. The exogenous drought index variable was not statistically significant in all the studied markets in Ethiopia except for the Abaala market.

All the four cattle market prices considered in Kenya are explained by their lagged values (1 to 2) without an exception. The exogenous drought index variable was not statistically significant in all the studied markets in Kenya except for the Dagoretti Nairobi market. The cattle markets in Kenya seem to interact less compared to those in Ethiopia.

To gain more insight on cattle market interaction, the innovation accounting techniques (forecast error variance decomposition and impulse response function) were performed.

The forecast error variance decomposition provide capabilities for analyzing how much change in the future (uncertainty or error variance) of one market price is caused by shocks from other markets in current time, at one week, four weeks and eight weeks ahead. It provides a percentage of forecast error uncertainty in one market accounted for by earlier innovations (shocks) from other markets (Table 1 & 2). The general observation from these 2 tables is that the level of price change accounted for by own-price shocks is higher in Kenyan markets than in Ethiopian markets meaning that cattle markets in Kenya interact less among themselves compared to Ethiopia. For instance at longer horizons (8 weeks ahead), the percentage of price changes in one Ethiopian markets accounted for by shocks from another market is higher (greater than 10%) compared to Kenya (less 10%). In Ethiopia, the Mekele market seems to be the most interactive among the four markets while in Kenya, the Chepareria market seems to be the least interactive among the four followed by the Emali market. These observations regarding the cattle markets interaction in Ethiopia and Kenya are supported by the impulse response function results.

The impulse response function (See Appendix II) shows how different markets (listed at the beginning of each row) respond over a certain period of time (8 weeks) to a one-time-only shock or innovation in other markets (listed at the heading of each column). However given the low number of cattle markets examined in this study, the observations on the cattle markets interaction in Ethiopia and Kenya cannot be conclusive.

Table 1. Forecast error variance decomposition on cattle prices in Ethiopia, 2007-2012

| Horizon | Addis-Kararo | Gondar | Abaala | Mekele |
|---|---|---|---|---|
| | | (Addis-Kararo) | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 99.37 | 0.62 | 0.01 | 0.00 |
| 4 | 96.40 | 1.71 | 0.20 | 1.69 |
| 8 | 88.12 | 4.31 | 1.29 | 6.28 |
| | | (Gondar) | | |
| 0 | 0.16 | 99.84 | 0.00 | 0.00 |
| 1 | 0.25 | 99.50 | 0.25 | 0.00 |
| 4 | 2.09 | 94.32 | 1.72 | 1.88 |
| 8 | 5.41 | 83.45 | 4.35 | 6.79 |
| | | (Abaala) | | |
| 0 | 0.00 | 0.01 | 99.99 | 0.00 |
| 1 | 0.01 | 0.64 | 95.88 | 3.48 |
| 4 | 2.09 | 0.72 | 90.98 | 6.21 |
| 8 | 5.12 | 1.50 | 82.89 | 10.49 |
| | | (Mekele) | | |
| 0 | 0.04 | 0.00 | 0.00 | 99.96 |
| 1 | 0.28 | 0.28 | 0.12 | 99.32 |
| 4 | 1.02 | 3.60 | 4.90 | 90.48 |
| 8 | 0.93 | 7.60 | 10.70 | 80.78 |

Table 2. Forecast error variance decomposition on cattle prices in Kenya, 2007-2012

| Horizon | Dagoretti | Chepareria | Garsen | Emali |
|---|---|---|---|---|
| | | (Dagoretti) | | |
| 0 | 100.00 | 0.00 | 0.00 | 0.00 |
| 1 | 99.78 | 0.04 | 0.17 | 0.01 |
| 4 | 95.50 | 2.37 | 0.91 | 1.22 |
| 8 | 90.10 | 5.61 | 1.22 | 3.08 |
| | | (Chepareria) | | |
| 0 | 0.17 | 99.83 | 0.00 | 0.00 |
| 1 | 0.33 | 98.87 | 0.36 | 0.44 |
| 4 | 0.18 | 99.32 | 0.25 | 0.25 |
| 8 | 0.12 | 99.14 | 0.21 | 0.53 |
| | | (Garsen) | | |
| 0 | 0.80 | 0.61 | 98.50 | 0.00 |
| 1 | 2.16 | 1.02 | 96.53 | 0.29 |
| 4 | 2.11 | 2.18 | 95.07 | 0.65 |
| 8 | 2.10 | 4.23 | 92.18 | 1.49 |
| | | (Emali) | | |
| 0 | 0.03 | 0.27 | 0.00 | 99.60 |
| 1 | 0.14 | 0.27 | 0.01 | 99.59 |
| 4 | 0.54 | 0.41 | 0.01 | 99.05 |
| 8 | 0.72 | 1.45 | 0.01 | 97.83 |

*Structural breaks analysis (Bai-Perron test)*

The Bai-Perron test was run for four cattle markets in Ethiopia and four cattle markets in Kenya. We tested sequentially four possible break points in each market to investigate whether there are multiple structural break points in the cattle price time series. The null hypothesis of zero structural break was rejected in all cases while we failed to reject the existence of four possible structural breaks. For the Ethiopia case (Table 3), if we input the maximum of one break point, the break date that comes up in three of the four markets is around August-September 2011 (except Gondar that has a break date around April 2008). If two break points are tested, the break dates are around 2010-2011 and 2011-2012. When three and four break are input, we notice that other possible break dates revolve around 2008 and 2009 in addition to the 2011 date. Overall, the period around 2010-2011 seems to be an important structural break date possibly due the drought that hit the Horn of Africa in 2010 and 2011 (FEWNET, 2011). Note however that, the intervention of the National Bank of Ethiopia (NBE), in Ethiopia, to devaluate the Birr by 20% in September 2010 may have contributed to the structural break in the cattle prices model.

Table 3. Number of break points and dates in four markets, Ethiopia 2007-2012

| | Break points | | | |
|---|---|---|---|---|
| Markets | 1 | 2 | 3 | 4 |
| Addis-Kararo | 2011:08:05 | 2011:08:05 | 2008:04:04 | 2008:04:04 |
| | | 2012:01:20 | 2009:06:19 | 2009:06:19 |
| | | | 2011:08:05 | 2011:08:05 |
| | | | | 2012:01:20 |
| | | | | |
| Gondar | 2008:04:25 | 2008:07:25 | 2008:07:25 | 2008:08:08 |
| | | 2010:07:16 | 2010:07:30 | 2009:04:10 |
| | | | 2011:01:28 | 2010:07:30 |
| | | | | 2011:01:28 |
| | | | | |
| Abaala | 2011:03:25 | 2011:03:25 | 2010:11:19 | 2009:09:11 |
| | | 2012:01:06 | 2011:05:27 | 2010:12:03 |
| | | | 2011:11:11 | 2011:05:27 |
| | | | | 2011:11:11 |
| | | | | |
| Mekele | 2011:09:30 | 2010:04:30 | 2008:08:08 | 2009:06:12 |
| | | 2011:09:30 | 2010:04:30 | 2010:02:12 |
| | | | 2011:09:30 | 2010:08:13 |
| | | | | 2011:09:30 |

As for Kenya (Table 4), the break dates that come up when testing for one and two break points revolve around 2010 and 2011 (except for Garsen market). We have similar results if we test for three and four break dates at the exception of Garsen again which consistently shows its break dates around 2008-2009. In summary the results seem to consistently indicate that the 2010-2011 drought may have caused a structural break in the cattle price time series. Given the drought cycle that keeps repeating every 2-3 years in the Horn of Africa (IFRC, 2011) we would not exclude the existence of other break dates (such as 2008-2009) as being caused as well by drought.

Table 4. Number of break points and dates in four markets, Kenya 2007-2012

| | Break points | | | |
|---|---|---|---|---|
| Markets | 1 | 2 | 3 | 4 |
| Dagoretti | 2010:11:15 | 2010:11:15 | 2010:04:12 | 2010:04:12 |
| | | 2011:08:01 | 2010:11:15 | 2010:11:08 |
| | | | 2011:08:01 | 2011:05:02 |
| | | | | 2011:10:17 |
| | | | | |
| Chepareria | 2011:08:01 | 2011:07:25 | 2010:05:24 | 2009:09:14 |
| | | 2012:01:30 | 2011:07:25 | 2010:08:09 |
| | | | 2012:01:30 | 2011:07:25 |
| | | | | 2012:01:30 |
| | | | | |
| Garsen | 2008:07:21 | 2009:04:06 | 2008:10:27 | 2008:02:25 |
| | | 2009:11:02 | 2009:04:13 | 2008:10:27 |
| | | | 2009:11:02 | 2009:04:13 |
| | | | | 2009:11:02 |
| | | | | |
| Emali | 2010:01:04 | 2010:01:04 | 2010:01:04 | 2009:05:18 |
| | | 2011:02:28 | 2011:05:09 | 2010:01:04 |
| | | | 2011:11:14 | 2011:05:09 |
| | | | | 2011:11:14 |

*Conclusions*

The analysis of cattle price dynamics in livestock markets from Ethiopia and Kenya show limited interaction among cattle markets in both countries. However the communication among cattle market in Ethiopia is slightly better than that of Kenya. The four Kenya markets analyzed in this study seem to be isolated; the level of price signals transmission is very weak. The results indicate that more than 90% of price changes in Kenya are due to local shocks (own-price shcks) while in Ethiopia the proportion is around 80%.

The structural break analysis revealed that the period around 2010-2011 seems to be the predominant break date in all the markets analyzed in Ethiopia and Kenya. This break date seemed plausible due to the prolonged drought period that hit the Horn of Africa around 2010-2011. However given the limited number of markets analyzed in this study, we recommend further studies that would include more markets to analyze this problem and clarify more on the structural break conclusions.

Implication: when markets are not integrated, the option of using the markets as a mitigating mechanism against drought, by selling livestock to destock during drought and buying livestock to restock after drought becomes unavailable for livestock herders. Thus, there is a high risk of losing part or the entire herd with dramatic financial consequences. The better the markets are integrated the lower the risk of losing animals during a drought.

## References

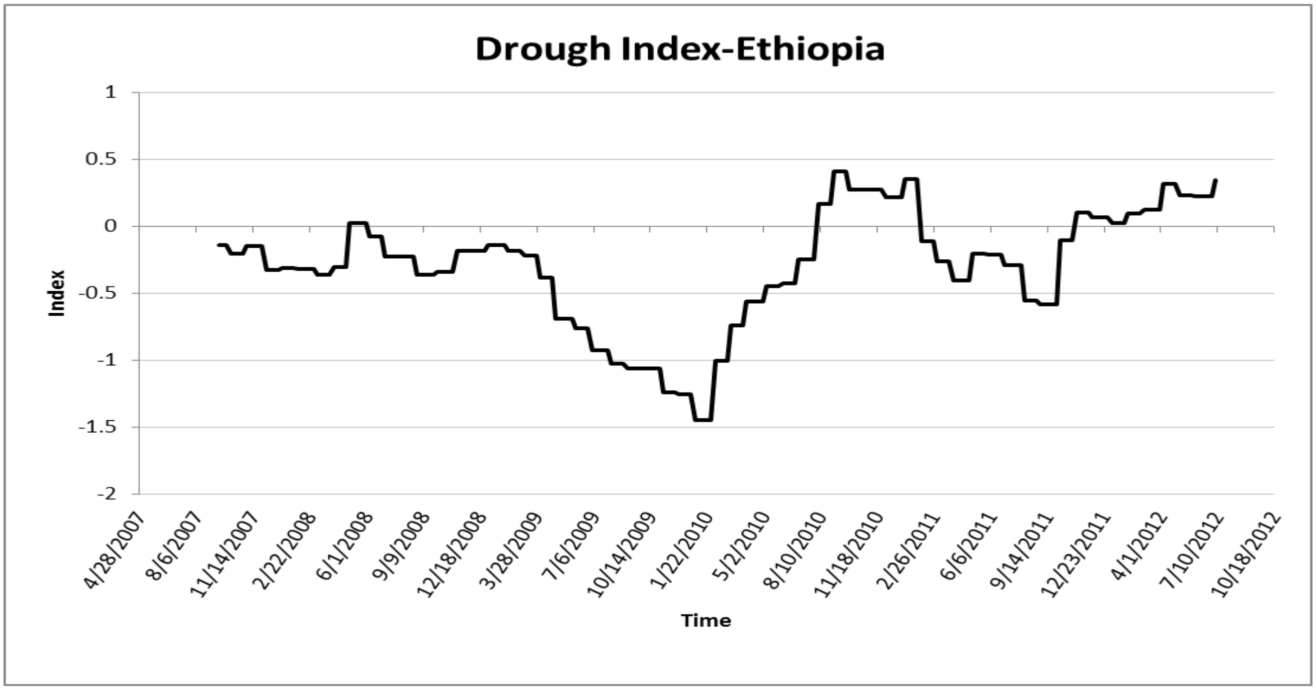

1. African Development Bank Group (AfDB). 2010. Regional Study on the Sustainable Livestock Development in the Greater Horn of Africa. LOG Associates, Nairobi, Kenya. http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Final_Synthesis_Report_AfDB_Regional_Livestock_Study_20_January_2010%5B1%5D.pdf; Accessed January 2014.
2. Alary, Corniaux and Gautier. 2011. Livestock's Contribution to Poverty Alleviation: How to Measure It? *World Development*, 39 (9), pp. 1638–1648.
3. Anderson, W. B., Zaitchik, B. F., Hain, C. R., Anderson, M. C., Yilmaz, M. T., Mecikalski, J., and L. Schultz. 2012. Towards an integrated soil moisture drought monitor for East Africa. *Hydrol. Earth Syst. Sci.*, 16, 2893–2913. doi:10.5194/hess-16-2893-2012
4. Awokuse, T.O. and D.A. Bessler. 2003. Vector autoregressions, policy analysis, and directed acyclic graphs: An application to the U.S. Economy. *Journal of Applied Economics*, Vol. VI, No. 1: 1-24 pp.
5. Bai, J. and P. Perron. 2003. Critical values for multiple structural change tests. *Econometrics Journal*, volume **6**, pp. 72–78
6. Bailey, D., Barrett, C.B., Little, P.D. and F. Chabari. 1999.Livestock Markets and Risk Management Among East African Pastoralists: A Review and Research Agenda. GL-CRSP Pastoral Risk Management Project Technical Report No. 03/99. Logan, UT: Utah State University.
7. Barrett, C.B. and Luseno, W.K. 2004. Decomposing Producer Price Risk: A Policy Analysis Tool with an Application to Northern Kenyan Livestock Markets." *Food Policy*, 29(4), pp. 393-405.
8. Bessler, D.A. and D.G. Akleman.1998. Farm Prices, Retail Prices, and Directed Graphs: Results for Pork and Beef. *American Journal of Agricultural Economics*, 80 (5): pp.1144-1149.
9. Bessler, D.A. and A. Kergna. 2003. Price Discovery: the case of millet in Bamako, Mali. *Journal of African Economies*, 11(4), pp. 472-502.
10. Coppock D.L., Gebru G., Desta S., Mesele S. and S. Tezerra. 2008. Are Cattle Die-Offs Predictable on the Borana Plateau. *ENVS Faculty Publications*. Paper 212, Utah State University. http://digitalcommons.usu.edu/envs_facpub/212. Accessed June 2012.
11. Desta, S. and D.L. Coppock. 2002. Cattle population dynamics in the southern Ethiopian rangelands, 1980-97. *J. Range Manage*, 55: 439-451.
12. Dutra, E., Magnusson, L., Wetterhall, F., Cloke, H.L., Balsamo, G., Boussetta, S. and Pappenberger, F. (2013). The 2010–2011 drought in the Horn of Africa in ECMWF re-analysis and seasonal forecast products. *Int. J. Climatology. 33: 1720–1729.* DOI: 10.1002/joc.3545
13. Enders, W.2010. *Applied Econometric Time Series*, 3rd Edition. New Jersey: John Wiley & Sons Inc.

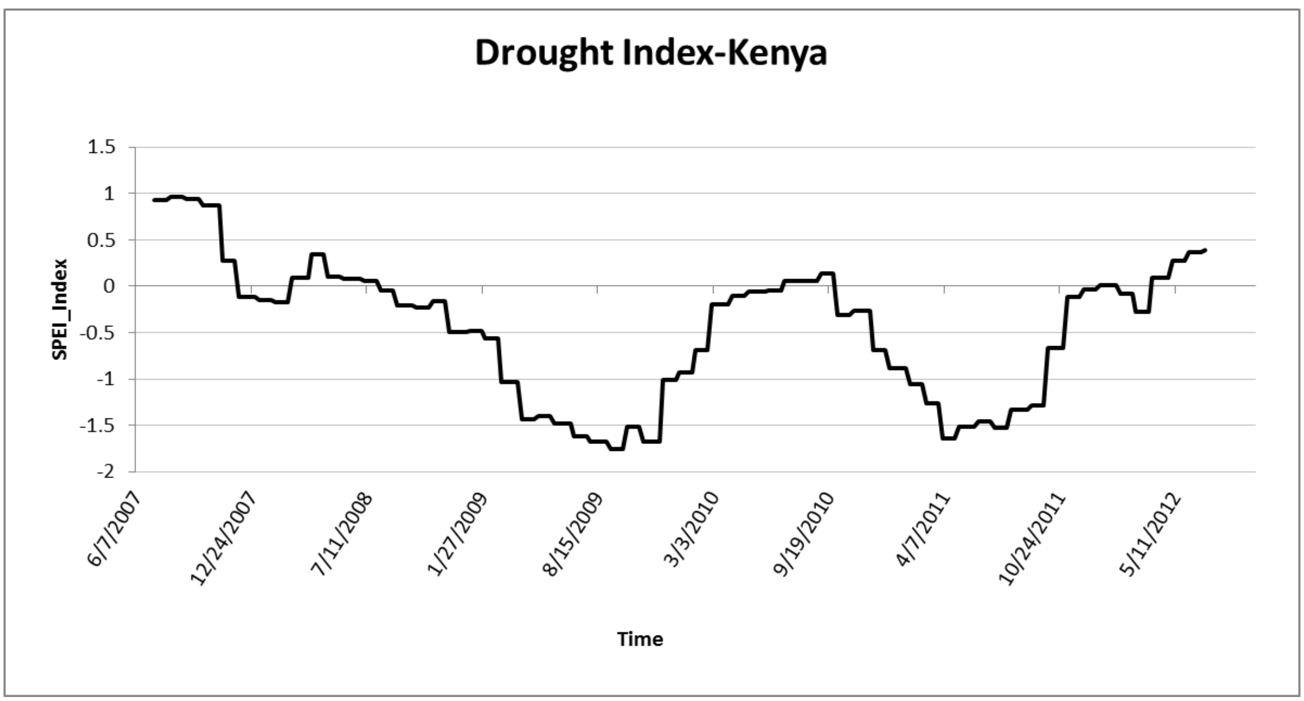
14. Famine Early Warning System Network (FEWS NET). 2015. Illustrating the extent and severity of the 2015 drought. Ethiopia Special Report, December 17, 2015. http://www.fews.net/east-africa/ethiopia/special-report/december-17-2015. Accessed December, 2015.
15. Haigh, S.M. and D.A. Bessler. 2004. Causality and Price Discovery: An Application of Directed Acyclic Graphs. *Journal of Business*, 77(4):1099-1121.
16. International Federation of Red Cross and Red Crescent (IFRC). 2011. Drought in the Horn of Africa: Preventing the next disaster. Geneva, Switzerland.
17. Kim, J.W., Leatham, D.J. and D.A. Bessler. 2007. REITs' dynamics under structural change with unknown break points. *Journal of Housing Economics*, 16:37–58.
18. Jin, H.J and D. Miljkovic. 2009. An analysis of multiple structural breaks in US relative farm prices. *Applied Economics*, 42: 3253–3265.
19. Morton, J.F. 2007. The impact of climate change on smallholder and subsistence agriculture. PNAS 2007 104 (50) 19680-19685. doi:10.1073/pnas.0701855104 http://www.pnas.org/content/104/50/19680.full.pdf. Accessed January 2014.
20. Masih, I., Maskey, S., Mussá1, F. E. F., and P. Trambauer. 2014. A review of droughts on the African continent: a geospatial and long-term perspective. *Hydrol. Earth Syst. Sci*., 18, 3635–3649.
*21*. McPeak, J.G. and C.B. Barrett. 2001. Differential risk exposure and stochastic poverty traps among East African pastoralists. *American Journal of Agricultural Economics*, 2001.
22. McPeak, J.G. 2004. Contrasting income shocks with asset shocks: livestock sales in Northern Kenya, *Oxford Economic Papers*, 56: 263–284.
23. Ledwith, T. Crisis in the Horn of Africa: Rethinking the Humanitarian Response, 5 October 2011. http://www.unicef.org/esaro/5440_Horn_of_Africa_seminar.html. Accessed December, 2015
24. Little, P.D., K. Smith, B.A. Cellarius, D. L. Coppock and C.B. Barrett (2001) 'Avoiding Disaster: Diversification and Risk Management among East African Herders', *Development and Change*, 32: 401-433.
25. Little, P.D., Stone, M. P, Mogues, T., Castro, A. P and W. Negatu. 2006. Moving in place: Drought and poverty dynamics in South Wollo, Ethiopia. *The Journal of Development Studies*, 42:2, 200-225.
26. Simel J.O. 2009. Pastoralism and the Challenges of Climate Change. Indigenous Affairs, 3-4/09, in International Work Group for Indigenous Affairs (IWGIA).
27. Swanson, N.R. and C.W.J. Granger. 1997. Impulse Response Functions based on causal approach to residual orthogonalization in vector autoregressions. *Journal of the American Statistical Association*, 92:357-367.
28. Thorntorn, P.K. and P.J. Gerber. (2010). Climate change and the growth of the livestock sector in developing countries. *Mitig Adapt Strateg Glob Change*, 15:169–184 DOI 10.1007/s11027-009-9210-9

29. United Nation-Office for the Coordination of Humanitarian Affairs (UN-OCHA). 2016. Weekly Humanitarian Bulletin: Ethiopia. http://reliefweb.int/sites/reliefweb.int/files/resources/humanitarian_bulletin_4_january_2016.pdf. Accessed Jan. 2016.
30. Vitale, J. and D.A. Bessler. 2006. On the discovery of millet prices in Mali. *Papers in Regional Science*, 85 (1):139-162.

APPENDICES

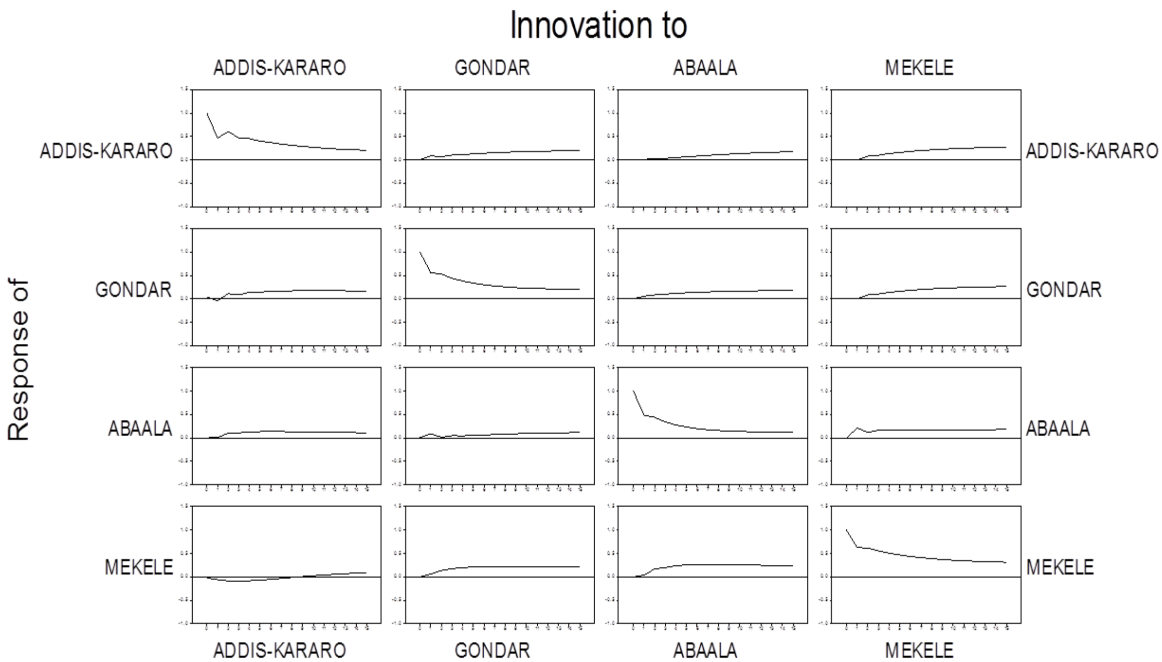
I. Drought Index



II. Impulse Response Function

- Ethiopia




- Kenya