ETHIOPIA

ANALYSIS OF WEATHER RISKS AND INSTITUTIONAL ALTERNATIVES FOR MANAGING THOSE RISKS

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Abbreviations, Acronyms, and Terms

BASIX	*Microfinance institution operating in India*
Bega	*A hot, dry period separating rainfall seasons in Ethiopia*
Belg	*Term used to describe both the minor growing season and the minor rainfall season in Ethiopia, falling between March and June, depending on location.*
CHARM	*Collaborative Historical African Rainfall Model*
Enset	*False banana, continue description*
FAO	*Food and Agriculture Organization of the United Nations*
FEWS	*Famine Early Warning System*
GDP	*Gross Domestic Product*
GLCRSP	*Global Livestock Collaborative Research and Support Program*
GRP	*Group Risk Plan (U.S. area-based crop insurance)*
Kiremt	*Major rainfall season in Ethiopia, called the "big rain"*
LEWS	*Livestock Early Warning System*
LINKS	*Livestock Information Network and Knowledge System*
M.T.	*Metric ton*
Meher	*The major growing season in Ethiopia, falling between May and November, depending on location*
MFI	*Microfinance Institution*
MPCI	*Multiple-Peril Crop Insurance*
PDF	*Probability Distribution Function*
Teff	*Staple cereal grain of Ethiopia*
USDA	*United States Department of Agriculture*
WFP	*World Food Program*
WMO	*World Meteorological Organization*

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Executive Summary

Ethiopia suffers from chronic poverty and hunger — conditions that are devastating when exacerbated by drought. Given that 85 percent of the 65 million people continue to live in rural areas, it is not surprising that weather-driven crises dominate the complex Ethiopian environment and, the situation worsens due to recent trends in climate. The droughts of 2000, 2002, and 2003, impacted 10 million people in *each* of those years. The drought of 1984 impacted 8 million people, of whom 300,000 lost their lives. However, beyond the severe humanitarian crises created by serious drought problems, these risks hinder economic development. The poor become extremely risk averse and hesitant to adopt yield-enhancing technologies. Furthermore, many are simply unable to make investments in production because they lack both assets and the access to financing. The broader financial community is constrained by ineffective coping strategies or management of weather risk dominating the Ethiopian landscape.

This report examines drought risk in Ethiopia in some detail by treating these risks as both a portfolio and an insurance problem. The portfolio is captured by the estimated value of the geographic spread of receipts from both crops and livestock in Ethiopia. The insurance approach uses rainfall insurance contracts that would pay for significant shortfalls of rain during critical growing seasons. Rainfall insurance is a relatively straightforward contract that would pay when rainfall is below a certain threshold. Previous designs of rainfall insurance contracts are limited, since payments are based either on cumulative rainfall over the entire season, or, on weighted average rainfall for the season reflecting critical rainfall periods. This report introduces a contract that would pay for shortfalls in rain for any month during the growing season. Thus, one could envision making multiple, and timely, payments as conditions become severe. This should help mitigate risk early on, before a crisis becomes full blown.

A close examination of rainfall data in Ethiopia gives cause for concern. A distinct negative trend in rainfall is present in most of the important growing areas. Furthermore, the relative risk of severe shortfalls in rain, as measured by rainfall insurance contracts developed in this study, is increasing. And while Ethiopia is a vast country with cropping patterns that vary by region, there are still significant correlated risks associated with drought. In other words, the most serious droughts have country-wide impacts. Nonetheless, this study systematically illustrates the degree of correlated risk problems for different regions and cropping seasons. As anyone who knows Ethiopia might expect, the southern and eastern rim of the country are most vulnerable to correlated risk problems driven by drought. When livestock are added to the portfolio of risk, the degree of these correlated risks does decline for the southern region. Even more interesting, severe drought for the two cropping seasons in the southern region appear to be slightly negatively correlated. This underscores the importance of supporting cropping when the early rains appear to be above average in the region. It also begs for improved forecasting in hopes that growers will make better early decisions about planting in the first season.

The results of the risk assessment should also prove useful to other policy prescriptions within the Ethiopian context. Knowledge of the relative risk across Ethiopia should benefit the development of both social and economic programs, in addition to risk mitigation and management strategies. The policy focus of this report involves the potential for rainfall insurance. Such insurance is emerging as a way to support a wide range of social and financial development. For example, the Indian microfinance group, BASIX, has recently begun selling rainfall insurance to small farmers. The group is also considering purchasing such insurance to hedge the portfolio of risk that they loan to small holders. Such innovations are possible in Ethiopia as well. This report provides background on how rainfall insurance would work, and what is required to support its development. A basic infrastructure of weather stations and weather services does exist in

Ethiopia. However, it is likely that public funds will need to be enhanced to strengthen the necessary infrastructure and institutions before weather insurance products could emerge. Such investments serve the public interest in a far broader context than simply opening the door for weather insurance.

The following potential uses for rainfall insurance are developed in the Ethiopian context:

- Linking rainfall insurance to loans
- Linking rainfall insurance to input usage
- Stand alone rainfall insurance
- Tying rainfall insurance to international food aid

Rainfall insurance can be used to spur lending. In some cases, lending is hampered by risk. One can envision a bundled lending arrangement whereby those obtaining loans would be purchasing a certain level of rainfall insurance. This could open the way for individual to gain better access to credit. However, such a system raises many questions regarding how the benefits of the arrangement might influence production decision. A special conceptual appendix (Appendix A) is presented to puzzle through these questions. The details of how much debt might be forgiven under what circumstances would also be a critical element to consider when linking debt to rainfall insurance. A better system may involve the purchase of the rainfall insurance directly by the bank or microfinance institution. This would allow the financial institution to hedge default risk that may arise in their portfolio of loans when there are widespread/correlated losses due to drought.

One can also envision linking rainfall insurance to input purchases such as fertilizer. The motivation for such an innovation ties back to concerns that poor farmers are reluctant to take the risk of investing in technology given the risk environment. Such systems have been introduced in Argentina. At this point, there is little knowledge regarding how these innovations change behavior (see Appendix A). One advantage of this approach is that it is easy to implement. When selling a bag of fertilizer one only need attach a coupon that can be redeemed if it does not rain in the area.

Direct sales of rainfall insurance are also possible. Insurers in Ethiopia expressed a keen interest in this idea. While basis risk (having a loss and not getting paid) is a concern, it is likely that a severe drought contract would have value in getting cash to many individuals when there is a regional problem.

The three scenarios presented above are not mutually exclusive in that these delivery mechanisms could co-exist, providing more options and flexibility. Keep in mind however, that the reach of input markets and financial institutions remains limited. Increasing the access to these services in rural areas should be a priority for improving agricultural production and risk management.

Finally, one can envision using the country-wide information that is generated from a portfolio model, such as what is presented in this study, to motivate cash payments to various key parties when a major problem is emerging. Results of the analysis show those years with severe rainfall shortages are correlated to World Food Program emergency assistance, supporting the idea that a rainfall index could be used as an early trigger for drought relief. It is well known that 1984 was among the worst drought years in Ethiopia. The analysis performed in this report demonstrates that 1984 was also, by far, the worst year from 1961 to 1996. A properly designed insurance solution could get cash into the hands of traders and others much earlier than food aid arrives. Using insurance-like solutions to provide early assistance is an idea that merits further development for Ethiopia.

In summary, this report provides a solid approach for assessing drought risk across Ethiopia. Several ideas introduced for using drought insurance to mitigate and manage risk in Ethiopia represent a blend of market and social solutions. It is hoped that the ideas presented in this report will spur further thinking and development.

Introduction

This report examines weather risk in Ethiopia and, in particular, drought risk and some specific innovations to help small holders and others manage those risks *ex ante*. Index-based insurance products that pay when there are shortfalls of rain during critical periods may find a role in the complex Ethiopian setting. Weather-based index insurance will not be the ultimate solution to the problems of drought and food insecurity in Ethiopia but it can serve as one instrument in a ‘toolbox’ of risk management strategies to help smooth the impact of certain economic shocks. It should be clear that these insurance-like solutions can only play a supporting role in combating the chronic poverty, underdevelopment, and famine that continue to plague Ethiopia.

Ethiopia is a vast territory with great diversity. Given the vast territory, localized disaster can occur and be completely missed by the international community. The propensity of the international community response to crisis is generally a function of the scope and size of the disaster. Therefore, it is critical that drought risk be examined at a local level. Further it is important to examine trends in rainfall and rainfall patterns as Ethiopian rains are quite seasonal and varied across the country. And while the work that is reported here can be used to motivate new financial solutions, it is equally useful for a wide range of policy-oriented programs that are targeted at adjusting to climate change in Ethiopia.

The study begins with an overview of agriculture and rainfall in Ethiopia and general discussion of using insurance and index-based insurance to hedge against weather risks. Rainfall and production data are examined to identify critical rainfall periods for various crops and regions. The data are crucial for the risk analysis needed to design reasonable weather-based index insurance contracts. Few developing countries have reliable yield data that can be used to examine the relationship between rainfall and productivity. For this study, it was possible to develop estimates of the expected value of crops and livestock by local region (zone). Thus, it was possible to perform a systematic analysis of where crops are grown, the timing of the growth process, and the value of the crops spatially. A portfolio approach was taken to examine the potential for risk pooling within Ethiopia. Daily rainfall data from 1961 to 1996 were used to design prototype rainfall index insurance contracts. Results from the losses that would have been realized in previous years can then be used to examine the spread of risk given the current plantings and value of crops in Ethiopia. These simulations provide insights into important questions about risk pooling in Ethiopia. While the results suggest that Ethiopia can pool a good deal of risk spatially, significant systemic risks still remain. This means that country-wide exposure to drought is still very high, despite the vast territory of Ethiopia. Furthermore, these results also demonstrate that global reinsurance would be needed if Ethiopia attempted to adopt an insurance-like approach to manage drought risk.

The report then examines the institutional environment within which weather-based insurance might be delivered. Because Ethiopia is such a poor country, the fixed and operational costs of setting up and running a new and far-reaching institution should only be incurred after very careful deliberation. Indeed, this study examines the role that existing institutions might play in the practical implementation of weather insurance schemes, minimizing the need for the development of new institutional capacity while building on what currently exists. In particular, the study examines the way an insurance function might change or augment the existing operations of fiscal authorities (e.g., resource allocations, particularly in the context of decentralization), regulatory agencies (e.g., the National Bank of Ethiopia), cooperatives, microfinance institutions (MFIs), and donors, and how their activities might complement one another.

Background on Ethiopian Agriculture

Agriculture has a dominant role in the well-being of the economy of Ethiopia and in the livelihood of the people, as eighty-five percent of the 65 million people live in rural areas, most of them engaging in subsistence or near-subsistence farming (Food and Agriculture Organization of the United Nations, FAO). According to data from 2000, Agriculture accounts for 52 percent of Ethiopia's US$6.4 billion gross domestic product (GDP). The major grain crops (see Table 1) can be divided into two groups: coarse grains (maize and sorghum), and cereals (barley, wheat, and teff). As will be developed below, this study estimates the value of crops using regional prices and production values. These estimates are used to develop Figures 1 and 2. Zones reporting "no data" in Figures 1 and 2 generally produce little or no crops.

Table 1. Production of Major Crops in Ethiopia

CROP	Average Production 1997-2000 (M.T.)	%
Maize	2,675,134	29
Teff	1,655,051	18
Sorghum	1,311,109	14
Wheat	1,256,867	14
Barley	859,598	9
Horse Beans	350,633	4
Millet	318,737	3
Chickpeas	154,806	2
Haricot Beans	135,035	1
Field Peas	118,629	1
Vetch	97,581	1

The average value of cereal production is about US$585 million. The value of coarse grains approaches US$380 million. Coffee accounts for a large proportion of agricultural export revenue with about half of production going to the export market. In 2002, Ethiopia exported 119,089 metric tons (M.T.) of green coffee by FAO estimates, valued at nearly US$160 million. Though coffee is a source of revenue for millions of Ethiopian peasants, this report focuses on the major food crops grown for both subsistence and market production. The staple diet, especially for the lowland pastoralists who are most vulnerable to drought-induced famine, comprises grain crops, in particular, corn, teff, and sorghum. (Foreign Agriculture Service/USDA). While the risk of drought for coffee production is not examined in this study, it is also likely that major droughts also adversely impact coffee yields.

Figure 1. Estimated value of coarse grains

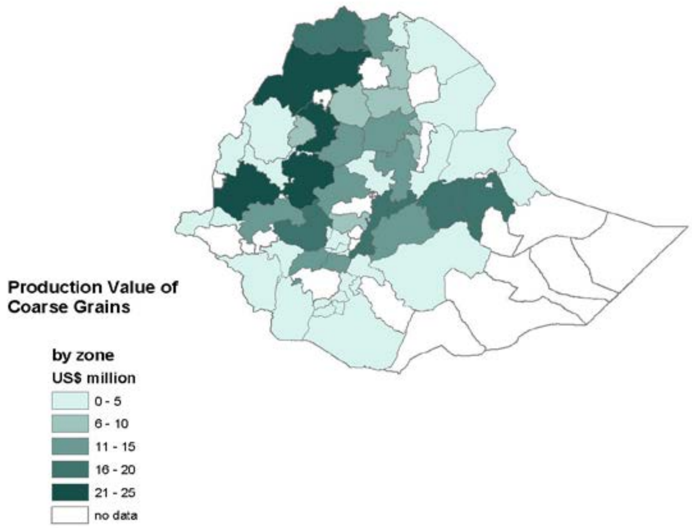
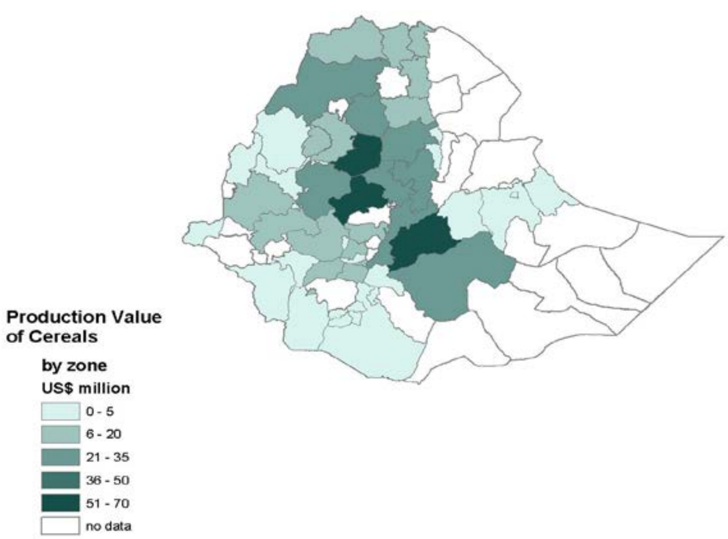


Figure 2. Estimated value of cereal grains



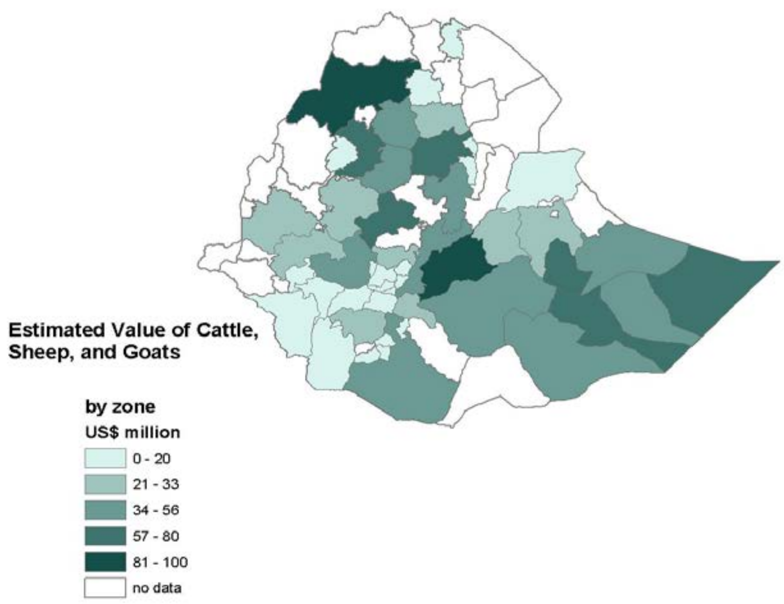
There are an estimated 35 million head of cattle in Ethiopia (Table 2). Again, this study develops a geographic (zone) estimate of the cash receipts for livestock. These data are presented in Figure 3. Methods used for this mapping do not reflect non-cash receipts. While less than 10 percent of cattle are slaughtered for commercial production, cattle and other livestock are important household assets for home consumption, draft power, and status. Approximately 30 percent of goats and sheep are raised for commercial production.

Table 2. Number of Animals by Species

Species	(million head)
Cattle	35.5
Sheep	11.5
Goats	9.6
Horses/Asses	4.7

Source: FAO, 2004.

Figure 3. Estimated value of cash receipts for major species of livestock in Ethiopia



Most of the farming activities undertaken by farmers and herders are rain-fed, with an extremely small proportion benefiting from irrigation. Ethiopia also suffers from highly variable rainfall from year to year. The dynamics of rain, closely correlated with income, change the profile of needs from persistent poverty and malnourishment to situations of desperate crisis. A prime example of such crisis was the widespread drought of 1984 that created extreme famine conditions in Ethiopia. Anomalies in rainfall patterns, especially droughts, have great economic implications. An agricultural drought can occur due to spatial or temporal fluctuations in rainfall. The usefulness of rainfall depends on the length of the rainfall season, distribution, and intensity of rainfall (Wilhite and Glantz, 1985).

The mean annual rainfall in Ethiopia ranges from 2000 mm over some pocket areas in the southwest highlands to less than 250 mm in the lowlands. In general, annual precipitation ranges from 800 to 2200 mm in the highlands where the altitude exceeds 1500 meters, and varies from less than 200 to 800 mm in the lowlands. Rainfall also decreases northwards and eastwards from the high rainfall pocket area in the southwest.

Figures 4 and 5 provide a closer examination of the differences in average rainfall across the 80 zones in Ethiopia for the March to May and June to September periods. The extremely low rainfall in the March-May period for the northern edge of Ethiopia is striking. By the same token, the eastern rim and the southern section of Ethiopia have extremely low rainfall during the period June to September.

Figure 4. Cumulative rainfall for March to May

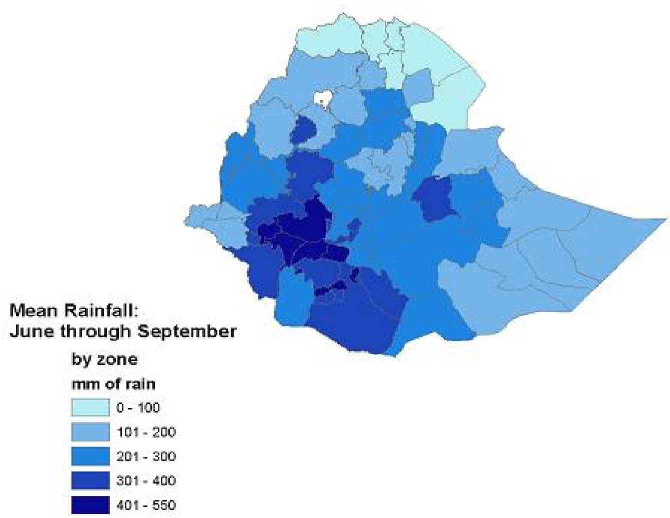
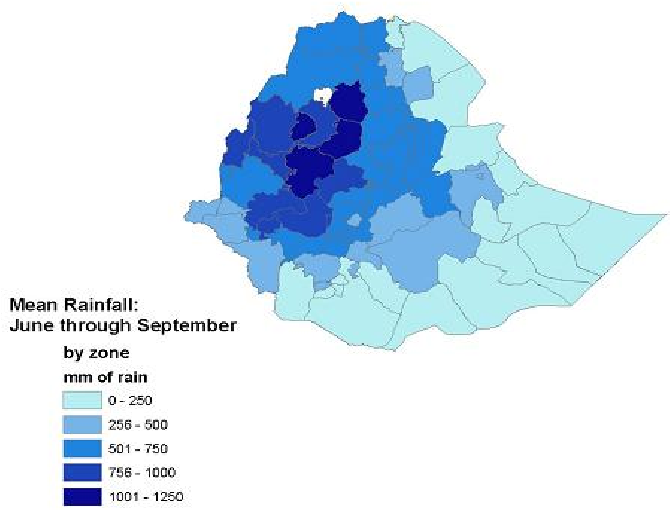


Figure 5. Cumulative rainfall for June to September



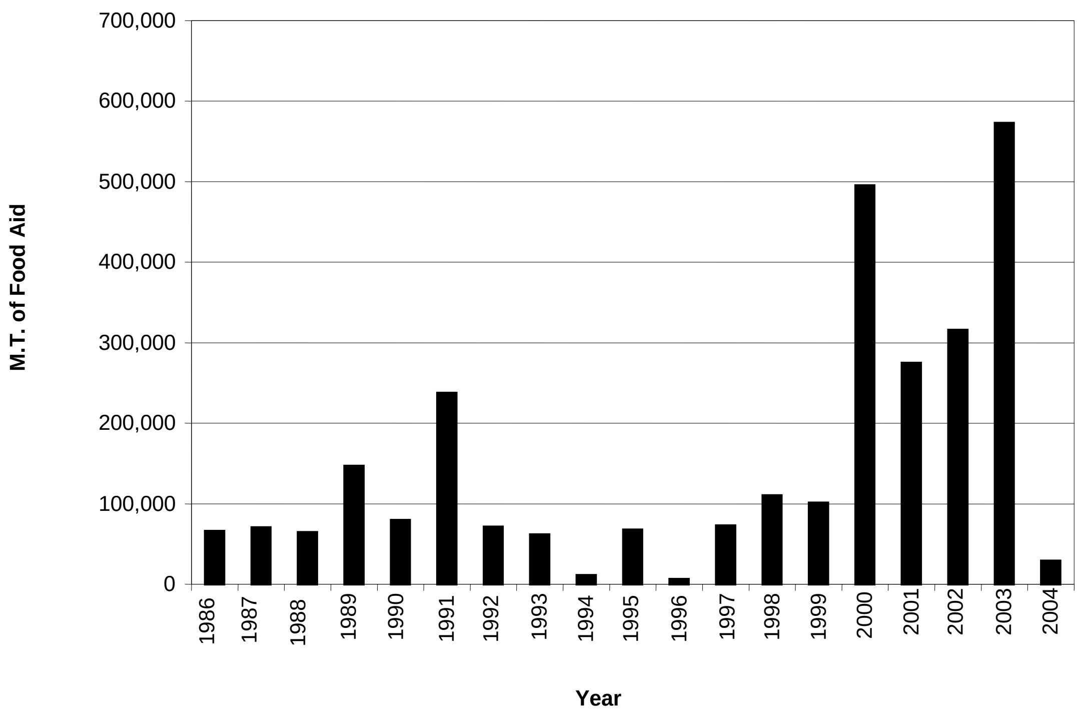
The timing of the rainfall is critical to planning and cropping patterns in Ethiopia. Ethiopia has two crop production seasons — *meher* and *belg*. Meher, the major crop season, depends on a long rainfall period called the big rain or *kiremt.* Kiremt rains occur between June and September for much of the country, with the exception of the southeastern lowlands where it occurs between August and November. Kiremt rainfall is critical. Most parts of the country receive 60-90 percent of their rainfall during this season. Belg crop season occurs in some areas, especially the highlands, supported by some short spring rains called the "little rains," or *belg.* These rains occur in March and April in the eastern and east central parts of the country, and from March through June, in the south and southeast (February to May by some sources). The two rainfall seasons are separated by a hot dry period, called the *bega*, from October through most of February. The west and west central parts of the country do not experience the belg rains and thus do not have a belg crop season (Famine Early Warning System, FEWS).

The meher crop accounts for about 93 percent of the annual national average crop production, and between 90 and 95 percent of the cereal production. The small rains, the belg, are also important even though they support a much smaller crop annually. Belg harvest accounts for only about 7 percent of the national average crop production. Belg rains are however valuable for preparing the ground for planting and for replenishing water sources. They are useful for short-cycle crops, such as wheat, barley, teff, and pulses, planted at the beginning of the season and harvested in June or July, depending on the region and the timing of rains. Longer cycle crops like corn, sorghum, and millet are also planted during the belg season but are harvested during the meher season. The belg rains may also provide up to 50 percent of the yearly food supply in some of the highland areas, such as the Wollo and Shewa regions. In farming regions where the belg rains do not produce an extra harvest, the rains are still crucial for seedbed preparation for short- and long-cycle meher crops, and for other agricultural activities, such as maintaining livestock conditions, including plow oxen that are crucial for agriculture. The belg rains are also the main annual rains for the pastoral and agro-pastoral areas of southern and southeastern Ethiopia.

In areas that experience dual rain cycles, farmers may switch to single rain production practices, and change crops if the belg rains do not come as expected. Shorter cycle crops are often used to substitute for the usual long-cycle crops when kiremt rains are late. Thus tracking and predicting of yields can be very difficult because producer decisions can change dramatically based on early season weather patterns.

Ethiopia receives on average around 1 million M.T. of food aid each year, although this fluctuates as the needs for food aid change. About 5-6 million individuals are considered chronically food-insecure, meaning that even when the rains come on time and pests are controlled, these households do not have enough food to last 12 months. In 2003, after good rains, about another 2 million people were expected to need food assistance, for a total of 7.2 million. In the 2002-03 period, after failed rainy seasons, around 13 million individuals were assessed as being in need of food aid. Figure 6 shows the World Food Program (WFP) shipments of food aid to Ethiopia for emergency situations[2]. It is important to note that the extreme famine year (1984) is not reported in this figure. The period 2000-2003 stands out as one of extreme need, and corresponds to successive years of drought, as shown in Table 3.

Figure 6. World Food Program (WFP) emergency food aid shipments to Ethiopia



WFP, unpublished data, 2004.

[2] Includes all types of emergency situations, including drought, conflict, and other disasters.

Table 3. Top 10 Natural Disasters in Ethiopia

Sorted by numbers of people killed		
Disaster	**Date**	**Killed**
Drought	14-Oct-1984	300,000
Drought	Apr-1974	200,000
Drought	1973	100,000
Epidemic	Sep-1988	7,385
Drought	Jul-1965	2,000
Epidemic	Jan-1985	1,101
Epidemic	1981	990
Epidemic	1-Jan-1970	500
Drought	1987	367
Epidemic	Nov-2000	311
Sorted by numbers of people affected		
Disaster	**Date**	**Affected**
Drought	Jan-2002	14,300,000
Drought	2003	13,200,000
Drought	Mar-2000	10,500,000
Famine	Jun-1999	7,767,594
Drought	14-Oct-1984	7,750,000
Drought	May-1983	7,000,000
Drought	1987	7,000,000
Famine	1993	6,700,000
Drought	Oct-1990	6,500,000
Drought	Oct-1991	6,160,000

Source: EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net
Université catholique de Louvain - Brussels - Belgium

Food insecurity is a result of many compounding factors. Though drought has a significant influence on rural livelihoods, the severity of the impact at the household level is determined by available resources and risk management strategies. Wealthier households with more assets at their disposal have some capacity to self-insure through savings and liquidation of assets. In addition, wealthier households generally have greater access to credit. Poorer households, however, are extremely limited in their capacity to manage risk. As a result, a single serious event can lead to long-term insecurity. Prolonged drought or a succession of bad seasons can deplete assets and prevent recovery. Traditional risk-coping strategies involve the liquidation of assets, namely livestock. This strategy is often the only option when there is no access to financial services (savings and credit) and can push poorer households deeper into poverty and destitution. Furthermore, livestock are also vulnerable to drought risk. Thus, the last-resort coping strategy of liquidation of livestock herds may not be an option when livestock losses are high. (Hammond and Maxwell, 2002). Finally, if everyone is attempting to sell livestock due to severe drought, it is highly likely that the prices will be greatly depressed.

Benefits and Limitations of Formal Insurance

Limited resources of the rural poor, compounded by a risky agricultural environment, discourage people from making investments in production or risk management strategies. This is a well-founded problem in the economic development literature. Drought can have a devastating impact on the livelihood of the rural poor. *Ex post* coping mechanisms are often a short-term strategy that creates long-term vulnerability. Crop failure can force the sale of assets for the acquisition of food. However, during a drought situation, purchasing power is decreased. The sale of productive assets leaves families more vulnerable to subsequent shocks, and can push them into a state of chronic poverty. Asset depletion in a crisis state (sale or death of livestock) is an ineffective coping strategy that makes recovery difficult (Barrett et al., 2002).

It is widely believed that exposure to risk itself holds back growth of average incomes, and that providing some protection against shocks to consumption will help the rural poor start the climb out of poverty. Conversely, adverse shocks can have long lasting and persistent negative effects on growth (Dercon, 2003; Little, 2002).

Given that shocks can be a considerable set back to the poorest segment, insurance solutions may become attractive. A precondition to obtaining a loan to withstand a shock generally involves a good credit history or some collateral. Insurance, on the other hand, requires an upfront premium. Thus, if the poor can obtain enough resources to pay a premium, they have immediate access to protection. Beyond this potential advance, there are several economic efficiency benefits of insurance. First, insurance improves the efficiency of allocation of consumption across states of nature — that is, it allows individuals to reduce the variance of consumption, which (under risk aversion) is welfare improving. Second, insurance can lead to production efficiency gains, increasing not only the precision of consumption, but also its expected value. The idea is that these production efficiency gains are available to uninsured households, but are not manifest because the resulting income stream is too risky. Access to risk financing (credit) and risk hedging (insurance) instruments can enable households to minimize the impacts of exogenous shocks, thereby protecting their resources and investments.

Another benefit of well-functioning and domestically financed weather insurance is that it can improve the spatial allocation of domestic production of food, thereby reducing the reliance of Ethiopia on external food aid. Still, such solutions are unlikely to significantly reduce the dependence on foreign aid. Instead, the development of domestic insurance markets could facilitate the redeployment of foreign food aid toward funding of infrastructure, and other investments. This would create a virtuous cycle, reducing transportation costs that presently impede domestic market integration, leading to a more efficient spatial allocation of domestically produced food, and freeing up more foreign aid currently devoted to the delivery of food aid. Thus, in the short term, it is unlikely that the “benefit” of rural insurance would be a reduction in the volume of external aid flowing to Ethiopia.

It is expected that the support of the government or international community is necessary for financing the costs of start-up, education, and reinsurance. Additionally, input costs include labor and capital used for administrative purposes, and will differ according to the institution that delivers the insurance. These costs could be quite high if policies are marketed on an individual basis and, if there is excessive competition amongst providers of insurance (leading to high advertising and marketing costs, for example).

Before concluding that all aspects of a well-developed rainfall insurance program are positive, caution is in order. To the extent that existing *informal* insurance mechanisms are functioning well in parts of Ethiopia, introducing a formal risk-transfer mechanism could create problems. As Morduch (2001) explains, if formal (rainfall) insurance improves the welfare of some individuals, their opportunity cost of *exiting* from informal risk sharing networks could fall, thereby destroying the stability of existing risk-sharing arrangements. This is not disadvantageous to those exiting, but reduces the welfare of those who continue to rely on the informal mechanisms.[3] However, if the rainfall index insurance is used to facilitate collective action among groups who currently cannot pool away correlated risk, the innovation could actually spur more active informal risk sharing arrangements (Skees, 2003).

Despite the potential for formal insurance markets to damage informal risk-sharing arrangements, the potential negative effects of formal insurance on individuals who are not covered are likely to be small or temporary. The chronically and desperately poor should continue to receive support through social assistance and direct transfers. Society should be better equipped to provide this support when it can access advanced risk management instruments. In fact, that is an important reason to assess risk for a country even to the point of performing that assessment with insurance-like principles as is done in this study.

As formal insurance markets for weather risk are considered, it is important to think about the impact of these products when taking into account market integration, price effects, and insurance. The current lack of market integration across geographical regions in Ethiopia is a well-recognized constraint on the development of the economy. This segmentation is manifest in wide cross-sectional regional price variations, which, as argued above, attenuate the incentives of peasants to increase production. However, it is important to recognize the fact that product/market integration in the absence of insurance market development can increase the exposure of individuals to risk, because with segmentation, local prices, and quantities are more negatively correlated. Thus, as long as there is a certain level of production, variations in income (price x quantity) are dampened.

This insurance function of prices, given the current lack of integrated prices across Ethiopia, should be interpreted carefully. First, if local net buyers of food (there might be few) have a fixed endowment of non-food items to trade, they face greater risk when food prices fluctuate, so the reduction in risk of net sellers is offset by an increase in the exposure of net buyers, and the welfare consequences are indeterminate.

More important than concerns about income volatility in subsistence economies, it is arguably more instructive to use food rather than income as the numeraire. Thus, high food prices are synonymous with low relative prices of non-food items. Income of peasants with no non-food income (e.g., from off-farm employment) depends only on the quantity of food they produce, and has the same statistical properties (i.e., riskiness) as income calculated when food prices are constant because of market integration. Thus, for a farmer who produces less than enough food to sustain his or her household, knowing that his potential cash income is not so bad because of high local food prices is of little consolation. If this farmer could protect the household consumption with insurance that would pay when he has a crop failure, this could alter the subsistence farmer risk-taking behavior in a positive way, i.e., the propensity to adopt yield improving technologies might increase.

[3] For a formal model of the stability of informal insurance mechanisms, see Attanasio and Rios-Rull (2000).

Some Fundamental Considerations for Weather Insurance

The provision of weather insurance to small rural households faces two fundamental problems. First, delivery of what is effectively a financial instrument to individuals who participate little in the monetary economy is a challenge in itself. This is not to say that individuals and households do not understand the benefits of insurance — indeed, the decisions of the poor and vulnerable are often hyperrational. Rather, the sales and marketing costs of operationalizing a formal insurance scheme with a wide enough reach seem daunting, particularly given the existing state of the communications infrastructure.

The simple delivery cost constraint means that to be practical and of widespread benefit, any insurance mechanism should use existing institutional constructs. This report reviews a number of possibilities existing in Ethiopia, including farmers' cooperatives, MFIs, peasant associations, and local governments, in addition to a recently liberalized insurance industry.

The second challenge to delivering rural insurance is that if realized or actual farm yields or incomes are insured directly on an individual basis, the costs of monitoring and validating each claim would be prohibitive. The international experience shows that where traditional insurance is used to insure crops, heavy government subsidies are required. The U.S. crop insurance program is a prime example of the government costs of implementing such a scheme. In the United States, farmers pay only 25 percent of the full cost of the crop and revenue insurance programs; the remainder of the cost is born by the government. Few developing countries can afford such costly social programs.

Beyond these cost considerations, the limitations of traditional insurance are particularly acute in the challenging environment of a developing country. The incentives for moral hazard and outright fraud could quickly lead to chronic losses and financial insolvency. In response to this limitation, practitioners have sought to protect endogenous and hard-to-measure incomes by writing formal insurance contracts on exogenous events that are correlated with realized incomes (Skees, Hazell, and Miranda, 1999). These index-based insurance contracts use an objective measure such as rainfall, as a proxy for economic losses. The key is that the likelihood of receiving an indemnity payment cannot be influenced by the policyholder.

A third problem, even if successful index insurance contracts could be designed to cover a significant share of loss at low cost, is the correlated risk problem. Traditional insurance is designed to smooth consumption by hedging against independent risks, such as a fire or automobile accident. Commercial insurance is viable under these scenarios because the risks are infrequent and independent. Drought and other weather-related risks impose correlated losses, where many people in the same area are affected simultaneously. For an insurance company holding these risks, the losses may exceed their financial reserves.

A Primer on Index-Based Insurance

Agricultural index insurance makes payments based not on shortfalls in farm yields, but rather on measures of an index that is assumed to proxy farm yields. Two types of index insurance products are those based on area yields, where the area is some unit of geographical aggregation larger than the farm, and those based on weather events.

Index insurance contracts utilize an objective measurement as proxy for the losses caused by a particular event such as a drought, hurricane, or an earthquake. Payments may be based on localized measures of rainfall, wind speed, or Richter scale readings. There are also index-based crop insurance policies, as in the United States and Canada, based on average yield within an area. Because index insurance indemnity payments are not linked to individual loss experience, moral hazard is not a concern. Basis risk is present, however. Basis risk is the possibility that the index will not be representative of individual experience, i.e. someone may experience a loss and not receive a payment, or conversely, someone may receive a payment when they did not suffer a loss. On one hand this possibility should encourage people to take measures to mitigate their risk. Nevertheless, the index should be sufficiently correlated to the loss experience to minimize the occurrence of basis risk; otherwise, there will be little demand for the insurance.

Index insurance is a different approach to insuring crop yields. A precondition for such insurance to work is that many farmers in a given location must be subjected to the same risk. In short, rather than the usual precondition of independent risk, index insurance is most suited for insuring against strongly correlated (yet localized) risks. When correlated risks are present, index insurance has the potential to offer affordable and effective insurance for a large number of farmers. Such insurance requires a different way of thinking. It is possible to offer such contracts to anyone at risk when there is area wide crop failure. Furthermore, unlike traditional insurance that pays the individual based on his or her losses, it is not necessary to limit the amount of liability that an individual can purchase. Nonetheless, similar contracts (such as GRP) do limit liability to no more than 150 percent of the average per acre value.

As more sophisticated systems (such as satellite imagery) are developed to measure events that cause widespread problems, it is possible that indexing major events will be more straightforward and thus, more accepted by international capital markets. Under these conditions, it will be possible for traditional reinsurers and primary providers to offer insurance in countries that previously would never have been considered. Insurance is about trust. If the system to index a major event is reliable and trustworthy, there are truly new opportunities to offer a wide array of index insurance products.

Various area-yield insurance products have been offered in Quebec, Sweden, India, and, since 1993, the United States (Miranda; Mishra; Skees, Black, and Barnett). Two Canadian provinces, Ontario and Alberta, currently offer an index insurance instrument based on rainfall. The Canadians are also experimenting with other index insurance plans. Alberta corn growers can use a temperature-based index to insure against yield losses in corn. Alberta is also using an index, based on satellite imagery, to insure against pasture losses. Mexico is the first non-developed country to enter into a reinsurance arrangement based on weather derivatives. The U.S. Group Risk Plan (GRP) or area-yield insurance product is also an example of a successful index insurance program (Skees, Black, and Barnett).

The information needed to run an index insurance program is much less than what is needed for a farm-yield insurance program. One needs sufficient data to establish the expected value of the index and a reliable and trusted system to establish the estimates of realized yield values. There is no need for any farm-level information. For example, area-yield insurance indemnities are based on estimates of official measurements of realized area yields relative to expected area yields. Areas are typically defined along political boundaries (e.g., counties in the United States) for which historical yield databases already exist.

The logic for using index insurance is relatively simple—there is no asymmetric information (Skees and Barnett, 1999). Usually, farmers have no better information than the insurer regarding the likelihood of area-yield shortfalls or unusual weather events; thus, there is no adverse selection. Farmers cannot, by changing their behavior, increase the likelihood of an area-yield shortfall (if areas are defined at large enough levels of aggregation) or an unusual weather event; thus, there is no moral hazard. All of the information needed for loss adjustment is available from public sources. Thus, it is easy to tell whether or not a loss has occurred and accurately measure the indemnity without having to rely on any information provided by the policyholder. All of these factors make it much less expensive for the insurer to provide index insurance than multiple-peril crop insurance. Thus, the cost of index insurance can be significantly lower than the cost of multiple-peril crop insurance. Also, since adverse selection and moral hazard are not problems, there is no need for deductibles. Some straightforward principles are used in designing index insurance:

1. Users should be able to select the liability or protection they desire to match their risk exposure. The important aspect here is that one does not need to be concerned with the level chosen since individual losses do not trigger payments.

2. Premium rates should be quoted as percentages, making it easy to calculate premium payments as the product of premium rates and liability.

3. Payouts will generally begin once a threshold or strike value is crossed.

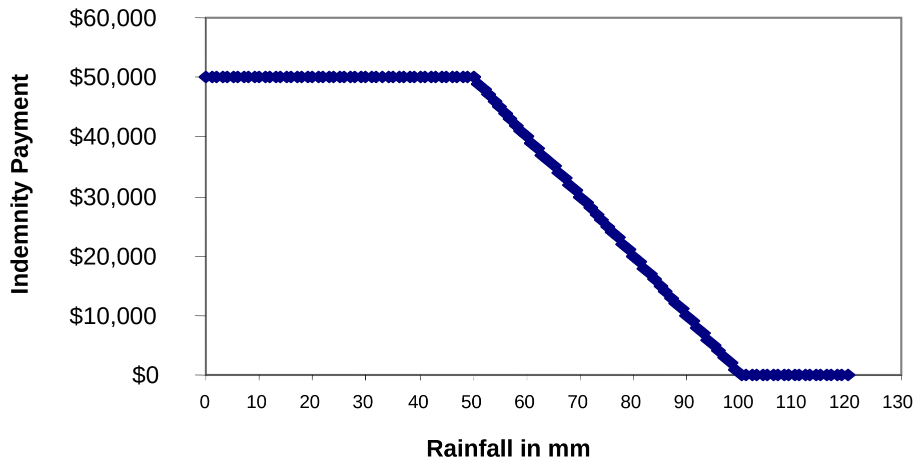
4. Payouts can be set for values either above or below the strike.

Payouts can be calculated using any number of structures. The most straightforward contract would simply pay a fixed amount for each unit (tick) of rainfall below a certain threshold (strike). Consider a situation where a contract is being written to protect against shortfall in rain. The writer of that contract may choose to make a fixed payment for every 1 mm of rainfall below the strike/trigger. If an individual or a microfinance institution (MFI) purchases a contract where the strike/trigger is 100 mm of rain and the limit is 50 mm, the amount of payment for each tick would be a function of how much liability was purchased. There are 50 ticks between the 100 mm and the limit of 50 mm. Thus, if $50,000 of insurance were purchased by a large bank to hedge against drought risk, the payment for each 1 mm below 100 mm would be equal to

$50,000/(100-50) or $1,000

Once the tick and the payment for each tick are known, the indemnity payments are easy to calculate. For example, if the rainfall is measured at 90 mm, there are 10 ticks of payment at $1,000 each; the indemnity payment will equal $10,000. Figure 7 maps the payout structure for a hypothetical $50,000 rainfall contract with a strike of 100 mm and a limit of 50 mm.

Figure 7. Payout structure for a hypothetical rainfall contract



In another form of payment, as in the Group Risk Plan (GRP) in the United States, payouts are proportional. Once area yields are below the strike yield selected, farmers receive a percentage payout.

Percentage payout = (Strike yield – realized yield) / Strike Yield

(when strike yield < realized yield)

Payment = Percentage payout x Liability

For a simple rainfall insurance product, the payout function may resemble terms that are more akin to products offered on futures exchange. The language may also be similar. For example, if a contract pays anytime the cumulative rainfall in a three month period is less than 100 mm (the strike), the user could select the value to be insured and the level of rainfall at which the full value would be paid (stop payment rainfall below). A tick size could be set as 1 mm of rainfall. If the user selected to insure $1,000 of value and receive the full payment when the rain reaches 50 mm, the payment per tick would be:

Tick payment = Value insured / (Strike – Stop payment)

$20 = 1000 / (100 – 50)

Under such a plan, if rainfall is 90 mm (or 10 mm under the strike), the payment = (10 x20) or $200.

Advantages and Disadvantages of Index Insurance

Index contracts offer numerous advantages over more traditional forms of farm-level multiple-peril crop insurance. These advantages include the following:

Low moral hazard. Moral hazard arises with traditional insurance when insured parties can alter their behavior so as to increase the potential likelihood or magnitude of a loss. This is less possible with index insurance because the indemnity does not depend on the individual producer's realized yield.

Low adverse selection. Adverse selection is a misclassification problem caused by asymmetric information. If the potential insured has better information than the insurer about the potential likelihood or magnitude of a loss, the potential insured can use that information to self-select whether or not to purchase insurance. Those who are misclassified to their advantage will choose to purchase the insurance. Those who are misclassified to their disadvantage will not. With index insurance products, insurers do not classify the individual policyholder's exposures to risk. Further, the index is based on widely available information. So there are limited informational asymmetries to be exploited. It is true that some will find index insurance products more attractive than others. However, unlike individualized insurance products, such self-selection will not affect the actuarial soundness of index insurance products.

Low administrative costs. Unlike farm-level multiple-peril crop insurance policies, index insurance products do not require costly on-farm inspections or claims adjustments. Nor is there a need to track individual farm yields or financial losses. Indemnities are paid solely on the realized value of the underlying index as measured by government agencies or other third parties.

Standardized and transparent structure. Index insurance policies can be sold in various denominations as simple certificates with a structure that is uniform across underlying indexes. The terms of the contracts would therefore be relatively easy for purchasers to understand.

Availability and negotiability. Since they are standardized and transparent, index insurance policies can easily be traded in secondary markets. Such markets would create liquidity and allow the policies to flow to where they are most highly valued. Individuals could buy or sell policies as the realization of the underlying index begins to unfold. Moreover, the contracts could be made available to a wide variety of parties, including farmers, agricultural lenders, traders, processors, input suppliers, shopkeepers, consumers, and agricultural workers.

Reinsurance function. Index insurance can be used to transfer the risk of widespread and correlated agricultural production losses. Thus, it can be used as a mechanism to reinsure insurance company portfolios of farm-level insurance policies. Index insurance instruments allow farm-level insurers to transfer their exposure to undiversifiable correlated loss risk while retaining the residual risk that is idiosyncratic and diversifiable (Black, Barnett, and Hu, 1999).

The following challenges must be addressed if index insurance markets are to be successful:

Basis Risk. It is possible for index insurance policyholders to experience a loss and yet not receive an indemnity. Likewise, they may receive an indemnity when they have not experienced a loss. The frequency of these occurrences depends on the extent to which the insured's losses are positively correlated with the index. Without sufficient correlation, basis risk becomes too severe, and index insurance is not an effective risk management tool. Careful design of index insurance policy parameters (coverage period, trigger, measurement site, etc.) can help reduce basis risk.

Security and dissemination of measurements. The viability of index insurance depends critically on the underlying index being objectively and accurately measured. The index measurements must then be made widely available in a timely manner. Whether provided by governments or other third party sources, index measurements must be widely disseminated and secure from tampering.

Precise actuarial modeling. Insurers will not sell index insurance products unless they can understand the statistical properties of the underlying index. This requires both sufficient historical data on the index, and actuarial models that use these data to predict the likelihood of various index measures.

Education. Index insurance policies are typically much simpler than traditional farm-level insurance policies. However, since the policies are significantly different than traditional insurance policies, some education is generally required to help potential users assess whether or not index insurance instruments can provide them with effective risk management. Insurers and/or government agencies can help by providing training strategies and materials not only for farmers, but also for other potential users such as bankers and agribusinesses.

Marketing. A marketing plan must be developed that addresses how, when, and where index insurance policies are to be sold. Also, the government and other involved institutions, must consider whether to allow secondary markets in index insurance instruments and, if so, how to facilitate and regulate those markets.

Reinsurance. In most developing country economies, insurance companies do not have the financial resources to offer index insurance without adequate and affordable reinsurance. Effective arrangements must therefore be forged between local insurers, international reinsurers, local governments, and possibly international development organizations. More will be said about this important aspect below.

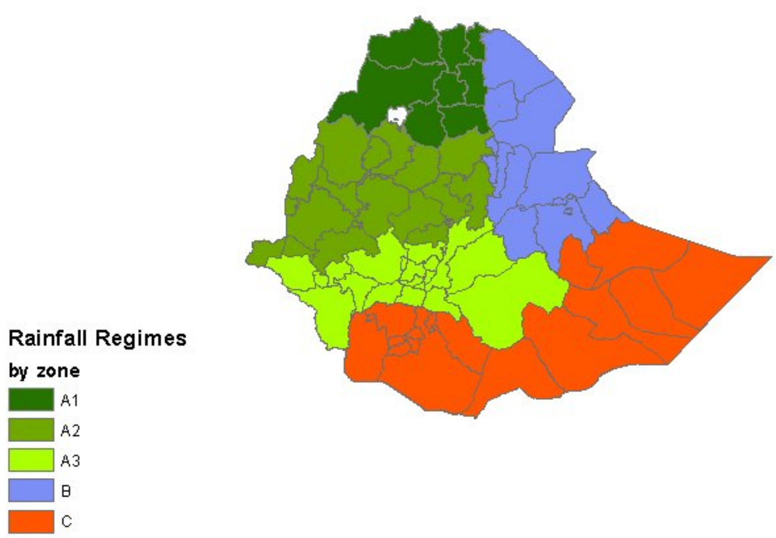
Designing Rainfall Insurance in Ethiopia

The first step in conceptualizing and designing weather insurance is to obtain sufficient data. To facilitate this work, the FEWS team at Texas A&M provided 36 years (1961-1996) of daily Collaborative Historical African Rainfall Model (CHARM) data for the centroid (geographic center) of each of the 80 zones in Ethiopia. CHARM incorporates climatologically interpolated rainfall data, precipitation reanalysis, and digital elevation data to develop a continuous grid of estimated precipitation data across Africa (Funk et al., 2003). This long series of data allows for an analysis of the temporal and spatial distribution of rainfall at the zone level. For performing a country-wide risk assessment such "processed data" are far superior to relying only upon actual weather station data. If one were focused on developing a true rainfall insurance product, the focus would have to return to the actual weather data and all of the detailed questions that must be addressed about the quality of these data.

Analysis of Rainfall Seasons and Rainfall Regimes in Ethiopia

Various parts of Ethiopia have unimodal and bimodal rainfall patterns which can be generalized into three rainfall regimes with two, three, or four seasons (FEWS).

Figure 8. Rainfall regimes in Ethiopia

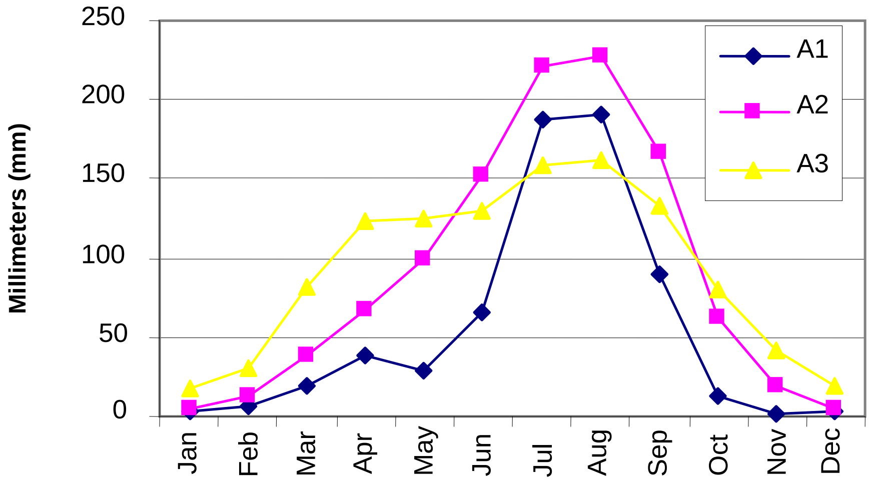


Combining information from the rainfall data and a general map of rainfall in Ethiopia (Abate, 2003) five rainfall regimes were identified according to the timing and length of the rainfall seasons in different areas. Figure 8 was created by sorting the rainfall data from 80 zones into groups. A general description of the rainfall seasons for these five rainfall areas follows:

Two Seasons: Area A.

The western half of Ethiopia has two distinct seasons: wet, from February to November; and dry, from November to February, with peak rainfall in July and August. Three sub-regimes are distinguished within this regime. The wet season occurs between June and September in the northern part (A1), between March and October in the central part (A2) and the southern part (A3). Figure 9 provides the average cumulative monthly rainfall for each of the sub-areas (A1-A3). Figure 10 provides the same information for areas B and C.

Figure 9. Cumulative monthly rainfall for areas A1, A2, and A3



Three Seasons: Area B

The central and most of the eastern part of the country have two rainy periods and one dry period. Kiremt rains are experienced from June to September, while belg rains occur between March and May. The dry bega season is between October and January.

Four Seasons: Area C

The southern and southeastern parts of Ethiopia have two distinct dry periods (December-February and July-August) and two rain seasons (March-May and August-November). The main rainfall season is referred to as the belg rains because it occurs from March to May (the belg period). Planting for the belg season starts in March, and harvesting for short season crops takes place in June or July. In this area, a second planting and harvesting takes place around the kiremt season, allowing for double planting of short season crops, and two rain periods for the longer season (meher) crops. Belg rains in the four-season regime are also critical for providing pasture and water for livestock.

Figure 10. Cumulative monthly rainfall for areas B and C

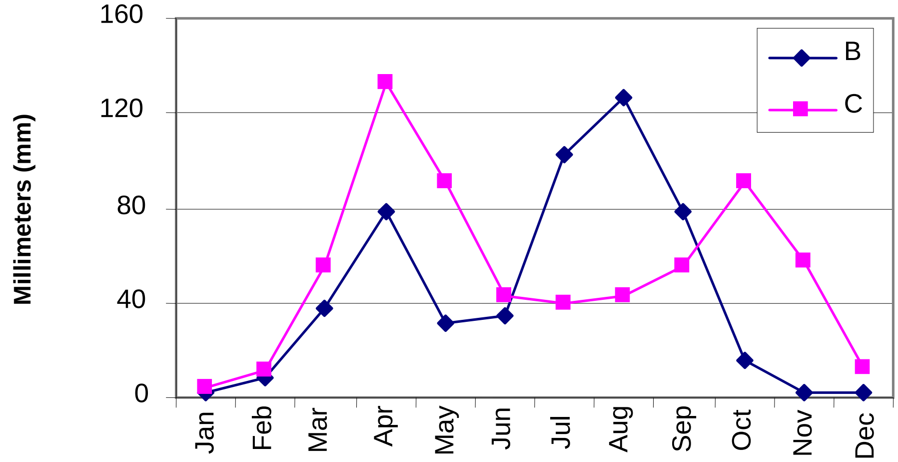


Table 4 presents the numbers used to plot Figures 10 and 11 above. Months that average more than 50 mm of rain are bolded. These months largely correspond to the planting seasons that are described by area. For example in sub-zone A3, March thru October have greater than 50 mm of rainfall. Table 5 presents these months explicitly for the different cropping seasons by rainfall regime area.

Table 4. Average Cumulative Monthly Rainfall by Rainfall Regime

	A1	A2	A3	B	C
			Rain in mm		
Jan	3	5	18	2	4
Feb	6	13	31	8	11
Mar	19	38	**81**	38	**55**
Apr	39	**68**	**123**	78	**133**
May	28	**100**	**125**	31	**91**
Jun	**66**	**153**	**130**	34	43
Jul	**187**	**221**	**158**	**103**	40
Aug	**190**	**228**	**163**	**126**	43
Sep	**90**	**166**	**133**	**79**	**56**
Oct	12	**62**	**80**	16	**91**
Nov	2	19	42	2	**58**
Dec	3	5	20	2	13

Table 5. Months Used to Model Seasonal Rainfall by Area and Contract

Area	Meher	Belg	Pastoral
A1	Apr to Sep		Mar to Sep
A2	Mar to Oct		Mar to Oct
A3	Mar to Oct		Mar to Nov
B	Jun to Sep	Mar to May	Mar to Sep
C	Aug to Nov	Mar to May	Mar to Nov

Matching Rainfall Periods to Risk Vulnerability by Area

In Ethiopia, the most appropriate exogenous variable upon which to base insurance is rainfall. Rainfall is highly correlated with income, relatively easy to measure, and there is available rainfall data going back more than 30 years. It also has the important advantage of being a timely indicator of need. Indeed, shortfalls in precipitation indicate the likelihood of future (e.g., 3-9 months), not current, needs. Waiting until harvests fail to measure shortfalls in income would increase the chances that benefit payments would be too little and too late. As will be demonstrated, it is possible to design an index insurance contract to provide early payments for slow-emerging events such as drought.

Given the knowledge of the rainy periods and the actual data, it is reasonably straightforward to determine the months most critical for crop growth and pastoral development. This information can lend itself to reasonably well-specified rainfall insurance contracts. This research uses three growth periods to match both crop and pastoral development: 1) meher; 2) belg; and 3) pastoral. The specific months were selected based upon the average cumulative rainfall for the months and the knowledge of the seasons supplied by information from secondary sources (FA0, Fews, etc.). The time periods for the pastoral season were determined based on the months in which rainfall would be available for pasture growth as observed in the data series.

In beginning an assessment of weather risk, it is important to examine how rainfall patterns may have changed over time. To address this question a linear trend line was fit for each of the areas and seasons, presented in Table 5. The trend values for the first and last year of the data series are reported in Table 6 to give an indication of the change in rainfall over this 36 year time period. The values indicate a downward trend in rainfall in all areas. For example, the expected annual rainfall (the value on the trend line) for 1961 was 1143 mm in sub-zone A2. By 1996, the expected annual rainfall was 1034.

Table 6. Forecast of Average Rainfall by Area and Season for 1961 and 1996

	Meher		Pastoral		Belg		Estimate of Value	
Area	**1961**	**1996**	**1961**	**1996**	**1961**	**1996**	**Crop**	**Livestock**
	Rain in mm						in million $	
A1	689	602	708	640			172	45
A2	1143	1034	1143	1034			385	87
A3	1144	928	1221	956			276	82
B	419	323	590	512	419	323	53	15
C	329	218	752	583	329	218	32	97

Rainfall in the meher/kiremt season in sub-area A3 declined 19 percent, from 1144 mm to 928 mm. This relatively important area comprises roughly $276 million of crop value and $82 million of livestock value in Ethiopia. These patterns are presented in more detail below using an insurance model.

Developing Index Insurance Contracts

A unique approach was developed to capture the risk for the different time periods that are represented in Table 5. These risks are modeled by zone. There are 80 zones in Ethiopia. The procedures used capture the timeliness of rainfall by measuring the percent below 70 percent of normal rainfall for each month. In other words, each contract was segmented into monthly portions to capture the rainfall spread over the covered seasons. The following steps are taken:

- The median rainfall is calculated for each month.
- A strike rainfall is calculated as 70 percent of the median.

$$\text{Strike}_z = 0.70 \times \text{median rainfall}_z$$

Where z= zone

- When rainfall is below the strike, a percentage payout is calculated

$$\text{Percentage payout}_{zt} = \max [0, (\text{Strike}_z - \text{actual rain}_{zt})/\text{Strike}_z)]$$

Where t = 1961-1996

- A simple rule is imposed to discount the percentage payout for months and zones where the median rainfall is below 50 mm. This is logical when median rainfall is relatively low for the month as it will have less value to crop growth. One need only examine table 4 closely to appreciate that in the main period of all of the growing seasons (other than for pastoral risk) the median rainfall is generally above 50 mm. These numbers will vary to some extent by zone given the lower level of aggregation than the general rainfall regime areas.

If $\text{median rainfall}_z < 50$ mm

$$\text{Percentage Payout}_{zt} = \text{Percentage Payout}_{zt} \times .50$$

The final payout percentage is simply the average of the percentage payouts for the months that match the area/crop periods divided by the number of months in the contract.

Importantly, the contracts that are presented here are significantly different than previous contracts that simply provide weights to different periods and add the weighted average rainfall to develop a trigger. To demonstrate how the proposed contract works, Table 7 provides the complete matrix for one of the most important zones in Ethiopia for the meher/kiremt season. This contract pays for losses below 70 percent of the median rainfall in any single month between March and October. There are no median rainfall values that fall below 50 mm for this zone. Since there are 8 months, one can divide each month's percentage shortfall by 8, to obtain a monthly payout percentage. The total payout is the sum of the payouts for the 8 months. Using these procedures, one could organize an early payment at any point during the 8 months. Average payouts are presented in the bottom of the matrix in Table 7. The average payouts for shortfalls of rain during March exceed 1 percent. The average payout (pure premium) for the entire season equals 6.53 percent. This value is also the sum of the average payouts by month. A loss ratio can be calculated by the ratio of the average indemnity payout for the season over the pure premium rate.

$$\text{Loss Ratio}_{Zt} = \text{Payout}_{Zt}/\text{Pure Premium}_{Z}$$

One can see that the average of the loss ratios is 100 percent (premiums over the 36 years equal the payouts).

Table 7. Sample Loss Matrix for Zone Arsi in Area A3 for the Meher/Kiremt Season

Year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total Pay	Loss Ratio
					(%)					
1961	0.0	1.9	2.4	0.0	0.0	0.0	0.0	0.0	4.2	65
1962	0.0	4.2	6.8	2.3	0.0	0.9	0.0	0.0	14.2	218
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	8.7	134
1964	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	29
1965	2.2	0.0	9.1	1.4	0.0	0.0	0.0	0.0	12.8	196
1966	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	1.7	26
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1969	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	1.3	20
1970	0.0	0.1	1.7	0.0	0.0	0.0	0.0	0.0	1.8	28
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	2
1973	11.1	3.1	0.0	0.0	0.0	0.0	0.0	0.6	14.7	226
1974	0.0	3.8	0.0	0.0	0.0	0.0	0.0	6.1	9.8	151
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	4.8	74
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1978	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	4
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1980	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	105
1981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1982	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1983	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1984	5.0	1.2	0.0	0.0	0.0	0.0	0.0	6.1	12.3	188
1985	0.1	0.0	0.0	0.8	0.0	0.0	0.0	3.1	4.0	62
1986	0.0	0.0	1.1	0.0	0.0	1.3	0.0	0.0	2.4	37
1987	0.0	4.9	0.0	3.8	11.4	9.5	7.8	6.3	43.8	671
1988	5.1	0.0	7.5	0.0	0.0	0.0	0.0	0.0	12.6	192
1989	0.0	0.0	7.4	4.4	0.0	8.1	1.7	0.0	21.8	333
1990	0.0	0.0	1.9	4.4	3.4	0.0	0.0	0.0	9.8	150
1991	0.0	0.3	0.4	5.9	3.5	4.6	2.4	3.6	20.7	316
1992	0.5	0.0	0.0	0.7	2.5	0.0	0.0	0.0	3.6	55
1993	7.8	0.0	0.0	0.2	3.2	0.0	0.0	0.0	11.2	171
1994	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	29
1995	0.0	0.0	1.8	5.0	0.0	0.0	0.0	0.0	6.7	103
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1	17
Averages	**1.2**	**0.5**	**1.2**	**0.8**	**0.7**	**0.7**	**0.4**	**1.1**	**6.53**	**100**

Premium rates are calculated for all zones using the timing that is presented in Table 5. The maps for premium rates by season are presented in Figures 11-13. These figures show the variation in risk across Ethiopia for the specific seasons.

Figure 11. Pure premium rates for the kiremt season

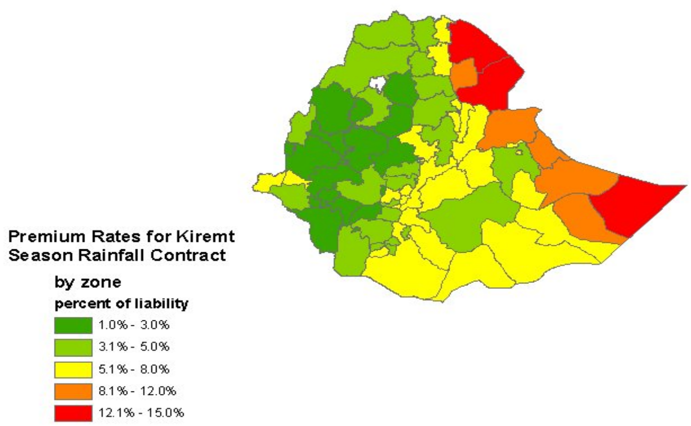


Figure 12. Pure premium rates for the belg season

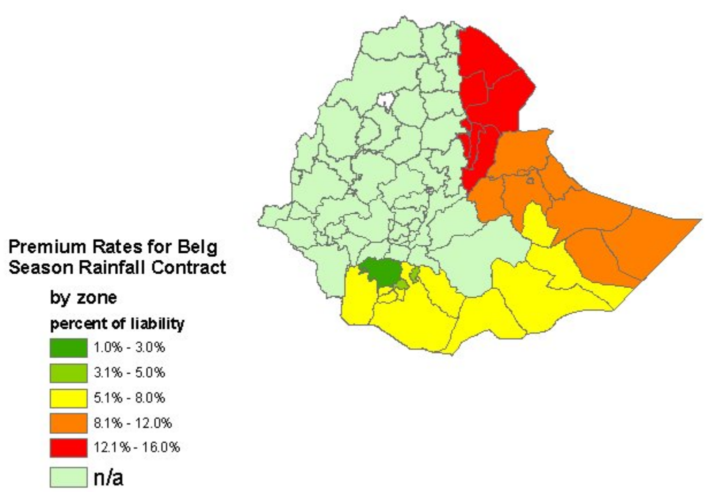


Figure 13. Pure premium rates for livestock contract

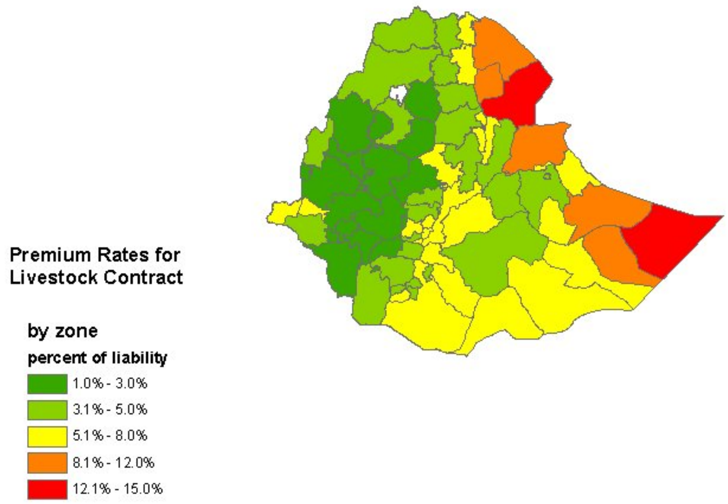


Table 8 provides the average pure premium rates by season and area. This gives a larger picture of the relative risk of the various regions. It is not surprising that over two-thirds of the value of crops is in sub-areas A2 and A3, since these are areas with higher average rainfall and lower relative risk. Livestock are also concentrated in the same areas and have the lowest relative risk, with the exception of a significant number of livestock in area C. Yet, the relative risk of area C for livestock (pasture) is less than area B. Further, area C is large and has little else beside pasture. Area B is the riskiest area for the belg crops. Here again, this represents a relatively small share of crops in Ethiopia.

Table 8. Average Pure Premium Rates by Season and Area

Area	Meher/Kiremt	Belg	Pastoral
	Percent		
A1	4.6		5.4
A2	4.3		4.3
A3	3.4		4.0
B	5.6	11.6	8.1
C	4.9	6.5	5.6

The procedures for developing pure premium rates are now clear. Examining each month's values by a smaller region can give a more complete picture of the relative risk by month and region. Figure 14 presents the administrative regions in Ethiopia. These are used to give a more complete assessment of the relative risk by months and geography in Figures 15-17. In the southeastern sections of Ethiopia, the premium rates for April to September clearly demonstrate that these are lower risk months (see Figure 15; all monthly values from April to September are less than 10 percent pure premium). This corresponds well with the critical months that are used to match crop growth. In the central sections of Ethiopia, the season is shorter and the risk lower only from June to September.

Figure 14. Administrative regions in Ethiopia

Figure 15. The monthly risk profile for a 70 percent proportional contract for administrative regions in the southeastern section of Ethiopia

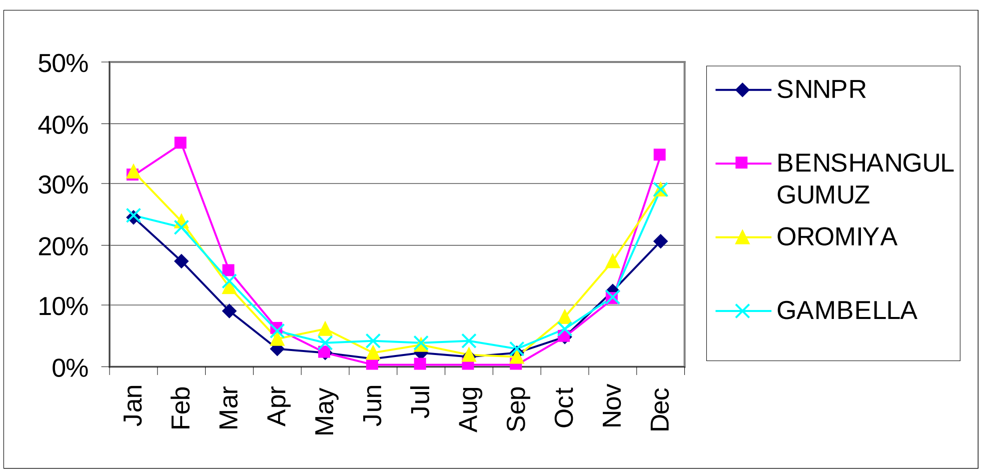


Figure 16. The monthly risk profile for a 70 percent proportional contract for administrative regions in the central sections of Ethiopia

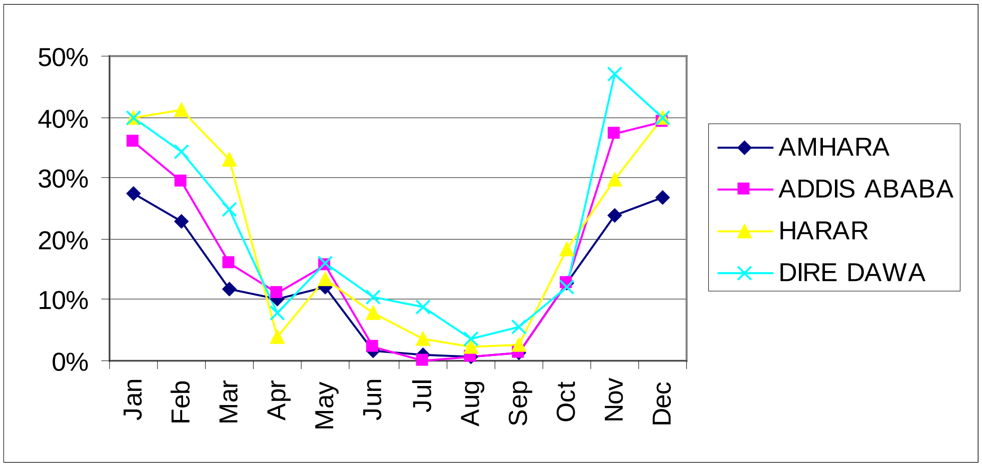
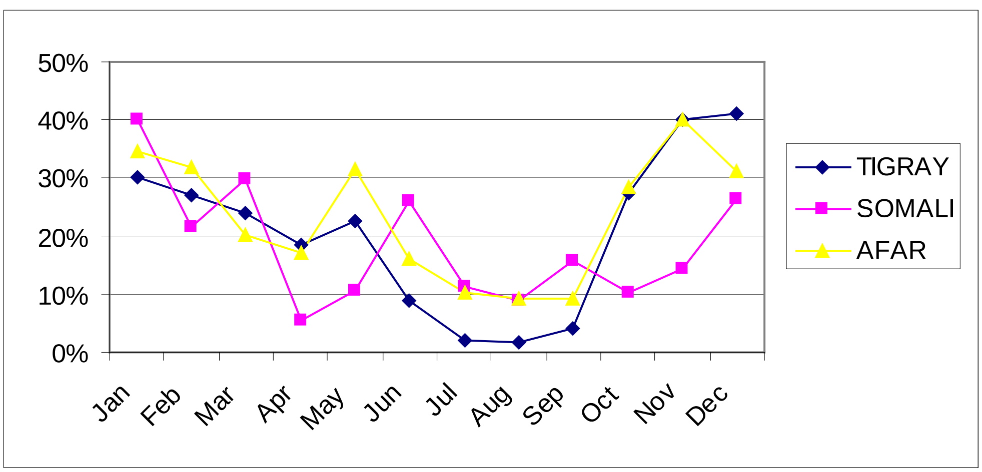


Figure 17. The monthly risk profile for a 70 percent proportional contract for administrative regions in the western section of Ethiopia



Portfolio Risk Assessment Using Pure Premium Rates

Up to this point, the focus has been upon the pure risks that are represented by the important seasonal rainfall within each zone. To fully appreciate how these risks relate to the agricultural sector, one must match the rainfall risk with the crops and livestock in Ethiopia. This becomes a spatial and temporal portfolio problem. More fundamentally, the best *current* estimates of the value of the crops and livestock are needed. It would be a mistake to use historic data on the distribution of crops and livestock to motivate the risk assessment. When insurance companies model earthquake or hurricane risk they also examine the *current* spatial value of property against the historic loss experience from earthquakes and hurricanes. A properly constructed portfolio model can reveal added information about the risk profile of the current agricultural sector in Ethiopia.

The starting point for evaluating the portfolio of risk for agriculture in Ethiopia is the complete matrix of payouts for tailored rainfall insurance contracts. Data sets now exist for the three seasonal contracts by rainfall regime area for each zone (timing for seasonal contracts and rainfall regime appear in Table 5). Thus, the payout matrix for a well-specified contract is available for all zones for each of the three seasons where they are important. This matrix has payouts for 1961-1996 for 80 zones for crops during the meher/kiremt season, 80 zones for the pastoral season, and 29 zones for the crops during the belg season. In fact, there are only 54 zones with any significant crop production. This highlights the importance of providing an analysis that is weighted by crop value. To highlight this point further, the top 10 zones in Ethiopia comprise over 50 percent of the value of major crop production in Ethiopia (authors' estimates).

Payout percentages are used to develop the pure premium rates. To perform the most effective risk assessments, the total value of Ethiopian crops and livestock can be insured in the model developed for this report.

$$Liability_{ZE} = Current\ Value\ Estimate_{ZE}$$

$$Premium_{ZE} = \frac{\sum Payout\ Percentage_{ZEt}}{36}$$

$$Cash\ Payouts\ (Indemnities) = Liability_{ZE} \times Payout\ Percentage_{ZEt}$$

$$where\ Z = zones\ 1\ to\ 8$$

$$E = Enterprise\ 1\ to\ 3$$

$$t = year\ 1961\ to\ 1996$$

Given estimates of payouts/indemnities for the rainfall insurance contracts developed here, one can develop annual loss ratios for any combination of areas or enterprises. These values reveal added information regarding the spread of risk within Ethiopia. For example, they reveal far more than simply examining the correlation matrix of rainfall. The insurance models capture the correlation by summing up the indemnities and comparing those indemnities to premiums for any combination of areas/seasons. If the risk across the major production zones were completely independent, the distribution around the loss ratio of 1 would be relatively tight (i.e., the pooling effect of insurance would be realized and the variance of the pool would be lower than the variance of the individual zones). However, given that the correlation of extreme drought is relatively strong in certain years, one can expect to see highly skewed loss functions where some years have far more losses than the sum of premiums.

$$Loss\ Ratio_{ZEt} = \frac{Indemnities_{ZEt}}{Premium_{ZE}}$$

The analysis focuses on the five major staple grain crops: maize, sorghum, wheat, teff, and barley. Using zone-level production data from World Bank village surveys, the average production was calculated for the five crops. The average production was calculated from four years of available production data (1997/1998 to the 2000/2001 season) for 55 zones. To determine the value of production across Ethiopia, market prices for the five crops by administrative region (see Figure 14) were obtained from the World Bank. The average market prices (1999-2002) for the mixed varieties, (e.g., "mixed wheat"), were used to create a value matrix by multiplying the zone-level production data by the corresponding regional price per ton, creating a matrix of the value of production by zone.

These data reveal the value-at-risk[4] across Ethiopia. For simplicity, the grains were grouped into two categories: coarse grains (maize and sorghum) and cereals (barley, wheat, and teff) according to growing seasons and production areas. Figures 1 and 2 presented earlier in this report provide a good estimate of the spatial distribution of crop production. This spatial matrix of value-at-risk is used with the portfolio model to examine drought risk through time. Data obtained from a previous World Bank study in Ethiopia suggest that the belg season accounts for roughly 20 percent of the total crop in the areas B and C. Thus, when evaluating the value-at-risk for these areas 80 percent of the total value was used for the meher/kiremt season and 20 percent for the belg season.

Data for livestock are from the Global Livestock-Collaborative Research and Support Program Livestock Information Network and Knowledge System (GL-CRSP LINKS) project in Ethiopia, obtained from Jerry Stuth at Texas A&M. This project is tied to the Livestock Early Warning System (LEWS), which attempts to model movement of animals across Ethiopia. The data provide a base for making a spatial estimate of the value of cash receipts from various species of animals. Three species of animals were used for these estimates: cattle, sheep, and goats. The estimates were scaled, based on the number of animals by species within each zone. An aggregate value was calculated that is roughly equal to the values reported by FAO. Thus, these estimates may be close for estimating the commercial receipts from the sale of animals and their by-products, but do not attempt to account for the value of animals for subsistence or status. Nor do they reflect the potential losses that may occur from animal deaths or liquidated sales during the most serious droughts. Nonetheless, they provide a reasonable base for a portfolio assessment of the risk exposure of animal agriculture across Ethiopia. Figure 3 (above) shows the spatial pattern for the estimation of sales of major animals in Ethiopia.

The best profile of risk can be demonstrated by using loss ratios. The zone example presented in Table 7 can be used. Zone Arsi is in rainfall regime area A3. Loss ratios for the meher/kiremt season can be examined at the zone level, at the area level for A3, and at the country level. Keep in mind that one is simply aggregating indemnities and premiums by year to make this simple calculation. A non-parametric kernel smoother is used with the 36 years of data to plot a "best-estimate" of the probability density function (PDF). Figure 18 provides a visual image of how the extreme losses are reduced to some extent as one moves from only the zone level to the rainfall area and then to a country-wide evaluation. However, even the country-wide evaluation suggests very strong patterns of correlation across the country when there are major droughts. Extreme events are greatest when only the risks of the single zone are considered. Estimates of the value of these extreme events can also be easily made by estimating the pure premium rates to "stop losses" when the loss ratio exceeds 200 percent (i.e., the reinsurer would pay for all losses above 200 percent). In effect, this is like integrating the area under the PDF beyond different stop loss points. This measure allows for a direct comparison and gives a sound measure that captures the systemic risk, i.e., the tail risk. For coverage of losses beyond 200 percent, the pure premium rate

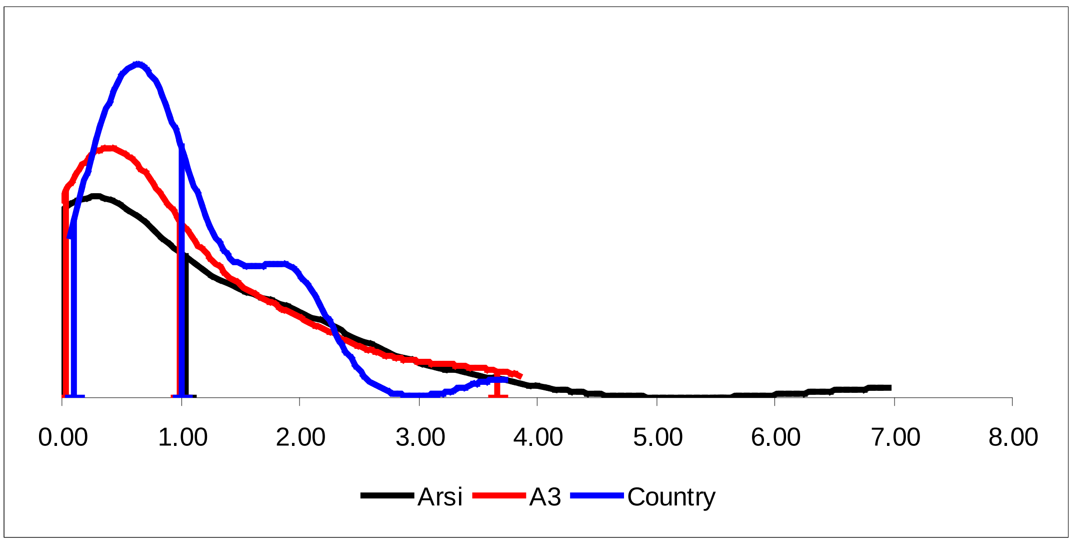
[4] The term 'value-at-risk' is used here to refer to the estimated value of production that is exposed to drought risk, where 100 percent loss would be the total value of production.

at the zone level would be 21.2 percent. By contrast, the pure premium for the area is 13.8 percent, and for the country, 5.4 percent.

Table 9. Estimated Pure Premium for Various Stop Loss Reinsurance by Geographic Spread

Stop Loss	Zone	Area	Country
	%		
100	48.7	39.7	29.1
200	21.2	13.8	5.4
300	11.7	3.4	2.0

Figure 18. Meher/kiremt season loss function for zone Arsi, area A3, and country



A more complete picture of the country risk can be developed using the pure premium for the stop losses for various contracts and areas. Table 10 gives a clear picture of the value of pooling the risk across areas as well as across enterprises. Pooling across enterprises allows for different months to influence the loss experience as well. The aggregate pure premium for the stop loss at 200 percent is equal to 4 percent. By contrast, pure premium for meher/kiremt season in the important production area A3 is 14 percent.

Table 11 provides the correlation matrix for the loss ratios. This table shows that crop risk between the two seasons for area C is actually negatively correlated, making for excellent pooling and removal of the long tail risk that are present for the crops taken separately. Referring back to Table 10, the pure premium for a stop loss at 200 percent for the pooled crops in area C is 15 percent, as compared to 27 percent for the meher/kiremt season, and 36 percent for the belg season. Similar results are found for area B, where the correlation between the two cropping seasons is also correlated at a low level (14 percent). In addition, in area C the contract that is developed to insure pastoral risk has little tail risk, with a pure premium of only 1 percent for the 200 percent stop loss, in part, because the average pure premium rate for the contract is relatively high. Additionally, there is good spread of risk across area C, as it encompasses most of the southern area in Ethiopia.

Table 10. Pure Premium for a Stop Loss of 200 percent

	Meher Kiremt	Belg	Pastoral	Crops and Livestock	Pooled Crop
Area A1	10		10	9	
Area A2	10		10	10	
Area A3	14		9	12	
Area B	21	16	13	9	10
Area C	27	36	1	1	15
Country	5	14	2	4	5

Table 11 also shows the correlation between the time series and the loss ratio (Time series is represented by the variable "year."). In every case other than the belg season, the correlation is positive. This is as expected, since the trend in rainfall is negative over the 36-year period.

Table 11. Correlation Matrix of Loss Ratios by Region and Season

	Year	Meher A1	Pastoral A1	Meher A2	Pastoral A2	Meher A3	Pastoral A3	Meher B	Belg B	Pastoral B	Meher C	Belg C	Pastoral C
						(%)							
Year	100	21	11	7	6	24	32	45	5	20	14	-2	54
Meher/A1		100	87	68	69	37	44	11	30	28	28	8	40
Pastoral/A1			100	75	77	33	42	6	37	32	28	19	33
Meher/A2				100	99	59	55	2	40	34	14	27	33
Pastoral/A2					100	60	55	6	43	38	15	29	33
Meher/A3						100	94	41	32	40	7	17	59
Pastoral/A3							100	44	31	40	24	8	63
Meher/B								100	14	49	46	3	49
Belg/B									100	92	26	11	35
Pastoral/B										100	41	9	47
Meher/C											100	-17	36
Belg/C												100	30
Pastoral/C													100

It is also useful to examine the high loss ratio years from this analysis. Table 12 provides information on the worst year by area and season. Two years appear most frequently in this table – 1984 and 1987.

Table 12. Largest Loss Year By Area And Cropping Season

Area	Meher/Kiremt	Belg	Pastoral	Combined
A1	1990		1984	1984
A2	1984		1984	1984
A3	1987		1987	1987
B	1987	1965	1980	1980
C	1970	1971	1993	1991
Country	1984	1965	1984	1984

If only crops are considered, there are 14 of 36 years with loss ratios that exceed 1.0 for the country. Those years are plotted in Figure 19. By some measure, 1984 is the worst year in the data set. Anyone who knows Ethiopia knows that 1984 was a terrible year of drought for important production regions and famine throughout the country. Figure 20 illustrates the extent of the 1984 drought by providing a breakout of the loss ratios by zone across the country. This figure clearly demonstrates that the worst problems were in the most important production zones. Figure 19 also suggests that if the same weather from 1965, 1973, or 1991 were repeated, there would be high crop failure in important regions of Ethiopia. To illustrate the contrast between two bad years, Figure 21 presents the loss ratio by zone for 1991.

Figure 19. Years with loss ratio in excess of 1.0 for combined crop in country

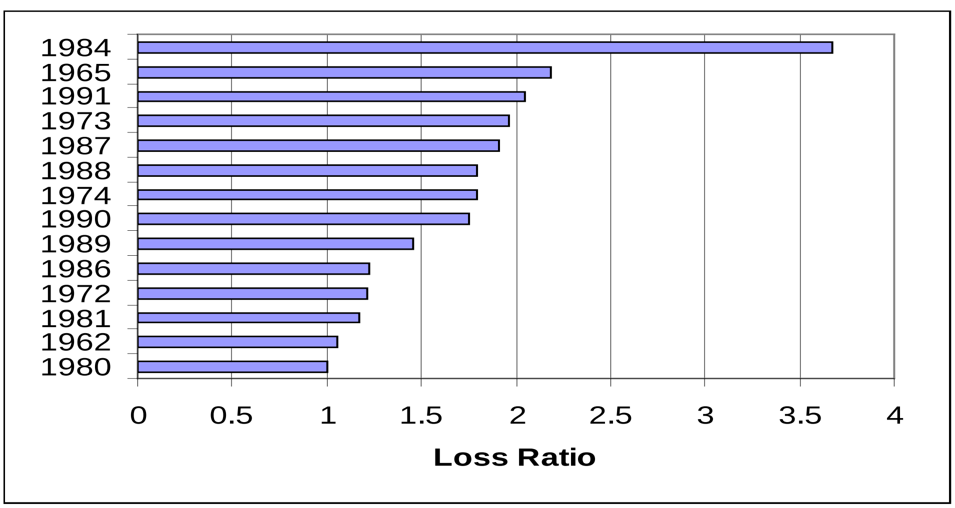


Figure 20. Loss ratios by zone for Ethiopia in 1984

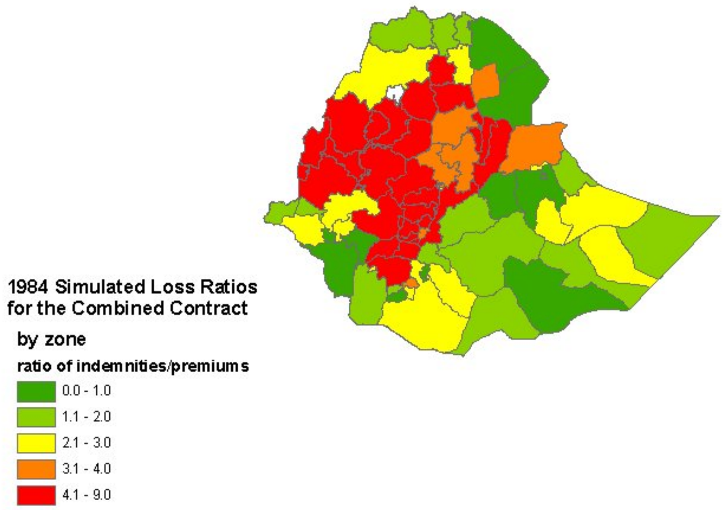
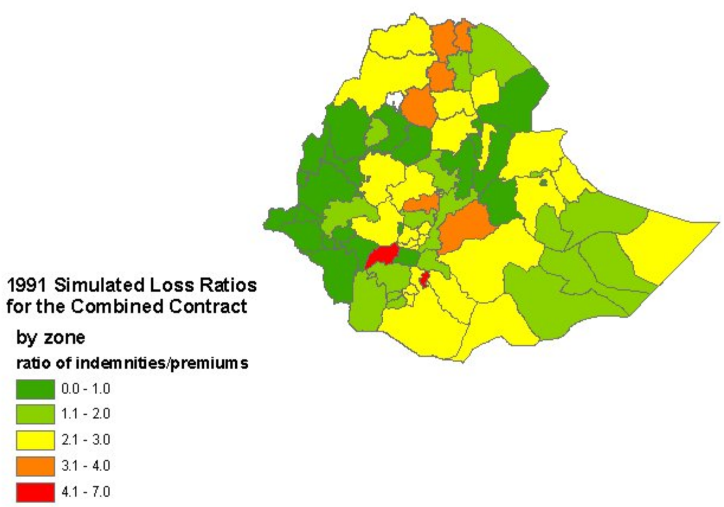


Figure 21. Loss ratios by zone for Ethiopia in 1991



Index Insurance in Ethiopia: Possible Applications

We next discuss institutional options for the delivery of both input loan insurance and stand-alone weather insurance. The ideas that seem most easily conceptualized are those that link rainfall insurance to a financial service agreement. Two applications that stand out are bundling weather insurance with a lending package or bundling weather insurance with an input bundle. It is also possible to have a stand-alone insurance product. On a larger scale, the report sets forth how the government and the donor community could use regional rainfall indexes for the distribution of disaster aid.

Rainfall insurance as part of lending

In a country like Ethiopia with underdeveloped financial markets, lending to rural households is not the norm. It is more common for some farmers to obtain loans to buy inputs like fertilizer and seed in areas of higher fertility and less common in drought-prone areas. In Ethiopia, all land is publicly held and, currently, the rights to farm a parcel of land cannot be used as collateral. As a result, it is very difficult for most farmers to get loans for inputs because they lack assets for collateral. To fill this need, many local governments have stepped in and provided loan guarantees for farmers who would like to buy inputs. In many cases, the regions could use their future budget for collateral to secure loans. As a result, the loan default risk has fallen heavily onto local government officials whose future salaries are on the line if loans are not collected. Undesirable situations result such as when state-funded extension agents act as both technical advisors to farmers and bill collectors. While regional governments try to move away from this structure, these lending arrangements still exist because of the inability of farmers to get loans. In addition to the obvious need for farmers to have some type of transferable land rights that can be used as collateral, insurance may be able to play a role in helping to make lending more attractive to farmers.

Risk aversion and the absence of insurance have led many Ethiopian farmers to resist the adoption of new technologies that increase average yields. If a farmer takes a loan and then has a crop failure he could face imprisonment for his lack of repayment. If a farmer has a total crop failure because he planted a new variety of seed that did not perform well, he faces the risk of his family starving. These types of risks and a lack of financial resources, result in farmers being very slow to make investments or adopt new technology.

One conceptual use of rainfall indexes would be to bundle loans and insurance together so that when a farmer gets a loan, he can choose to pay a higher interest rate to cover the premium on a rainfall contract. At the time of getting the loan, a farmer might be able to choose between three different interest rates, one with no insurance, one with a high level of rain protection (i.e., low deductible), or a rate that encompasses a lower level of rainfall protection (i.e., high deductible).

Instead of the issuer of the loan providing insurance (i.e., instead of the loan having state-contingent repayments), coverage for individuals might be provided by another institution. This seems administratively inefficient, but there might be legal constraints on the ability of co-ops and MFIs to formally carry (be exposed to) risk. An insurance company would then guarantee repayment of (some proportion of) all loans issued in a given area, contingent on a well-defined rainfall event. This insurance could be financed either *ex ante* or *ex post*: *Ex ante* financing could be implemented by increasing the size of the loan (by the premium amount), and having the individual (or, more cost-effectively, the lender) transfer this amount to the insurance company. The interest paid on the loan would be the “risk-free” rate. Alternatively, *ex post* financing would involve issuing an unadjusted loan, but increasing the interest rate above the risk-free rate. Profits earned on interest payments in good years would then finance (in expected value) shortfalls in repayments in bad years.

The design of the payout of such a financial tool is limited only by the creativity of the institution writing the contracts. This type of instrument could be structured to allow repayment to be delayed by a year, with little or no interest accrual until after the following crop. Contracts could also be designed that pay for a percentage of the loan in the event of adverse weather. The percentage paid could be a function of the degree of drought, where a modest shortfall in rain produces a modest principle payment, and a high degree of drought produces a high amount of payment.

Rainfall insurance as part of an input bundle

Suppose that without certain inputs (e.g., hybrid seed, fertilizer, etc.), farm productivity on average is low. It does depend on rainfall, and is higher when the rains are good. A given input bundle increases productivity for all rainfall outcomes. It is possible that without insurance, the farmer prefers not to purchase the input bundle because, although the average increase in productivity is greater than the cost of the inputs, the increase in productivity when the rains fail is (sufficiently) less than the cost.

The optimal policy or market outcome would be for the farmer to purchase the input and fully offset the risk he is exposed to. In the absence of a well-functioning insurance market, at least some level of insurance (and perhaps the efficient amount) can be provided by the seller of the input. One could imagine a scheme where every fertilizer bag has on it a tag that is an insurance policy. Upon purchase, the merchant or salesman simply punches a hole on the tag next to the appropriate year, region, and amount of coverage (e.g., 50 percent of the price of the fertilizer) and then looks up the appropriate insurance rate from a rate book. The insurance premium is then added to the price of the bag of fertilizer. If a farmer does not want the insurance the merchant can simply remove the tag and return it, unmarked, to the insurance company. To make a claim on this type of insurance, a farmer would return to the merchant or underwriting insurance company with the aforementioned tag and claim his insurance indemnity based on the actual rainfall in his area. For example, the seller could agree to refund some, or all, of the cost of the input in the event that the rains fail.

Alternatively, the input supplier could provide credit and ask only for partial (or zero) payment for the input when the rains fail. The amount repaid in the event of good rains would be larger than the principal, plus the risk free interest rate; the differential acting as an implicit premium. This latter policy amounts to partial (or full) forgiveness of a loan to purchase the input. Appendix A presents the theoretical discussion regarding how much of a loan should be forgiven.

In principle, insurance against bad weather events could be marketed to any and all households on a case-by-case basis. Linking insurance directly to input loans builds on existing arrangements that link individual households with institutions (co-ops, MFIs, etc.) that could act as insurance providers. For example, a microcredit institution might provide loans to farmers to purchase inputs, and then offset the risk on a secondary market (if one existed). However, this comes at the cost of excluding individuals who do not require fertilizer or seed inputs from the insurance market.

Except for the limitation of not being applicable to other industries, this scheme has all of the benefits of the loan-based product mentioned above. This scheme has the added benefit of not requiring a third-party lender involvement. The limitations are similar to the limitations for loan-based insurance. This scheme would require the involvement of an insurance company because of the risk-transfer nature of the contract and the regulatory environment of Ethiopia.

Stand-alone weather insurance

Direct marketing of unbundled weather-based insurance might lead to faster take-up rates, as well as allowing non-fertilizer users to access the insurance market. Any institution that sells weather-based insurance must be able to purchase reinsurance directly, or reduce its risk exposure through some other means. For example, local cooperatives could reinsure their risks first through cooperative unions, and then through national cooperative associations. Table 13 provides information on the regional distribution of cooperatives. There are a large number of agricultural and non-agricultural cooperatives.

Table 13. Regional Distribution of Cooperatives

Region	Agricultural Cooperatives	Nonagricultural Cooperatives	Cooperative Unions
Tigray	556	26	3
Afar	15	2	
Amhara	993	249	10
Oromiya	1533	900	16
Somali	12	9	
Beneshangul Gumuz (Ben-Gum)	72	6	
SNNPR (Southern)	798	175	6
Gambella	12	3	
Harar	11	99	
Dire Dawa	8	98	
Addis	24	1767	
Total	4034	3334	35

Woreda governments could similarly sell insurance to individuals and be reinsured through zonal, regional, and finally the central government. This insurance could be in the form of an explicit "contract", or it could be part of the regional-woreda fiscal allocation mechanism. Since the responsiveness of fiscal allocations to changes in local circumstances seems limited (officials at the Oromia regional government informed researchers that discretionary reallocations across woredas amounted to only 1 or 2 percent of the regional budget), a separate and formal insurance arrangement between regions and woredas might be desirable. In turn, the regions would pool their risks through the central budget. Regional/central earmarked funds could be earmarked, to which woredas/regions would make contributions (premium payments) in return for benefit payments in the event of bad weather outcomes.

Microfinance institutions could also sell insurance directly to individuals. These institutions currently serve only about half a million individuals, and their geographical reach is not clear. Table 14 reports financial information for 20 MFIs. While there is a relatively large number of MFIs operating, the industry is very concentrated. As Table 14 indicates, the first three MFIs in the table account for over 80 percent of assets at the end of June 2003. This concentration may not support competitive supply of insurance, but it would have a benefit if there are significant fixed costs to marketing and administration, not to mention the ability of the larger firms to pool risk (if they have a wide enough geographic reach).

Table 14. Financial Indicators of Microfinance Institutions (June 2003)

MFI	Deposits	Loans	Assets	Loan/ Deposit	Loan/ Asset
Amhara Credit and Savings	112	188	250	1.7	0.75
Dedebit Credit and Savings	131.3	180.3	314	1.4	0.57
Oromiya Credit and Savings	21.1	61.6	81	2.9	0.76
Omo Credit and Savings	19.8	22.7	44	1.1	0.52
Specialized fina. and prom.	3.5	6	9	1.7	0.67
Gasha Microfinancing	1.8	3	8	1.7	0.38
Wisdom Microfinancing	4.2	10.7	18	2.5	0.59
Sidama Microfinancing	2.4	7.9	16	3.3	0.49
Asseer Microfinancing	0.1	0.3	1	3	0.3
African Village Fina. Serv.	0.1	1.7	2	17	0.85
Buus. Gon. Microfinancing	0.2	2.2	3	11	0.73
PEACE Microfinancing	1	4.4	6	4.4	0.73
Meket Microfinancing	0.2	0.3	1	1.5	0.3
Addis Credit and Saving	2.7	9.8	18	3.6	0.54
Meklit Microfinancing	1.3	1.9	3	1.5	0.63
Deshet Microfinancing	0.3	2.8	5	9.3	0.56
Wassassa Microfinancing	0.5	2.1	3	4.2	0.7
Ben Gum. Microfinancing	0.3	0.7	5	2.3	0.14
Sha.Idi.ye.Ag.Microfinancing	1.4	1.4	3	1	0.47
Metemamen Microfinancing**		0.3	1		0.3
Mekdella Microfinancing*					
Dire Microfinancing*					
Total	304.2	508.1	791	1.7	0.64

The role of insurance companies in providing both individual insurance policies and reinsurance for local level institutions should not be overlooked. There is a growing network of insurance branch offices across the country, although it is still concentrated in Addis Ababa (44 percent of all branches are there) and the regional centers. All but one of the nine registered insurance companies have offices outside the capital. It is expected that initially, the comparative advantage of the insurance companies might be in providing reinsurance to local institutions, especially given their access to international reinsurance markets.

Table 15. Geographic Distribution of Insurance Companies

Region	Number of branches	(%)
Addis Ababa city administration	48	44.4
Amhara	13	12.0
Oromiya	21	19.4
SNNPR (Southern)	10	9.3
Tigray	5	4.6
Dire Dawa city council	8	7.4
Harar	2	1.9
Somali	1	0.9
Gambella	0	0.0
Beneshangul Gumuz (Ben-Gum)	0	0.0
Total	108	100

Table 16. Insurance Industry Structure in Ethiopia for General Insurance

Company Name	Gross premiums	Market share (%)
NICE	17173	3.1
Global	5220	0.9
Nib	20661	3.7
Awash	38450	6.9
UNIC	41328	7.4
Nyala	47142	8.5
Nile	58798	10.6
Africa	59292	10.7
EIC	267510	48.2
Total	555574	100

Linking a Rainfall Index to the Distribution of International Aid

As mentioned above, a single index may be utilized for different commercial and social objectives. For example, a rainfall index can be used by international aid organizations as an indicator of emerging drought and a trigger for disaster relief. There is increasing donor interest in shifting away from in-kind relief (food aid, material goods) by increasing the proportion of monetary assistance, i.e. cash payments rather than grain and a rainfall index could be used to facilitate these efforts. Cash payments have some distinct advantages over grain shipments in terms of timing, mobility, and flexibility. Resources could be mobilized more quickly and targeted to areas of prime need in a more efficient manner. Though the index would not replace ground-level assessments, it should provide an additional mechanism for identifying need and expediting the relief process. Further, monetary assistance can be used for local procurement of food from areas of surplus production.

A simple correlation analysis between the WFP emergency food aid shipments presented in Figure 3 and the loss ratios generated from the model gives a 65 percent correlation. This degree of correlation is encouraging for the conceptualization of linking relief shipments or payments to a rainfall index, especially when it is considered that the data on food aid includes aid provided for any type of emergency requirements and is not exclusive to drought or weather related events. Additionally, one would expect a stronger correlation if the data included 1984, the year of expansive drought and famine. Further refinement of data could yield a higher correlation between drought-induced relief needs; however it is not suggested that a rainfall index replace existing processes and mechanisms for identifying food aid needs, but rather that such an instrument is supplemental to facilitating an objective and rapid response to emerging problems.

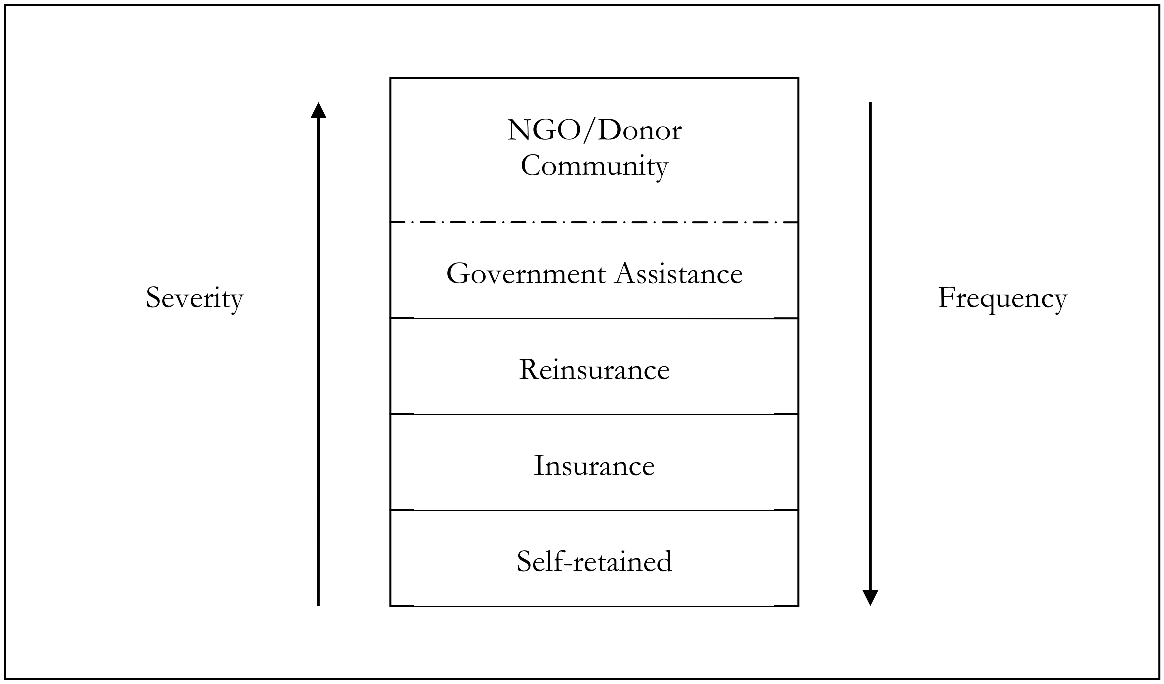
Practical Issues

Commitment not to pay for the uninsured: This would be a potential benefit of having profit-focused insurance companies providing the reinsurance of lower-level bodies rather than higher levels of government.

Voluntary or mandatory insurance: Since "premiums" (explicit or otherwise) would reflect exogenous and known weather-event probabilities and local production possibilities, adverse selection problems would be limited. That is, it should be possible to make premiums actuarially fair for different individuals. It is possible that fixed costs (administrative, etc.) would lead to differential take-up rates across localities. This kind of selection could leave a national-level reinsurer (an insurance company or a government organization) exposed to more than just the systemic risk of the country, which would then need to be reinsured externally. There is a case then for financing fixed costs of insurance (like any fixed cost of production) through general taxation or other means, and not through price (premium) increases.

Institutional Requirements: Early warning systems (e.g., FEWS, oceanic oscillation indicators, etc.) for famine and drought are already in use in parts of eastern Africa and serve as indicators of future food aid needs. A rainfall index insurance contract could be structured to provide indemnities at the first signs of an impending drought. Early payments could help to mitigate or circumvent the economic impacts of a drought to prevent a real crisis situation. Furthermore, a rainfall index would be complementary to existing early warning systems. The same index used for commercial sector insurance could also be used to support social objectives as well. The government, NGOs, and/or international donors could each carry some level of risk, utilizing the index as a signal for disaster assistance. Segmenting the layers of risk can make commercial insurance more viable by removing the exposure to the most catastrophic events. Different layers of risk could be distributed to different parties. At low levels of risk, (low severity), households should be able to employ self-insurance mechanisms such as savings or informal credit to manage their risk. The next layer of risk can be carried by insurance companies in the private sector. Their risk exposure can be limited through the use of reinsurance to protect against catastrophic losses. For the most extreme events, however, some form of free or low-cost disaster assistance may be needed, provided by a government disaster program or the international community.

Figure 22. Proposed risk sharing arrangement (layering risk)



Regulatory Considerations. There are some specific demands on regulatory capacity posed by weather-based index insurance. To begin with, the regulator needs to license products and monitor portfolios and the insurer's ability to pay for claims. Weather index insurance differs from traditional insurance products only insofar as the coverage is limited to one, or a clearly defined basket of risk parameters. An actuarial analysis of the historical series for these parameters, as well as a loss or burn analysis to determine loss histories usually reveals a rather accurate picture of the exposure. Weather index insurance introduces at least three new challenges for regulators:

The nature of risk parameters. Weather risk is subject to structural changes that the regulator should understand at least in principle: global warming and climate patterns (El Niño in certain parts of the world), as well as the nature of microclimates are prime examples.

The nature of reinsurance markets. As opposed to traditional crop insurance the ultimate risk takers in the weather-risk market are not necessarily the big name reinsurers, but could be banks or even power traders. While the contractual format will be a reinsurance treaty with an acceptable reinsurer, there are potentially more efficient risk transfers should the regulator choose to accept other risk transfer formats.

The nature of risk portfolio management. The insurer may have unique opportunities for risk diversification and hedging. A weather-risk portfolio can be managed in a fashion that allows for limited risk capital to support a large amount of underwritten notional risk, if at least some of the exposures offset one another due to low correlations. For example, if an insurer writes both flood and drought risk in one place for the same period, only one of the two contracts can pay out and the same traditional insurance reserves can support twice as much premium underwriting. Therefore the regulator should recognize the hedging and portfolio diversification effects on capital needs and allow for a competitive use of risk capital by insurers and reinsurers.

Analysis and oversight of new types of products and insurers in the market require specific skills and profiles currently not available in the Ethiopian regulatory environment.

Summary and Recommendations

Ethiopia continues to suffer from chronic poverty that is exacerbated by a harsh climate. Given that 85 percent of the 65 million people continue to live in rural areas, it is not surprising to see that weather driven crises dominate the complex Ethiopian environment. In excess of 10 million people were adversely impacted by droughts in 2000, 2002 and 2003. The 1984 drought killed some 300,000 people in Ethiopia. However, beyond the severe humanitarian crises that are created by serious drought problems, these risks hinder economic development. The poor become extremely risk averse and are hesitant to adopt yield enhancing technologies. Furthermore, many are simply unable to make investments in production because they lack both assets and access to financing. The broader financial community is constrained by ineffective ways to cope or manage the weather risk that dominates the Ethiopian landscape.

This report examines drought risk in Ethiopia in some detail by treating these risks as both a portfolio and an insurance problem. The portfolio is captured by the estimated value of the geographic spread of receipts from both crops and livestock in Ethiopia. The insurance approach uses rainfall insurance contracts that would pay for significant shortfalls of rain during critical growing seasons. Rainfall insurance is a relatively straightforward contract that would pay when rainfall is below a certain threshold. Previous designs of rainfall insurance contracts are limited, since payments are based either on cumulative rainfall over the entire season, or, on weighted average rainfall for the season reflecting critical rainfall periods. This report introduces a contract that would pay for shortfalls in rain for any month during the growing season. Thus, one could envision making multiple, and timely, payments as conditions become severe. This should help mitigate risk early on, before a crisis becomes full blown.

A close examination of rainfall data in Ethiopia gives cause for concern. A distinct negative trend in rainfall is present in most of the important growing areas. Furthermore, the relative risk of severe shortfalls in rain, as measured by rainfall insurance contracts developed in this study, is increasing. And while Ethiopia is a vast country with cropping patterns that vary by region, there are still significant correlated risks associated with drought. In other words, the most serious droughts have country-wide impacts. Nonetheless, this study systematically illustrates the degree of correlated risk problems for different regions and cropping seasons. As anyone who knows Ethiopia might expect, the southern and eastern rim of the country are most vulnerable to correlated risk problems driven by drought. When livestock are added to the portfolio of risk, the degree of these correlated risks does decline for the southern region. Even more interesting, severe drought for the two cropping seasons in the southern region appear to be slightly negatively correlated. This underscores the importance of supporting cropping when the early rains appear to be above average in the region. It also begs for improved forecasting in hopes that growers will make better early decisions about planting in the first season.

The results of the risk assessment should also prove useful to other policy prescriptions within the Ethiopian context. Knowledge of the relative risk across Ethiopia should benefit the development of both social and economic programs, in addition to risk mitigation and management strategies. The policy focus of this report involves the potential for rainfall insurance. Such insurance is emerging as a way to support a wide range of social and financial development. For example, the

Indian microfinance group, BASIX, has recently begun selling rainfall insurance to small farmers. The group is also considering purchasing such insurance to hedge the portfolio of risk that they loan to small holders. Such innovations are possible in Ethiopia as well. This report provides background on how rainfall insurance would work, and what is required to support its development. A basic infrastructure of weather stations and weather services does exist in Ethiopia. However, it is likely that public funds will need to be enhanced to strengthen the necessary infrastructure and institutions before weather insurance products could emerge. Such investments serve the public interest in a far broader context than simply opening the door for weather insurance.

The following potential uses for rainfall insurance are developed in the Ethiopian context:

- Linking rainfall insurance to loans
- Linking rainfall insurance to input usage
- Stand alone rainfall insurance
- Tying rainfall insurance to international food aid

Rainfall insurance can be used to spur lending. In some cases, lending is hampered by risk. One can envision a bundled lending arrangement whereby those obtaining loans would be purchasing a certain level of rainfall insurance. This could open the way for individual to gain better access to credit. However, such a system raises many questions regarding how the benefits of the arrangement might influence production decision. A special conceptual appendix (Appendix A) is presented to puzzle through these questions. The details of how much debt might be forgiven under what circumstances would also be a critical element to consider when linking debt to rainfall insurance. A better system may involve the purchase of the rainfall insurance directly by the bank or microfinance institution. This would allow the financial institution to hedge default risk that may arise in their portfolio of loans when there are widespread/correlated losses due to drought.

One can also envision linking rainfall insurance to input purchases such as fertilizer. The motivation for such an innovation ties back to concerns that poor farmers are reluctant to take the risk of investing in technology given the risk environment. Such systems have been introduced in Argentina. At this point, there is little knowledge regarding how these innovations change behavior (see Appendix A). One advantage of this approach is that it is easy to implement. When selling a bag of fertilizer one only need attach a coupon that can be redeemed if it does not rain in the area.

Direct sales of rainfall insurance are also possible. Insurers in Ethiopia expressed a keen interest in this idea. While basis risk (having a loss and not getting paid) is a concern, it is likely that a severe drought contract would have value in getting cash to many individuals when there is a regional problem.

The three scenarios presented above are not mutually exclusive in that these delivery mechanisms could co-exist, providing more options and flexibility. Keep in mind however, that the reach of input markets and financial institutions remains limited. Increasing the access to these services in rural areas should be a priority for improving agricultural production and risk management.

Finally, one can envision using the country-wide information that is generated from a portfolio model, such as what is presented in this study, to motivate cash payments to various key parties when a major problem is emerging. Results of the analysis show those years with severe rainfall shortages are correlated to World Food Program emergency assistance, supporting the idea that a rainfall index could be used as an early trigger for drought relief. It is well known that 1984 was among the worst drought years in Ethiopia. The analysis performed in this report demonstrates that 1984 was also, by far, the worst year from 1961 to 1996. An insurance solution could get cash into the hands of traders and others much earlier than food aid arrives. Using insurance-like solutions to provide early assistance is an idea that merits further development for Ethiopia.

The lack of a long time-series of production data limited the ability to analyze the relationship between rainfall and agricultural production. However, a risk profile for agricultural production in Ethiopia identifying critical periods and trends in rainfall was constructed using a 36-year time series for rainfall. Furthermore, a picture of the regional rainfall variation emerged that is helpful in understanding rainfall patterns and distribution across time and space. The variance in rainfall across Ethiopia in a given year evidences the potential for pooling risk spatially, as well as revealing the need for improvements in infrastructure, allowing better distribution of food from surplus areas to deficient ones.

In summary, this report has provided a solid approach for assessing drought risk across Ethiopia. Several ideas are introduced for using drought insurance to mitigate and manage risk in Ethiopia. These ideas represent a blend of market and social solutions. It is hoped that the ideas presented in this report will spur further thinking and development.

References

Abate, Getachew. 2003. "Early Warning Activities in Ethiopia", presentation for Regional Workshop on National Adaptation Programmes of Action for Least Developed Anglophone African Countries." Addis Ababa, Ethiopia, July 25-27, 2003.

Attanasio, Orazio and Jose-Victor Rios-Rull (2000): "Consumption smoothing and extended families," mimeo University of Pennsylvania.

Barrett, Christopher B., Lawrence E. Blume, John G. McPeak, Bart Minten, Festus Murithi, Bernard N. Okumu, Alice Pell, Frank Place, Jean Clause Randrianarisoa and Jhon Rasambainarivo. (2002). "Poverty Traps and Resource Degradation". Basis Brief, No. 6. January.

Black, J.R, B.J. Barnett, and Y. Hu. 1999. Cooperatives and capital markets: the case of Minnesota-Dakota sugar cooperatives. *American Journal of Agricultural Economics* 81(5):1240-46.

Dercon, Stefan (2003): "Growth and shocks: evidence from rural Ethiopia," CSAE WPS/2003-12.

Funk, Chris, Joel Michaelsen, Jim Verdin, Guleid Artan, Greg Husak, Gabriel Senay, Hussein Gadain, and Tamuka Magadzire. 2003. "The Collaborative Historical African Rainfall Model: Description and Evaluation." *International Journal of Climatology* 23:47-66.

Hammond, Laura and Daniel Maxwell. (2002) "The Ethiopian Crisis of 1999-2000: Lessons Learned, Questions Unanswered." *Disasters*, 26(3):262-279.

Little, Peter D. "Building Assets for Sustainable Recovery and Food Security". Basis Brief No. 5. January 2002.

Morduch, Jonathan (2001): "Rainfall insurance and vulnerability: Economic principles and cautionary notes," mimeo, New York University.

Miranda, Mario J. "Area-Yield Crop Insurance Reconsidered." *American Journal of Agricultural Economics* 73 (1991): 233-42.

Mishra, Pramod K. *Agricultural Risk, Insurance and Income: A Study of the Impact and Design of India's Comprehensive Crop Insurance Scheme.* Brookfield: Avebury Press, 1996.

Skees, J.R. and B.J. Barnett. 1999. "Conceptual and practical considerations for sharing catastrophic/systemic risks". Review of Agricultural Economics 21(2):424-41.

Skees, J.R., J.R. Black, and B.J. Barnett. 1997. "Designing and rating an area-yield crop insurance contract". *American Journal of Agricultural Economics* 79(2):430-38.

Skees, J., P. Hazell, and M. Miranda. 1999. "New approaches to public/private crop-yield insurance". Unpublished working paper, The World Bank, Washington, D.C.

Wilhite, D., A. and M. H. Glantz. 1985. "Understanding the drought phenomenon: The Role of definitions." *Water International* 10, no. 3: 111-20

Appendix A: How much of a loan should be forgiven?

Suppose that there are only two states of rainfall — good and bad. There is some crop output in both states, and those output levels respond to fertilizer use. In the absence of moral hazard concerns, it turns out that it is sometimes optimal to forgive more than the size of the initial loan covering input costs. This is simply because the optimal amount of insurance provided depends on net incomes under the two possible contingencies, and not separately on the cost of the input. This becomes more likely the more productive the input is in the good state relative to the bad state — that is, the more risky input makes gross farm output. This is easiest seen graphically.

In Figure A1, the input is more productive (adds more to gross output) in the good state than in the bad, and greater than 100 percent loan forgiveness is optimal. In Figure A2, the input adds more to output in the bad state than the good, and less than 100 percent loan forgiveness is optimal. By continuity, if the input adds equally to output in both states, optimal insurance is provided by forgiving exactly the amount of the loan in the bad state.

The relationship between output increases and costs also needs to be considered. Figure A3 is a simple example of inputs that are so costly relative to their effects on gross output (or, alternatively, they are so inappropriate for the particular land conditions, etc.) that even a perfect insurance market cannot make their purchase attractive to the farmer. This is presumably what happened with loans ill-advisedly "pushed down peasants' throats" through (but not by) the microcredit institutions.

In all the diagrams, if the insurance is provided directly by the input supplier, then in order to break even, the price (re)paid for the input (when the rains are good) is greater than the cost, c. This excess is not quite the same as a risk premium, because it is only paid in the good state and could be referred to as the risk adjustment (although this has another meaning elsewhere in the insurance literature). Assuming the safe interest rate is positive, the total excess of the repayment over the cost of the input would be equal to the risk adjustment plus the safe interest rate times the cost. A possible advantage of implementing insurance through the input supplier is that it weakens any liquidity constraint the farmer might face.

Of course, if some or all of a loan is to be forgiven under some specified contingencies, the repayments must be larger in the set of complementary contingencies so as to on average cover the cost of the inputs. If the input supplier is large enough, and sells to buyers with uncorrelated risks, then the supplier can effectively spread the risk or insure the (residual) risk he is exposed to in another market. It seems reasonable to assume that it would be more feasible for an insurance market to arise at the level of input suppliers than at the individual farmer level, especially for small farmers.

Figure A1. Output with input insurance

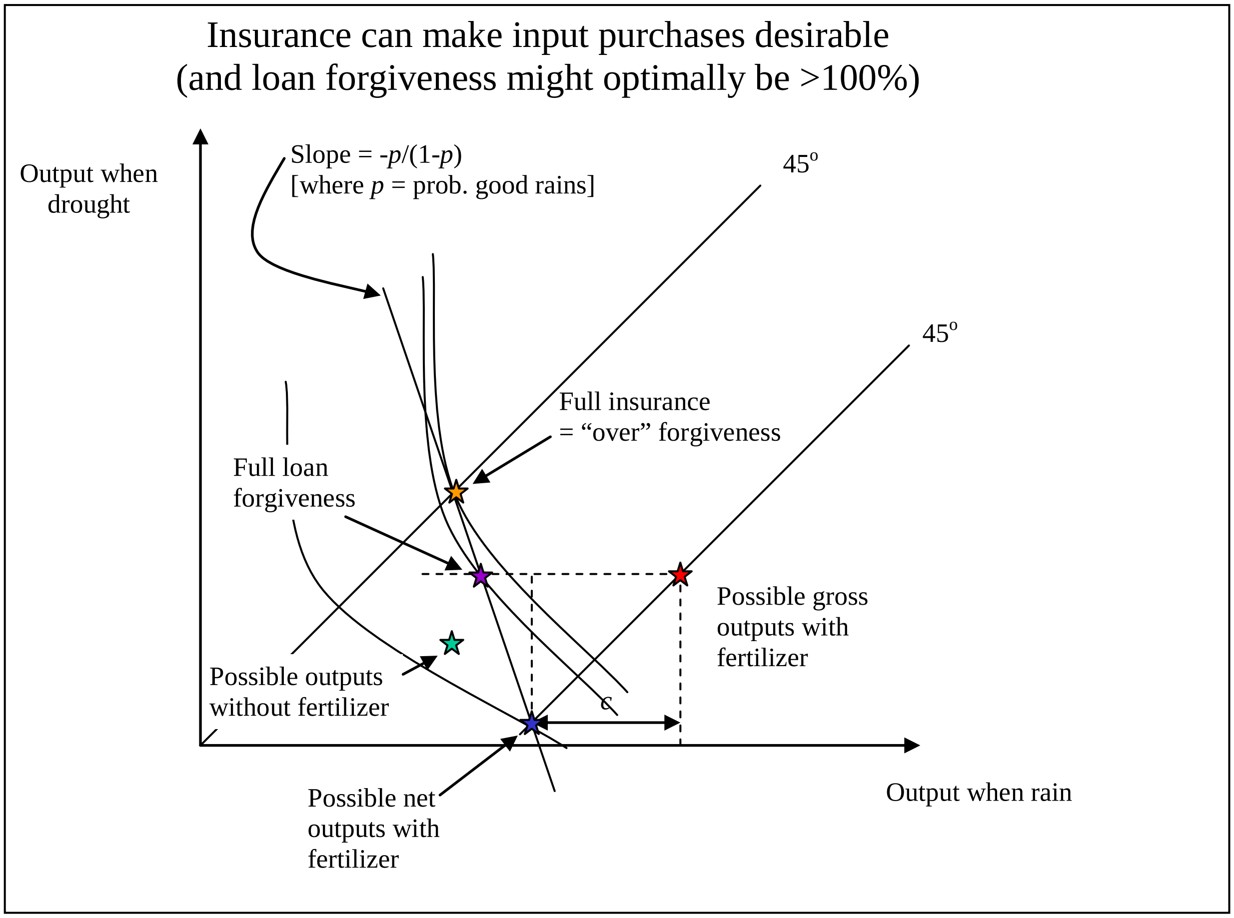


Figure A2. Partial loan forgiveness

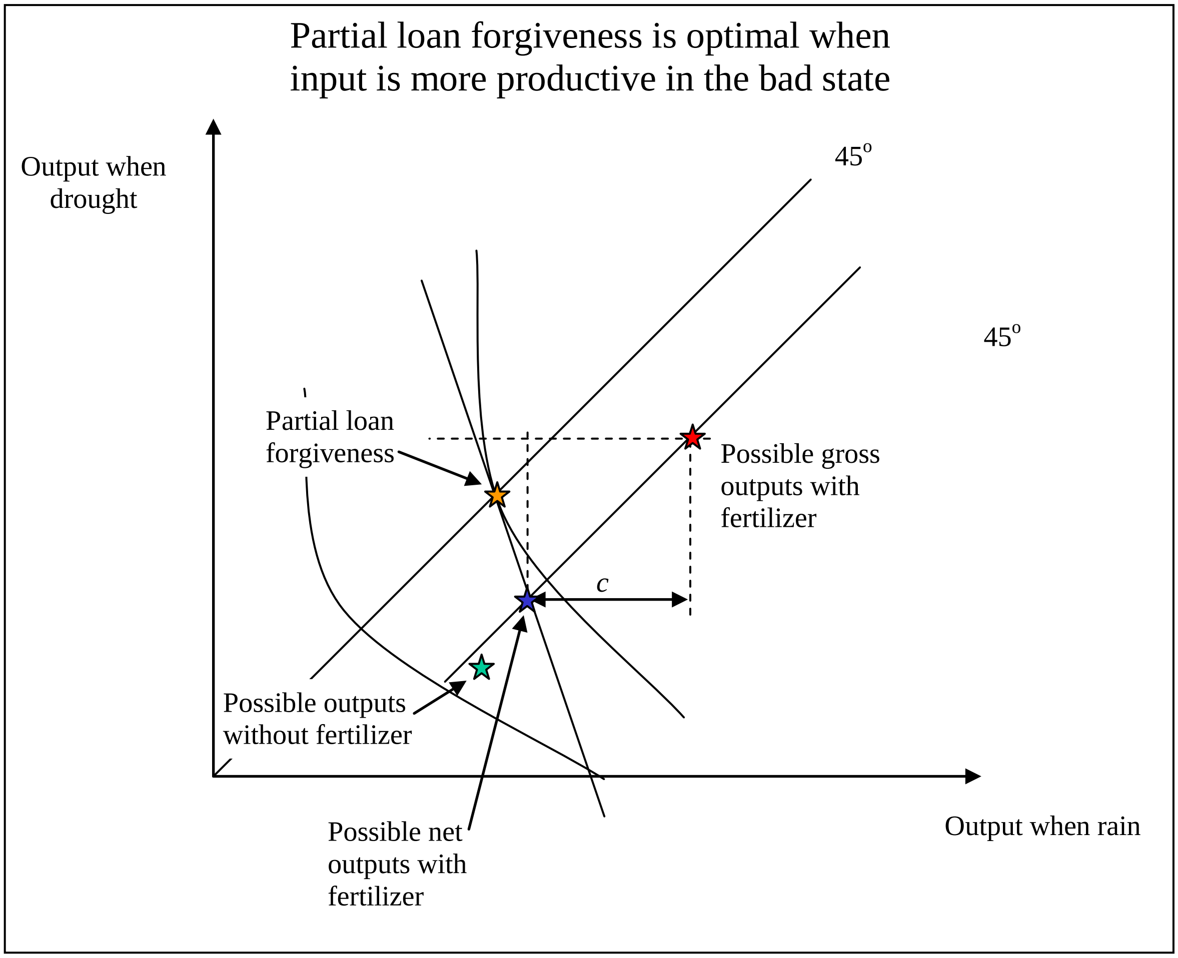


Figure A3. Optimal price of outputs