PRE-FEASIBILITY ANALYSIS:

INDEX-BASED WEATHER RISK TRANSFER IN MALI

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Malian agricultural producers and microfinance lenders are exposed to the risk of extreme drought. When lenders loan to large numbers of farmers, the highly correlated losses from drought events will create significant default risk. For microfinance institutions that serve agriculture, a capital rationing problem has emerged because donors are reluctant to increase their capital exposure to this non-diversifiable risk. Small farmers remain vulnerable to the correlated event and are restricted in the amount of working and investment capital they are able to obtain. This prefeasibility analysis presents the basic conditions necessary to support development of a market for index-based insurance products that may allow either farmers or lenders to transfer highly correlated drought risk and investigates the opportunities and constraints of this type of market development in the Malian context.

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SAVE THE CHILDREN

Save the Children is the leading independent organization creating real and lasting change for children in need in the United States and around the world. It is a member of the International Save the Children Alliance, comprising 27 national Save the Children organizations working in more than 120 countries to ensure the well-being of children. Save the Children has implemented programs in Mali since 1987. Our current portfolio includes health, education, nutrition, and livelihood programs, including the development and expansion of financial services for rural households with its long-term local microfinance partner, Soro Yiriwaso.

DISCLAIMER

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Executive Summary

Interviews with stakeholders support the contention that drought is a problem for farmers in Mali who are attempting to grow maize and other cereal crops. Drought is usually a pervasive event that affects many farmers at the same time. This *correlated risk* also has implications for lenders, as a large number of farmers may suffer a crop failure and be unable to repay loans. When interviewed, lenders in microfinance institutions (MFIs) generally support the hypothesis that this correlated risk has become a constraint to gaining access to capital to loan to farmers. Thus, a market to transfer drought risk could improve lenders' access to capital to loan to farmers. The expansion of lending to farmers could improve their use of productivity increasing technologies such as improved seeds and fertilizer. The development process can gain significantly if the risk-averse behavior of farmers and lenders can be changed so that these technologies are more rapidly adopted. It follows that there should be a role for weather insurance to encourage greater use of capital and technology that can lead to economic growth and provide a safety net for the poor.

Nonetheless, there is nothing simple about developing weather insurance markets. Traditional forms of crop insurance that pay for farm-level losses have proven unworkable in developing countries for a wide range of reasons. Since developing countries are generally populated by large numbers of small farmers, the costs alone to administer traditional crop insurance are prohibitive. Index-based weather insurance offers some promise to transfer risks in a cost-effective fashion. However, there are many preconditions that must be considered before embarking on this approach.

This prefeasibility study was targeted at reviewing the core conditions for developing a weather insurance market and making some recommendations about next steps. The key preconditions include a preliminary assessment of the:

1. Legal and regulatory environment;
2. Acceptance of the concept by users;
3. Quality of the weather infrastructure;
4. Correlation of weather events across space; and
5. Potential for developing a weather index that matches crop yields.

During a short mission, it is difficult to thoroughly judge all of these preconditions. The assessment of data is constrained by that quality and amount of data that were successfully obtained. Success in obtaining weather data was better than the success in obtaining yield data. This limits the ability to draw strong conclusions. Nonetheless much of any assessment is based on expert judgment as well as data analysis. The value of this process is to provide information for potential next steps—and to avoid costly mistakes associated with moving forward if the prospects for developing sustainable weather insurance markets are severely limited.

Legal and Regulatory Environment

Visits with the insurance regulator in Mali were informative. The preliminary assessment is that the regulatory environment appears to be adequate and willing to handle index-based weather insurance. This is based primarily on the expressed interest from the regulator. No formal legal and regulatory review was done to understand the complexity of using index insurance contracts under current law and regulations.

Organizing the legal aspects of index insurance could potentially be somewhat complicated by a requirement to obtain approvals for new products from a supranational insurance regulatory body.

Acceptance of the Concept by Users

Farmers and operators of MFIs seemed to understand the basic concept of rainfall insurance and provided details about drought events that match normal agronomic patterns for maize and other crops. Thus, the correspondence between their knowledge of weather risk and the concept of weather insurance match well enough to believe that demand for this product may emerge with the proper contracts and market development.

Quality of the Weather Infrastructure

Quite possibly the largest concern that emerged from this brief mission relates to the weather infrastructure. While it appears that Mali has a large number of weather stations, few are currently maintained. The pattern of when these stations went out of service shows that most were discontinued in the late 1980s or early 1990s. Many of these were in service for about 30 years. This would suggest that donor support may have been involved in maintaining this infrastructure which was later discontinued. There are also few operational synoptic stations in the major production regions. For example, south of Bamako, we found that there are only four stations. If the spatial correlation were stronger for the two stations where data were obtained, this may be less of an issue; however, it raises some concerns.

Correlation of Weather Events across Space

During the mission, data from two weather stations, Bougouni and Sikasso, were purchased. Bougouni is approximately 200 km directly west of Sikasso and about 125 km southeast of Bamako. These two stations are in the core area for cereal production. The correlation of cumulative monthly rainfall between Bougouni and Sikasso is strongest in the months of May and June, 52 and 65 percent, respectively. In July, it drops off to 27 percent and in August, to 20 percent. The early months (May and June) demonstrate reasonably strong correlation in rainfall.

Potential for Developing a Weather Index that Matches Crop Yields

Our analysis of the weather data from the two available stations was extensive. What is clear is that the Sikasso region of Mali normally receives a large amount of rainfall, and during the months of July and August it rains, on average, about every other day. The analysis we performed suggests that there are few periods where there is very low rainfall in any 20-day period during the growing season. However, given that drought was clearly mentioned as a major problem, the available data were tested to search for any possible relationships between rainfall shortfalls and yield shortfalls. To identify what might be possible, we organized a monthly rainfall deficit contract for each month between April and August for both weather stations. Even with these data, which represents 10 monthly contracts with the possibility to receive payments, there was very little correlation: neither with national-yield shortfalls nor for a more limited, regional-yield series for maize, sorghum, and millet. These two stations are in the midst of an area responsible for roughly half of the national maize production and 40 percent of sorghum production.

One important reason for these confounding results is that crop yields are strongly conditioned on soil quality. We have learned that soil erosion, poor soil quality with low organic carbon, and poor water infiltration and retention characteristics are of serious concern across large parts of Mali and Africa generally. Limited water infiltration essentially means that rain is largely running off and contributing to surface erosion because moisture holding capacity of the soils is limited. This very likely explains why some farmers also cited the occasional flood, especially in the month of August when rainfall is highest, as a concern. Further, we believe it partially explains the difficulty in finding a correspondence between various rainfall windows and crop yields. To test this further, we examine the correlation between crop yields when they are below normal with rainfall levels for different months and different time periods. These tests are limited by having only two rainfall stations of data and only national crop yields for maize, sorghum, and millet. The correlation results are weak and don't suggest a relationship between rainfall in this key production region and national crop yields. The levels of aggregation may explain the weak relationships. However, one might expect some levels of correlation. This raises an important concern regarding soil infiltration characteristics and intensity of rainfall. If intensity of rainfall becomes a driving variable then the pre-requisite for rainfall index insurance of strong spatial correlation may not be present. A variable like intensity of rainfall is more likely to be idiosyncratic than strongly spatially correlated.

While finding no correlation with these data sets and our concerns regarding the soil conditions do not lead to the conclusion that a rainfall drought insurance contract cannot be properly designed, both of these findings raise the specter that any index rainfall insurance will need to be a complex product potentially reflecting compounding variables like length of time with little or low rainfall, intensity of rainfall, and even some measures to capture flooding. Potentially, with enough data resources, in combination with agronomic modeling that takes into account soil characteristics, it could be possible to fit a rainfall index to the yield data for specific crops. This, however, raises other important considerations related to *basis risk* that results from frequent "over-fitting" and other factors such as the assumption of uniform management practices that underlie many agronomic models. Complex models also increase the difficulty in transferring the basic skills needed to manage the index to local entities once technical assistance has departed. Furthermore, complex models also make it more difficult for smallholders to understand the insurance contract. The current lack of operational rainfall gauging infrastructure also means that it will be difficult to design a product that can serve a meaningful percentage of the farming population. This is particularly troubling if the weather station must also capture more localized conditions like intensity of rainfall or measures of flooding where the spatial correlation breaks down. The basic conclusion regarding developing rainfall-based weather index insurance for Mali is that it will be quite challenging.

Potential of Other Index Approaches

During the mission there were discussions regarding area-yield estimates developed on the basis of the *cercle*, or district, which is composed of communes. The process for estimating these yields involves field cuttings, which is a standard process. If the administrative units where yield estimates are made at small enough geographical levels then there may be the potential to design an area-yield insurance product. The reason why area-yield contracts are interesting is because the yield estimates could capture many complex weather events and other interactions such as with soils. If data have been estimated for 20 or more years, and if the quality and methods used are deemed to be acceptable and consistent during those years, developing an area-yield contract may be possible. An area yield insurance product could be suitable for individual farmers as well as MFIs and other agricultural lenders. Area-yield contracts, like weather index contracts, also preserve and even enhance incentives for farmers to improve their management knowledge and practices. Unfortunately, it has been difficult to get a good sense of the quality of the yield estimates. The length of the data series also appears limited, 15 years at the regional level and even more restrictive at levels of observation needed to avoid significant basis risk.

A second type of index approach that could be considered is one based on satellite remote sensing. One index that has applicability to drought detection is the Normalized Difference Vegetation Index (NDVI). The NDVI is based on the principle that vegetation that is actively growing and photosynthesizing absorbs certain wavelengths while reflecting others. A time series of NDVI values can be used to establish an average or normal value for vegetative health at a given geographic level and at a well-defined period in time. Subsequent values of the index can be compared to the norm to detect below-average plant growth, which is most commonly associated with moisture availability. An index based on remote sensing is most appropriate for risk aggregators, such as agricultural lenders, rather than individual farmers. While attractive in principle, remote sensing indexes still require significant start-up costs, calibration of index values with yields, and finally a correspondence to some measure of insurable interest on the part of risk aggregators. In general, remote sensing indexes of this type are best for detecting pervasive drought events rather than identifying localized and mild drought.

INTRODUCTION AND BACKGROUND TO THE PREFEASIBILITY ANALYSIS

To begin answering questions about the potential for index-based weather insurance in Mali, Save the Children with support from USAID and an Anonymous Donor commissioned a prefeasibility study to examine if the basic conditions exist to support an index-based initiative and to gauge the level of interest and support among key local stakeholders for index insurance. This prefeasibility study focuses primarily on the Sikasso region (see Figure 1), situated to the south of the capital city Bamako, where climatic conditions are generally favorable to agriculture and where MFIs and other lenders have concentrated their efforts. Detailed weather information was collected for the Bougouni and Sikasso *cercles*.[1] Efforts were also made to also obtain cropping specific information for these areas.

Around 70 percent of Mali's population depends on farming for their livelihoods. These are smallholder farms that are mostly farmed with hand labor under various climate conditions that vary from desert in the north to subtropical in the south. While cotton has been a major cash crop, the export of cotton has fallen on hard times globally, and significant adjustments are occurring. Switching from cotton to maize offers an opportunity for progress and improved well-being.

For many years the focus of rural financial market development in developing economies has been directed toward savings and credit institutions. The lack of credit for seasonal production needs and long-term investments is seen as the primary constraint to development of the agricultural sector and its

Figure 1: Location of Sikasso region

[1] The cercle is an administrative unit, a subset of a region, composed of communes, each of which includes numerous villages.

contribution to overall economic growth. In Mali, there are a variety of participants in the agricultural lending market for smallholder farmers including commercial banks and microfinance institutions (MFIs) operating under a variety of different charters. However, there remain many areas where agricultural lending is largely missing and it is estimated that less than 2 percent of rural households have access to formal credit channels (World Bank, 2008). Further, there appears to be a lack of depth in credit products for the majority of smallholders, such as for medium to long-term investment, due in part to regulatory impediments, lack of sufficient or appropriate collateral among rural borrowers, and a perceived high level of risk in agricultural lending. Without the opportunity to gain access to credit and savings, farmers are unlikely to adopt new technologies that can increase productivity and income. Highly risk-averse farmers typically use investment and production strategies that involve low-risk and low-returns.

By all accounts, there is a great deal of unmet demand for agricultural lending. Enterprising MFIs and banks are expanding their network of agents and "caisse" especially into favorable production environments. However, mindful of the problems associated with lending to a narrow client base (i.e., following the collapse of the cotton market and associated loan default), most are aiming at diversifying their portfolios among crop lines and rebalancing their portfolios between agricultural and small-scale "commercialization" (petty trade) lending, the latter of which is generally seen as being more profitable. For some MFIs, opportunities for lending to agriculture have followed rural lending for commercialization activities, which involve quite a different cycle of lending and repayment. Agricultural lending requires patience as farmers borrow for inputs at planting time and are generally unable to pay off the debt until harvest, which can be more than 90 days later. Microfinance has been most successful when the borrower can make small payments on a regular basis.

In regard to credit market expansion, rural lenders in Mali have encountered their own special problems of credit rationing and capital constraints, especially the MFIs who often borrow from commercial banks or who rely on non-governmental organizations (NGOs) to generate capital to fund their lending activities. Lenders retaining a large portfolio of undiversifiable agricultural loans simply carry too much risk as many of the borrowers can be negatively affected by the same event at the same time, such as extreme drought or price shocks. Lenders facing these types of correlated risk circumstances have difficulties in attracting capital. Again, this partly explains why lenders are working to diversify their lending to the non-farm sector.

The use of innovative weather risk transfer mechanisms for agricultural risk is being presented as one possible opportunity to attract additional capital providers by better addressing their tolerance for risk. Index-based insurance has captured the attention of many development agencies and NGOs as a possible means to deliver affordable and cost effective catastrophe weather insurance to poor smallholder agricultural producers and/or to partially indemnify the agricultural portfolios of lenders. Traditional indemnity-based agricultural insurance structures have proven to be commercially unsustainable largely due to the classic problems of adverse selection and moral hazard and the associated high cost of information required to monitor and administer insurance that attempts to pay for individual farm losses. These problems are compounded in developing countries that are dominated by large numbers of small farms. Much of the monitoring and administration costs are fixed for these programs which drive the unit cost to extreme levels for small farms. Index-based insurance, which relies on an independent external index that serves as a proxy for loss, is seen as a viable alternative since it requires far less information and there is little opportunity for adverse selection and moral hazard. Fundamentally, index-based insurance foregoes the high cost of loss adjustment on the individual farm. The appropriate blending of commercially sustainable risk transfer mechanisms such as index-based weather insurance with existing credit and savings activities is one step in the development of more complete and efficient rural financial markets to serve the needs of the poor.

MAJOR FEATURES OF MALIAN AGRICULTURE

The structure of the Malian economy, with heavy dependence on agriculture and a handful of export activities, is typical of a developing economy. Agriculture, livestock, and fisheries contribute ~36 percent of domestic output while cotton, livestock, and gold account for greater than 80 percent of export earnings. With a population just over 12 million, agriculture absorbs nearly 70 percent of the labor force, with the majority dominated by small-scale traditional and subsistence farming (US Department of State, 2008; FAO 2008).

Only the southern part of the country, about 45 percent of the land area, is suited for agricultural activities and can be characterized as agro-pastoral. The northern part of the country is either desert or arid and is characterized predominantly by nomadic and transhumant pastoralism. Principle agricultural crops include millet, sorghum, maize, rice, cotton, and sugarcane. Other agricultural crops and products include cassava, sweet potato, fonio, peanuts, cowpea, shea nut, as well as a variety of fruits and vegetables. Production intensity is fairly low and evenly distributed across the southern zone, with the exception of small pockets of higher intensity farming, mainly of cotton and irrigated rice (Figure 2). Overall, only small percentage of the land area is cultivated and cereal production is of a subsistence nature for approximately 90 percent of farming households.

Smallholders still largely depend on manual labor technologies for agricultural production. Land preparation, planting, fertilization, weeding, and harvest are accomplished using simple hand tools and extended family and village labor, although labor is sometimes hired especially for field preparation tasks when the timing of planting is more critical. Draft animal traction and mechanization (tractor and disc harrow or disc plough) are sometimes available for primary tillage. Average farm size among households varies by location and the degree of mechanization.

In the south, the size of unequipped farms ranges from 4–5 hectares and of farms equipped with animal traction or mechanization, up to 27 hectares. In the west, farm holdings range from 2 to 7 hectares. The land tenure system is governed by both national and traditional law. While all lands belong to the state, legal changes have allowed for private title. In rural areas, however, traditional collective law dominates with land use and allocation is under the jurisdiction of a village chief (Coulibaly, 2002).

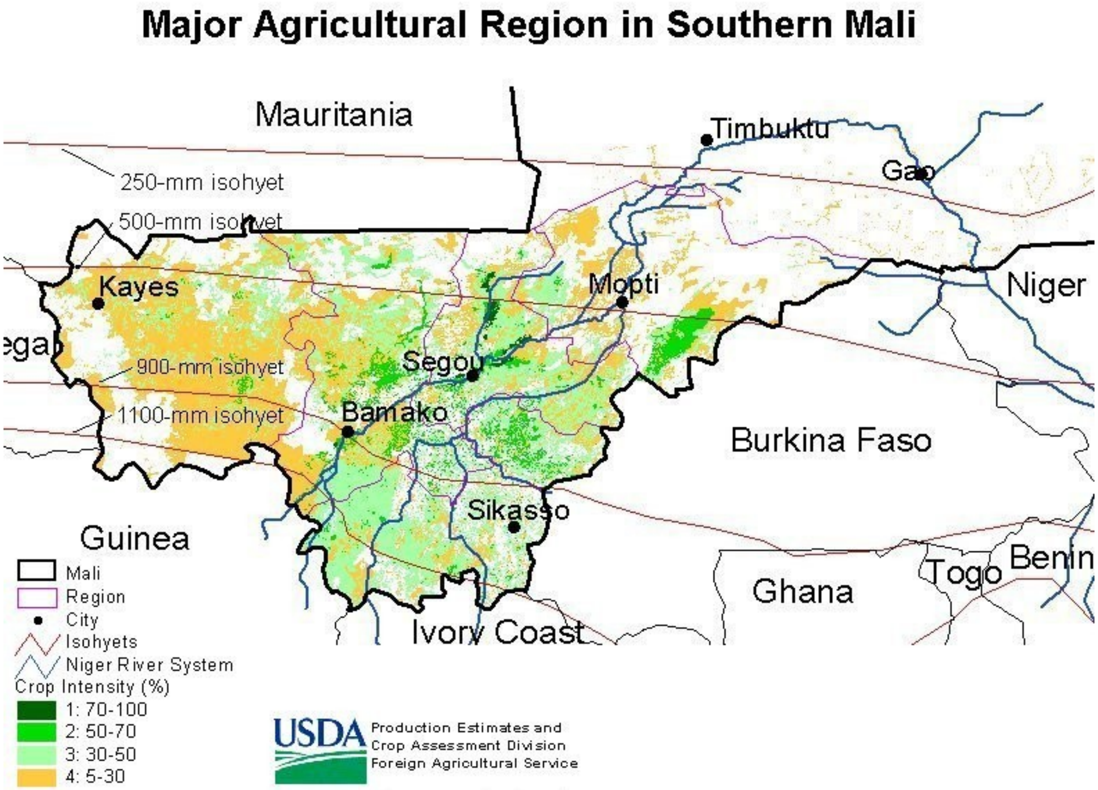

Figure 2: Crop intensity
Source: USDA, 2001

The essential topography of Malian agriculture is well-summarized by the FEWS NET livelihood definitions in combination with agro-ecological zones which groups regions on the basis of similar soils, rainfall, and vegetation (Figure 3). The dominant characteristic of Mali's agro-ecological zones is the great variation in annual rainfall between the north and south of the country which ranges from less than 200 mm to as much as 1,200 mm annually (see insert, Figure 3). Also evident are a number of smaller specialized and more intensive cropping areas coinciding with the natural ebb and flow of the Niger River and its inland delta. In one of these areas, the Office du Niger, state-supported efforts have existed since 1932 to develop the irrigation and rice production potential in the Niger River delta and covers in excess of 138,000 ha.

Over half of the country's millet production is centered in the Sudan zone while the majority of sorghum and maize and cotton production is further south. Figure 4 gives a snapshot of the crop distribution and diversification activities for the Bougouni cercle. Bougouni lies in the North Guinea zone of Sikasso region and is the location of an important rainfall gauging station from which data were obtained. The crop proportions reported for Bougouni cercle reflect what farmers in the area described during interviews and reveal their heavy reliance on millet and sorghum, both relatively low-input, low-return crops in their livelihood strategies. (For details of the geographic orientation and administrative units composing Bougouni cercle, see Appendix A.)

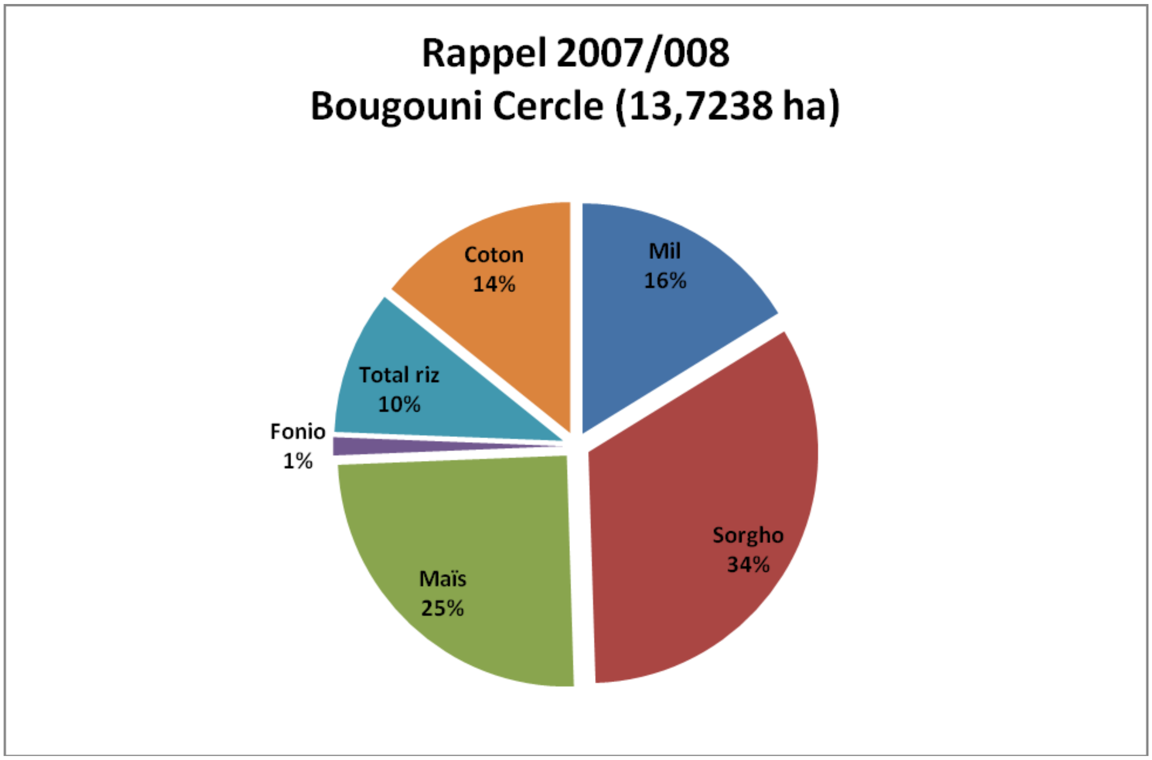

Figure 4: Crop distribution, Bougouni, 2007/2008

Rainfall Topography, Crop Calendar, and Soil Characteristics

Agricultural activity is tied to total annual rainfall (Figure 5) and the commencement of the rainy season which, in areas to the south, begins in mid-May and lasts for 120–180 days depending on the zone. The southern half of the country is the primary region for cereals production and has generated surpluses during the last several years due to favorable climatic conditions. Figure 6 combines a generalized cropping calendar with the annual rainfall topography measured at the Bougouni gauging station from 1978 to 2007. This represents the average rainfall situation against which farmers make their planning decisions. For successful cereals production, the timing of early season rain is important for plant establishment while later in the season total available moisture becomes more important for yield realization. In this region, planting usually takes place in late May or early June, after sufficient rainfall makes the soil workable. Monthly rainfall peaks in August and total cumulative rainfall is just less than 1,200 mm.

Agricultural productivity is only partly dependent on rainfall. Soil fertility and physical soil characteristics such as permeability, texture, and water-holding capacity are critical in defining soil water availability and nutrients in the root zone. Soil quality across Africa has been in decline for and is known to be moderately to seriously degraded, particularly in continuously cropped areas (Smaling et al., 2006;

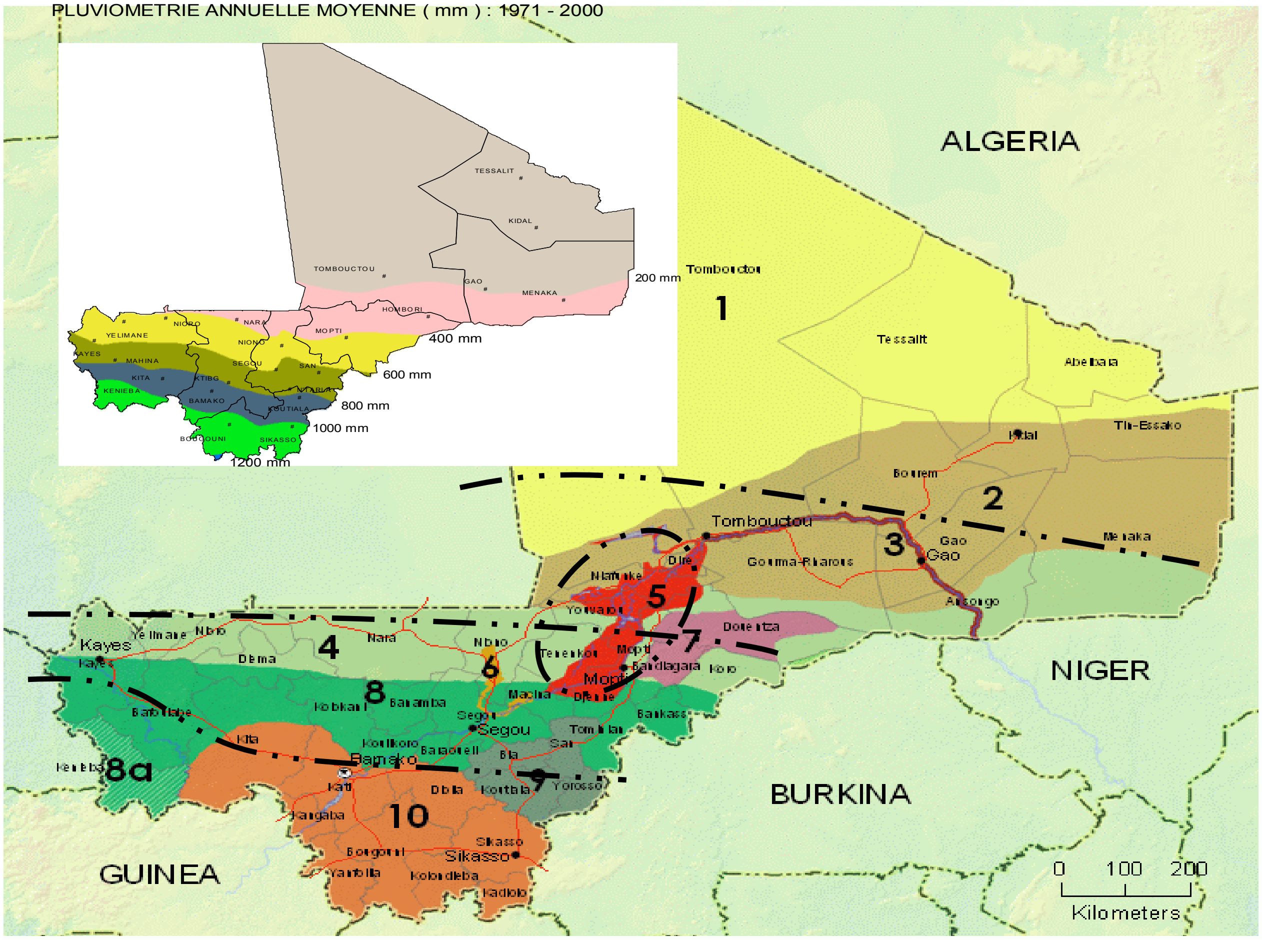

Figure 3: Agro-ecological units and livelihood zones

Saharan Zone:	Hyper-arid and desert aggravated by the harmattan. Rainfall is low and random (>250mm annually) with high temperatures with large fluctuations between night and day. Skeletal soils having poor water holding capacity.			
	1	Desert	**2**	Nomadic and transhumant pastoralism
Sahel Zone:	Arid with annual rainfall between 250 and 550 mm and characterized by a long dry season from 9 to 11 months. Soils are either skeletal or sandy supporting only subsistence agriculture.			
	4	Millet – transhumant herding	**7**	Dagon Plateau: millet, fonio, onions
Sudan Zone:	Semi-arid to sub-humid with rainfall between 550 and 1,100 mm annually. Soils are (i) tropical ferruginous with a clay-enriched subsoil having relatively high native fertility though deficient in Nitrogen and Phosphorus, and (ii) weakly developed mineral soil characteristic of eroding lands.			
	8	Rainfed millet, sorghum	**9**	Millet, sorghum, cotton, cowpeas
North Guinea Zone:	Sub humid climate with rainfall over 1,100mm annually with a rainy season lasting 5 to 7 months. Soils, which are easily exhausted, are clay rich with accumulation of iron oxide.			
	8a	Rainfed millet, sorghum, fruits	**10**	Maize, cotton, fruit
Interior Delta	**5**	Delta lakes: rice, flood retreat sorghum	**6**	Office du Niger: irrigated rice
and River ways:	**3**	Riverine rice – transhumant herding		

Source: Adapted from FEWS NET; Direction Nationale de la Météorologie du Mali; Coulibaly, 2002

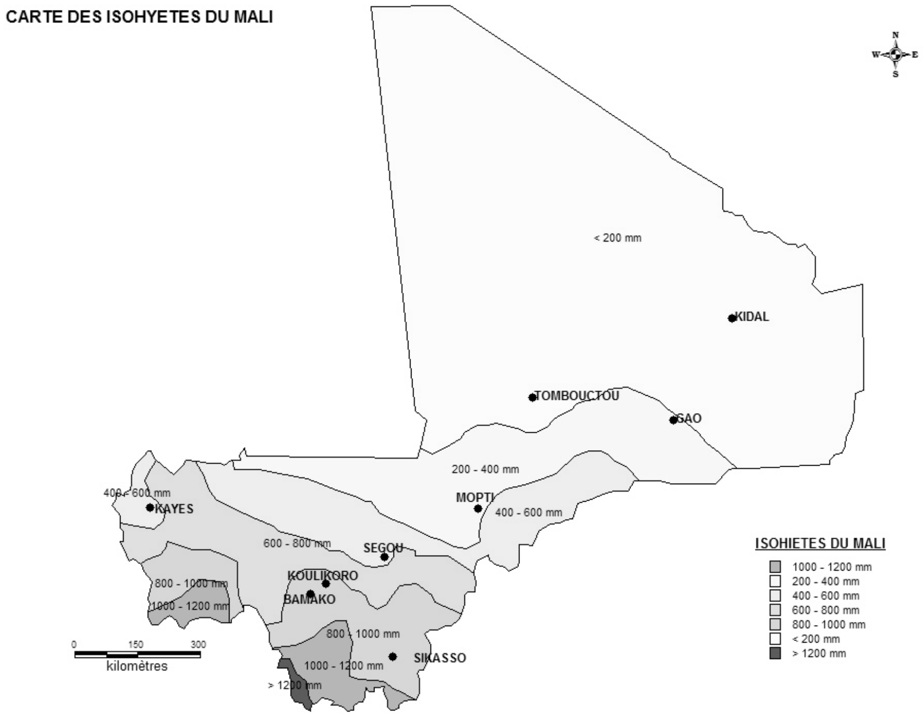

Figure 5: Annual rainfall isohyetal lines

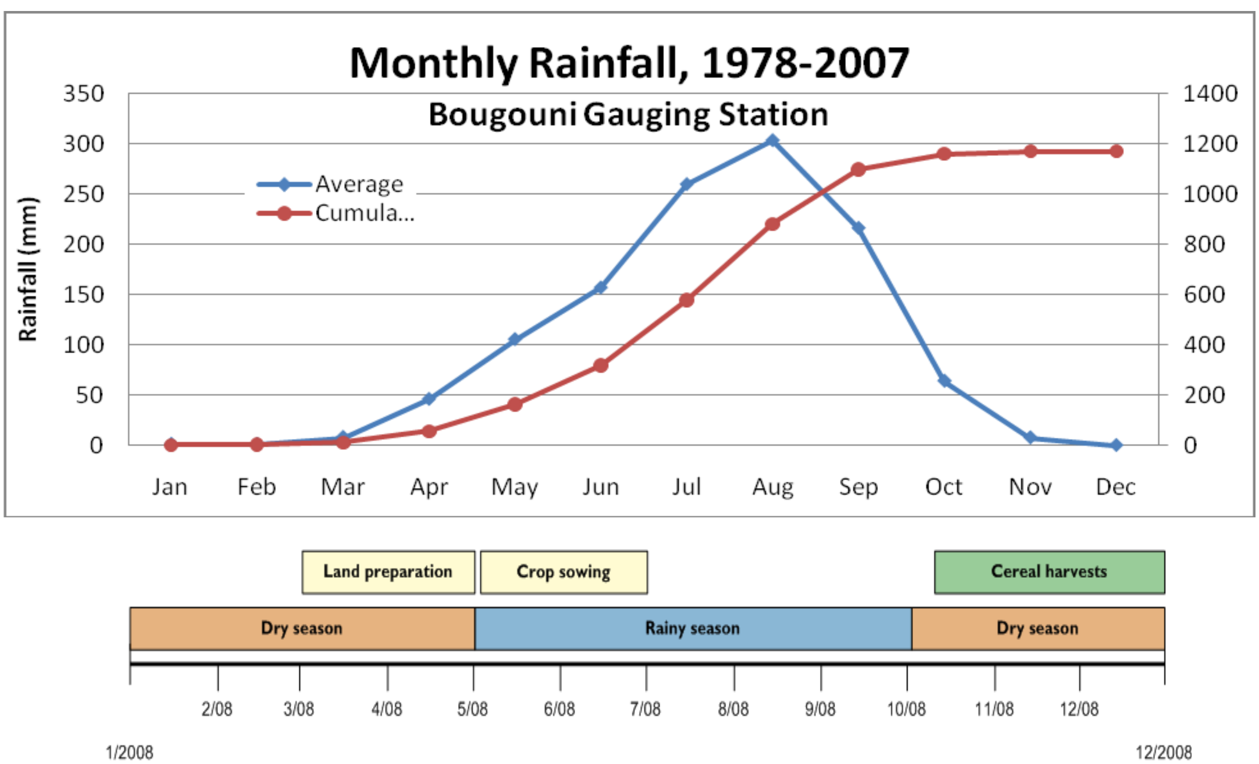

Figure 6: Annual average and cumulative precipitation and crop calendar correspondence
Source: Authors and FEWS NET, 2008

Scherr, 1999).[2] Poor management practices accompanied by erosion have resulted in severe nutrient loss across the continent (figure 7) as well as loss of soil organic matter (Henao and Baanante, 2006; Sanchez, 2002; Donovan and Casey, 1998). Soil organic matter is important for maintaining soil structure water infiltration (Doraiswamy et al., 2005). Low water infiltration and low moisture-holding capacity contributes to erosion and means that plant growth becomes even more dependent on the timing of rainfall since the soil has lost much of its ability to retain moisture between rainfall events. In addition to timing, degraded soils also become more sensitive to rainfall intensity. Easily saturated or low infiltration capacity soils will quickly erode even under a moderately intense rainfall. This condition makes it difficult to use even inorganic fertilizers to improve crop productivity due to the possibility that applications, particularly surface applications, are easily relocated. The implications for agricultural productivity and rural livelihoods are serious: soils removed of organic matter, rather than acting as a buffer, actually cause plant growth to become more sensitive to the timing and intensity of rainfall events during the growing season even if total available moisture is at normal levels. Fundamentally, if intensity of rainfall becomes a driving variable (either because it creates flooding or that such intensity affects the saturation of rain creating more sensitivity to drought conditions even when there is rainfall) then one of the pre-requisites for rainfall index insurance (strong spatial correlation) may also be absent. Rather than having a strong spatial correlation, a variable like intensity of rainfall is more likely to be idiosyncratic.

Cotton Sector Activities

Cotton is produced primarily in the southeast part of the country in the regions of Bamako, Ségou, and Sikasso and is grown on non-irrigated fields. Cotton has played an important role in export earnings. In 2003–2004 Mali became the largest African producer of cotton, supported by the activities of the parastatal Mali Textile Development Company (CMDT) which buys, processes, and sells cotton. Since 2005 however, cotton production has declined following a series of poor harvests, declines in world cotton prices, escalating cost of inputs, and because of delays in payments to producers by CMDT for the cotton it received. CMDT is in the process of restructuring and privatization but this initiative has experienced delays due to debt accumulated by the company and planning difficulties.

In the past it was common practice, particularly among more marginal producers, to use part of the fertilizer obtained from CMDT for other crops, primarily maize, which is highly responsive to fertilizer. Producers abandoning cotton have expanded primarily into sorghum production and only to a limited extent, maize production. The reason for this choice appears to be that the high cost of fertilizer needed for maize production is limiting producers' ability to expand, in contrast to sorghum, a relatively low-input crop.

MFIs, notably Kafo Jiginew, who previously lent to cotton producers, have been diversifying their lending portfolios away from cotton. Soro Yiriwaso, another MFI though with a smaller cotton portfolio, subsequently developed a maize production loan for male farmers that has generated strong demand among former cotton producers.

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[2] Knowledge of the extent of soil types and degradation is also poor. A recent initiative by the International Center for Tropical Agriculture (CIAT) has been launched to update and increase the precision of digitized maps of African soils as an aid to management of soil health, with the ultimate aim of increasing the productivity of agriculture. http://www.globalsoilmap.net/

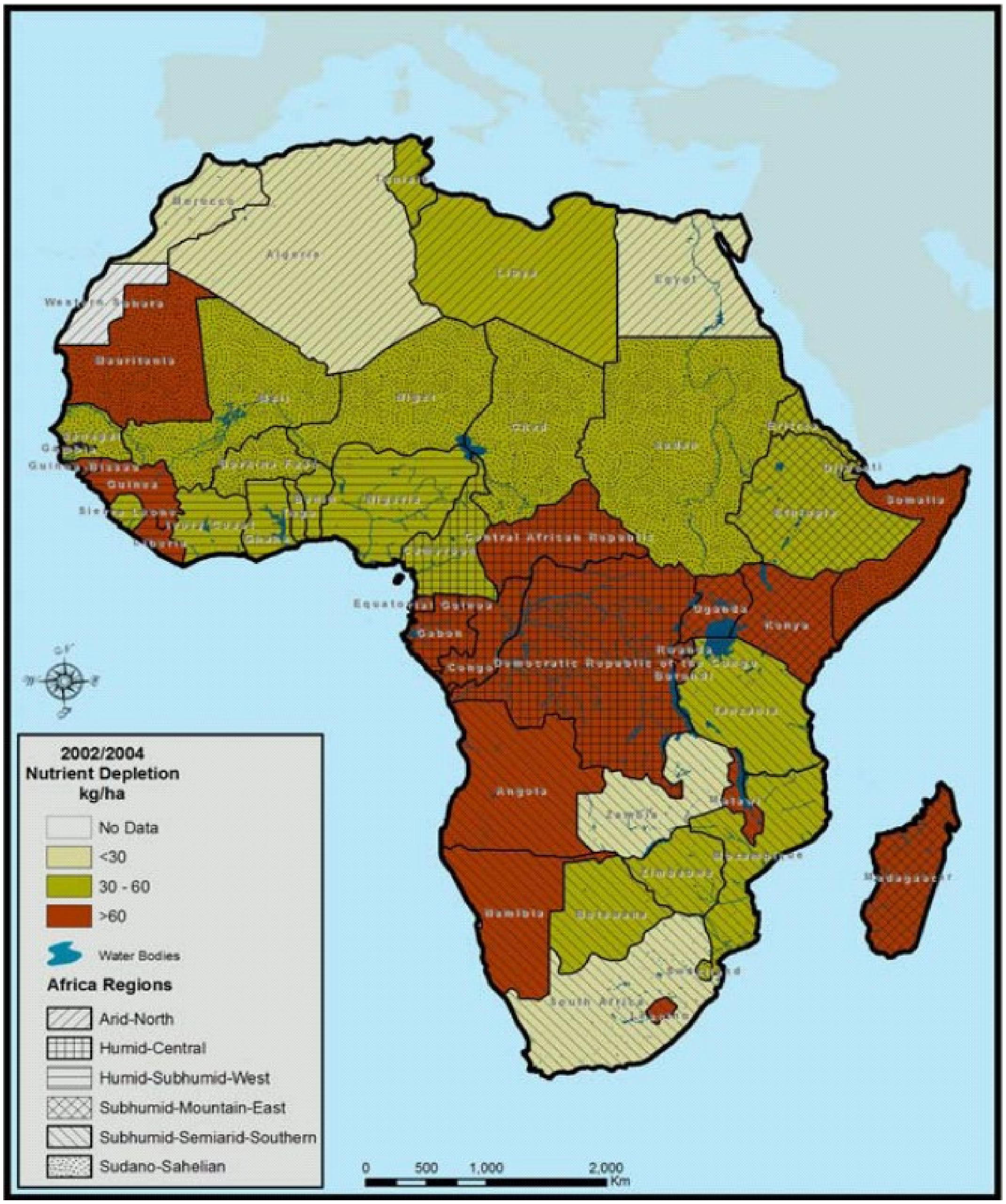


Figure 7: Nutrient depletion across Africa, 2002–2004

Source: Henao and Baanante, 2006

Recent Experience with Agricultural Insurance in Africa

This section outlines lessons learned from the experiences with index insurance pilot programs in Malawi and Ethiopia and the preliminary results of a weather index insurance feasibility study conducted by the World Bank in Senegal. The two pilots demonstrate the diverse applications of weather index insurance. In the case of Malawi, the product is primarily designed for individual farmers, while in Ethiopia, the insurance was designed to aid the government's response to a serious regional drought. The cases also illustrate the approaches possible given different conditions of weather infrastructure and yield information. The two case studies profiling these pilot programs are included in Appendix C.

Malawi: Lessons Learned

The drought index insurance product developed in Malawi is bundled with a loan and a specific input package that has improved seed. Without the associated drought index insurance, farmers would not be offered credit to purchase the improved seed varieties. The weather index insurance protects the loan from drought risk as the lender is the one who receives any insurance indemnity.

Enhancing Linkages in the Value Chain. The Malawi pilot project has required a great deal of resources; however, it is an excellent example of working with farmer organizations, lenders, and an input supplier, and should remain a case study for improving linkages in the value chain for stakeholders considering using index insurance in new contexts. An important consideration for these linkages is that it must be clear that the insurance company is holding the weather risks and not the lender. The revelation that some groundnut farmers were side-selling and defaulting on their loans is quite an important lesson for working in the value chain. Because of this problem, the weather index insurance was switched to tobacco, a crop for which farmers use forward contracts. Considerations of possible moral hazard problems and taking advantage of already developed partnerships in the value chain should be important for any future index insurance product working to enhance value chain activities.

Product Design. One concern associated with weather index insurance products targeted to specific crops, as was done in Malawi, is that farmers can have the mistaken impression that these products are substitutes for traditional crop yield insurance policies. The educational and marketing efforts that must accompany these products are quite important.

Another concern is that, given that field-level, crop-yield data are nearly nonexistent in most African settings, insurance product designers generally use plant growth simulation models that link rainfall or soil moisture to the plant growth process. While this may seem an appealing approach to finding a solution to data availability problems, several cautions are in order. First, these models assume that all farmers are using the same production methods and are farming the same type of soil. This assumption is questionable given the variety of farming techniques and soils in many regions of Africa. Second, these models may rely on limited or unsecured weather and crop data with missing values. These data are less likely to estimate extreme crop losses accurately. Finally, in some cases, these index insurance products are designed to insure moderate declines in crop yields, potentially creating more misunderstanding of their potential value if basis risk remains high. In short, these models can over-fit the weather index insurance product to the available data, leading product designers to overestimate the effectiveness of their design as a proxy for household-level losses.

Capacity Building and Commitment of Local Partners. Some reports indicate the insurance company partners in Malawi have not yet taken ownership over the index insurance program, and are waiting to learn from several years of pilot testing before committing more fully to sustaining and expanding the program. The World Bank project team has been very heavily involved in insurance market development and the insurance companies may not have the capacity to manage and expand the program, especially given the complicated product development methods using plant growth simulation described above. This finding strongly supports the recommendation that appropriate insurance partners, who are willing to commit to the program financially in its development stages, are key to program development. Additionally, it highlights the importance of building capacity among local insurers and allowing them to play an integral role in important program decisions. If local insurance partners are unable or unwilling to manage the insurance program after a time, the progress made by any project team is unsustainable.

Importance of Weather Station Infrastructure. Malawi was chosen for a weather index insurance pilot because its infrastructure of 22 government-supported weather stations is one of the strongest in the region (Hess and Syroka, 2005). This weather station infrastructure, plus planned additional investments in rain gauges, may make feasible the scaling up of weather index insurance to the national level. As Malawi appears to have a better infrastructure of weather stations than many African countries, we would not recommend attempting to replicate a Malawi-type insurance product in countries with less-developed weather station infrastructure. Instead, products that rely on aggregated data will be more feasible in those regions; however, using aggregated data may limit development of weather index insurance products that attempt to insure against household-level yield losses for specific crops.

Ethiopia: Lessons Learned

In 2006, the World Food Programme (WFP) purchased weather index insurance against extreme drought for regions of Ethiopia during its agricultural season. The WFP would use payments to fund some of the relief aid for food insecure households and needy agricultural producers if extreme drought occurred.

Ex ante Financing for Disaster Relief. The WFP pilot is an example of the expansion of formal *ex ante* risk financing in developing countries and could be a model for future macro-level risk management planning. Careful planning of how these funds will be distributed in the event of a disaster is also needed. Early and timely payouts would likely be of interest to a number of governments and donors. In particular, these products could be used to insure against subregional disasters that fail to capture media attention and most likely these places fail to receive relief from the international community.

Weather Data Constraints. When products are designed for regional or subregional levels, weather data needs are greatly reduced. Payouts could be based on an aggregate of rainfall station data (as was done in the WFP pilot) or satellite data. Thus, even in regions with very little weather station infrastructure, developing a food security index insurance product may be feasible.

Protection against Localized Price Shocks. Additionally, insuring against subregional disasters may also be effective for localized price shocks. When local markets are not highly integrated, insuring against weather yields on the regional level may hedge against commodity price spikes that are created by localized shortages. In regions where drought is a major risk and markets are not well-integrated, a drought index insurance contract purchased by the government or a donor could fund the costs of bringing food relief into the stricken region in a timely fashion. Alternatively, if this insurance product were injecting cash into a subregion with inadequate food supplies, food prices may increase enough for markets to overcome the high transport costs and to sell commodities in the food insecure region. In other words given the infusion of cash, the need resulting from food shortages could potentially be met through arbitrage within the country. It should be clear that such contracts are limited — they will not protect against global price spikes.

Senegal: Feasibility Assessment

Agricultural production in Senegal is largely rainfed. In some regions, drought risk limits farmer access to the value chain — inputs and credit, in particular. The government of Senegal (GoS), with support of the

World Bank, is pursuing agricultural insurance market development to address this problem. In 2007, the World Bank initiated feasibility assessments of weather index insurance for the groundnut value chain. These assessments indicated weather index insurance is likely feasible for two of the three regions assessed, and a drought product was designed for the pilots in the two feasible areas. In the pilot areas, the GoS is working to enhance the value chain for groundnut and integrate weather index insurance market development into this framework. The World Bank identifies challenges for market development including determining appropriate delivery channels, capacity building needs, regulatory issues, and identifying a suitable insurance partner. Complicating the task of finding a suitable insurance partner is the plan of the GoS to develop a National Agricultural Insurance Company (NAIC) and possibly offer area-yield insurance. Private-sector insurers seem unwilling to commit to a weather index insurance pilot until clarity regarding the NAIC is reached. Currently, decision-makers seem to be continuing to clarify the potential role for drought insurance in the agricultural insurance market development policies of the GoS (CRMG, 2008).

Agricultural Risk Identification

As is typically the case for agriculture, climatic conditions in Mali and much of the Sahel is the main source of production risk and food insecurity. Drought and erratic rainfall are the primary sources of concern throughout the rainfall zones. The impact of precipitation irregularity increases as one moves northward through the precipitation bands of decreasing total annual rainfall during the rainy season. While agriculture producers have adopted production choices generally suitable to the average rainfall conditions in each precipitation zone, there is substantial inter-year variability in precipitation that can negatively affect crop yields.

Agricultural producers and other stakeholders were asked to rank which agricultural crops or activities concerned them most in terms of weather risk and rainfall, in particular. They were asked to consider this question generally in terms of agricultural activities taking place in the southern region of Sikasso. Maize was identified as the most vulnerable and important component in their livelihood strategies. Other important crops such as millet and sorghum were seen as more flexible with regard to planting dates and hardiness to drought conditions. Millet and sorghum also require lower production costs especially as they are often, though not always, unfertilized. As described by local farmers, the attractive feature of maize was that in a good year, and with proper fertilizer applications, yields and thus total production were much higher than other cropping choices. Farmers also prefer to grow maize as production in excess of consumption is easily marketed. Still, given that maize requires higher input requirements, production loans are critical if farmers are to grow maize. Crop failure due to drought makes it more difficult to repay loans.

Agricultural producers and other stakeholders were asked to more fully describe drought situations that create production losses or increase production costs. Two main periods of vulnerability were identified:

1. Delay in the onset of the rainy season or erratic and lower than normal precipitation in the early rainy season contributes to difficulties in successful plant emergence and establishment. Farmers identified the establishment period as June and July. In addition, they pointed out that early season rain occurring in May is also important for soil preparation. Farmers usually replanted if the crop failed during the establishment period. This increased production costs by 50–60 percent for maize.

2. Lack of sufficient rain, or long periods between rains, roughly for the months of July and August were identified as critical to a successful production season. This period corresponds to the flowering and kernel/seed development of many crops, and maize yield is especially sensitive during this period to moisture stress. Farmers emphasized that failure of the crop during this period is especially of concern since there is no chance of replanting.

Rainfall variability or shortfalls at particular critical growing periods, not necessarily total annual rainfall, is the characteristic of drought risk that matters most for agricultural producers. Figure 8 shows the distribution of monthly annual rainfall using box and whisker plots for rainfall measures taken at the Bougouni rainfall station from 1978 to 2007. Clearly, during the critical periods identified, there are multiple examples of rainfall shortages, as well as extreme rainfall events. Many of the plots of the monthly distributions are negatively skewed with considerable probability of lower than average rainfall.

Descriptions provided by farmers regarding rainfall effects on maize yields correspond well with the agronomic literature on maize production. For example, yield reduction in maize due to drought is most dramatic during the late vegetative and early reproductive stages where the total reduction over a 15-day period can be as much as 50 percent. This increases the likelihood that farmers would respond favorable to a well-designed index-based rainfall insurance product. A first condition for demand for such products is that farmers understand the underlying process that contributed to yield shortfalls.

While drought and erratic rainfall are the most commonly cited risks among stakeholders interviewed during the prefeasibility study, other hazards and market conditions were also identified. Consistent with concerns about the timing of precipitation, excess rainfall is also of concern particularly during critical growing stages such as during maize tasseling where a once-off heavy rainfall can negatively affect successful pollination. Heavy rains and localized flooding can wash away fertilizer applications and contribute to physical crop destruction. Locust infestations are also mentioned as a concern which has prompted monitoring and control efforts on the part of the government, but this hazard was always seen as secondary to drought concerns. Input prices affect production outcomes in important ways. For example, high fertilizer prices in the 2008 growing season limited the application rates on maize which contributed to lower yields. Lack of capital and the high price of insecticides sometimes make a timely response to crop pest infestations difficult. Weed control was mentioned as source of concern as well as occasional direct crop destruction by birds and other animals. Constraints to labor availability for initial field preparation are also sometimes encountered.

Ideally, an index-based insurance for catastrophic drought risk should be useful across several crop types. To investigate this possibility, aggregate yields for maize, millet, and sorghum were obtained to examine if there are broad correlations between crop types and specific years when there are serious yield shortfalls in common. Figure 9 depicts the detrended yields of major crops to help isolate yield variability. When using yield measures at this level of aggregation, one can be reasonably certain that substantial yield shortfalls are due to broad impacts such as drought, rather than location-specific factors or management practices.

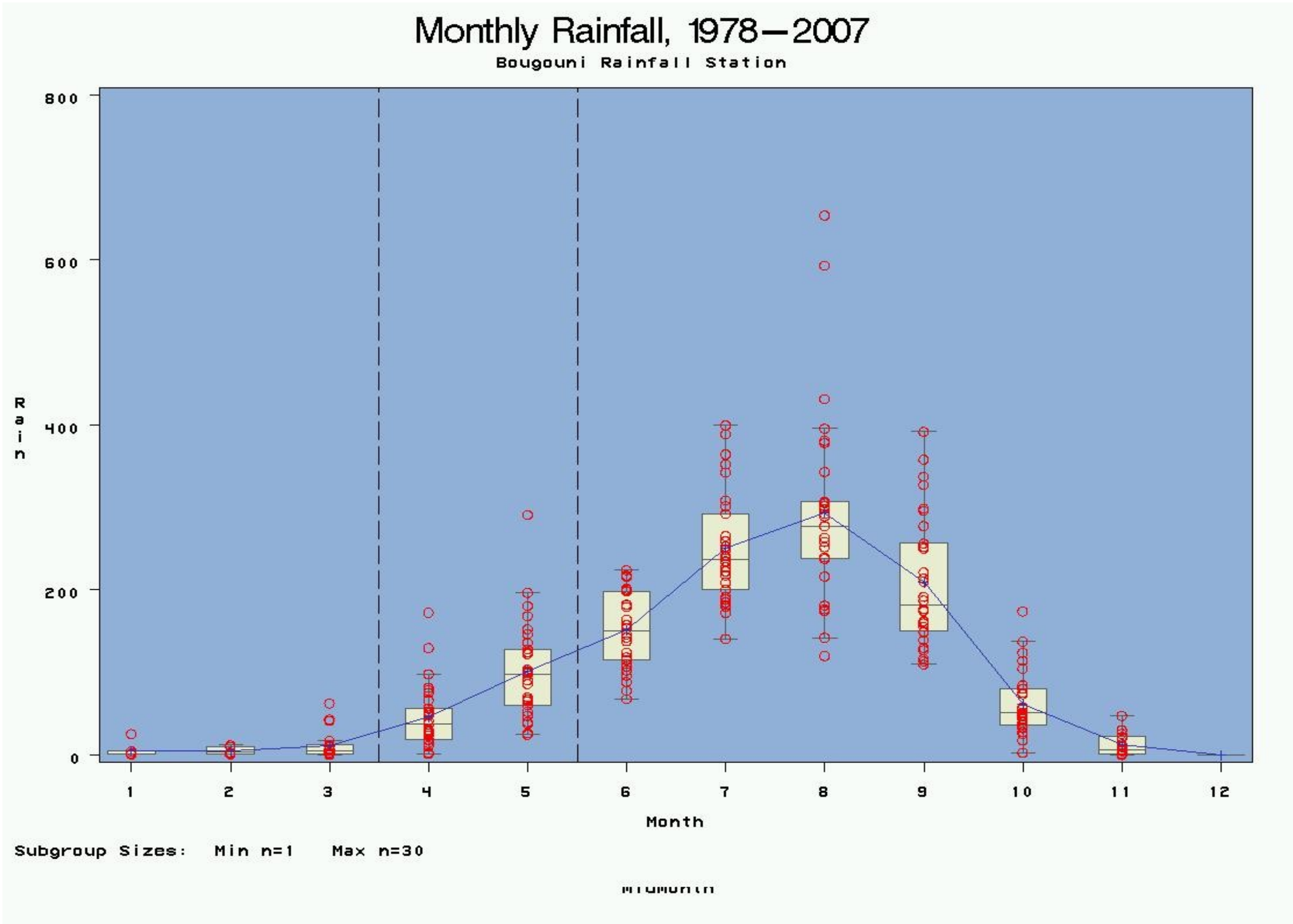


Figure 8: Monthly rainfall distribution, 1978–2007

Table 2 reports the simple correlation of detrended historical aggregate crop yields as well as yields from Sikasso region, but using only 10 years of data. At the aggregate level, strong correlation is found between yields of millet and sorghum which is reasonable given their similar habits and common cultivation practices. Detrended maize yields are less strongly associated with other crops. Rice has only weak correlation which is likely due to its being irrigated. From the series, the years 1977, 1992, and 2002 are identified where yields of maize, millet, and sorghum are negatively affected at the same time. These are important indicators, as they represent those years when crop diversification activities would generally fail in providing the intended risk mitigation benefits. At the regional level, maize is strongly correlated with millet and sorghum yields while the latter two show less correlation. Rice is also correlated with the other crops which may be because rice in this zone is often planted in natural low-lying areas which capture and retain rainfall, rather than being irrigated. Fonio, in this region, is negatively correlated with yields of other crops, suggesting that perhaps it thrives better in a slightly dryer climate, and makes it a useful choice in household food security risk management.

Market Development Preconditions

For weather index insurance to be considered potentially viable, a number of minimum criteria should be met. Some of the institutional needs for weather index insurance can be developed or enhanced during the market development, such as strengthening the regulatory environment through capacity building and technical assistance. However, there are some other criteria that if missing may make it unwise to pursue any further development of index insurance, including the next step which must be a full feasibility study. The following are initial findings regarding each of the prefeasibility criteria:

Weather Event Creates Correlated Losses

Index insurance relies on a measurable variable that indicates the occurrence of an event that is likely to cause large losses for many households. Information gained from stakeholders, farm interviews, and third party monitoring organizations suggest that widespread drought, as well as rainfall shortfalls during key critical time periods, do cause farm household losses, either in terms of increased cost, reduced agricultural output, or both. Broad rainfall patterns across Mali suggest that significant geographic areas can have extreme low levels of rain at the same time. Determining the degree of correlation across geographic space, however, is not a straightforward matter and requires significant empirical observations from as many different locations as possible. While farmers observed, jokingly, that rainfall does show variability from "one side of the field to the next," none indicated that some nearby areas differed significantly from negative rainfall events when considering critical periods of serious shortfall.

Table 1: Farmer and stakeholder identification of problematic production years

Year	Problem Description
1984, 1985	Extensive drought
2002, 2007	Dry in early season and many people had to replant
2003	Too much rain in August
2005	Dry in early season, over all low accumulation; Too much rain in August
2007	Dry in early season, some had to replant twice
General	Beginning of rainy season delayed
General	Sufficient rainfall but timing is critical; High variability

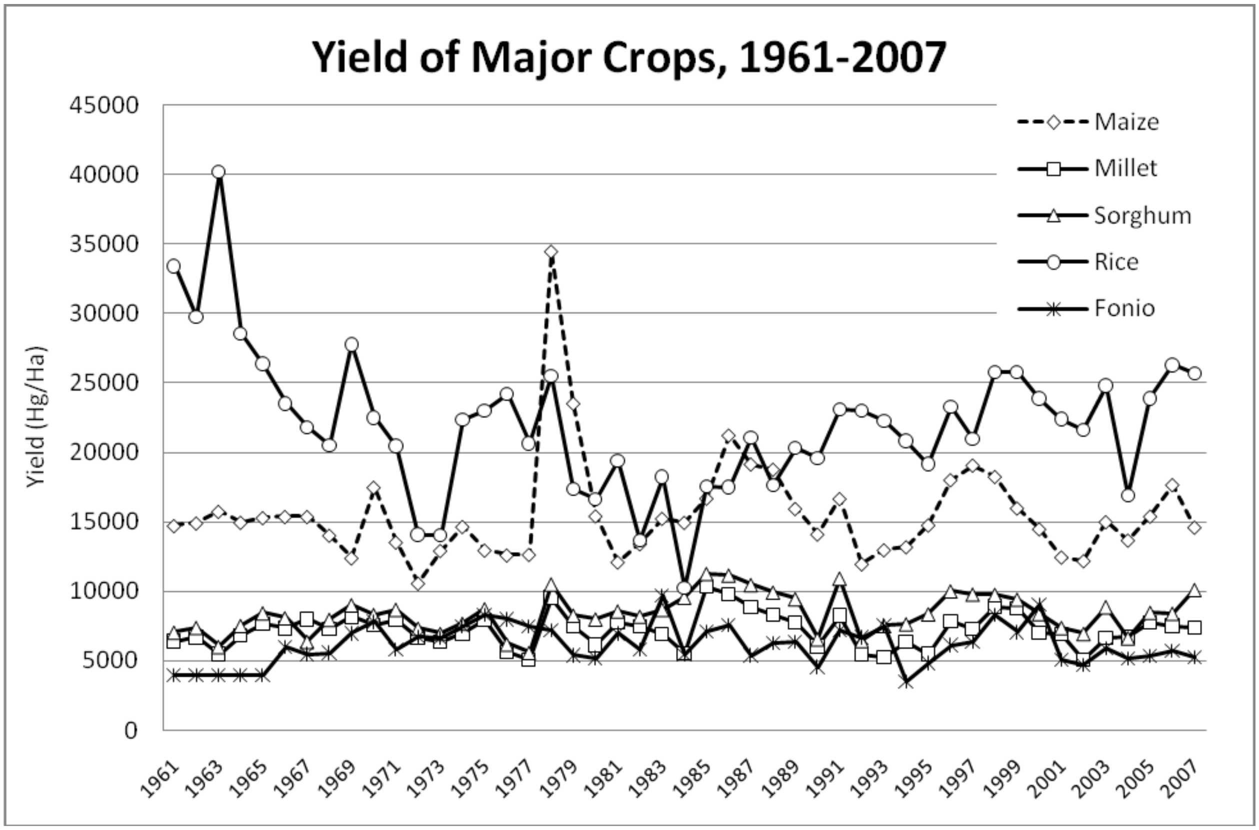


Figure 9: Aggregate yield series of major crops, 1961–2007

Table 2: Yield correlation of national and Sikasso region major crops

(National Yields, 1961–2007)					
	Millet	Sorghum	Maize	Rice	Fonio
Millet	1	0.77	0.55	-0.02	0.28
Sorghum	0.52	1	0.54	-0.17	0.28
Maize	0.78	0.74	1	0.08	0.10
Rice	0.91	0.32	0.68	1	-0.23
Fonio	-0.23	-0.23	-0.19	-0.31	1
(Sikasso Region Yields, 1998–2007)					

While many efforts can be made to construct an index that is highly correlated with crop yields, at the outset it is likely adequate to focus on extreme catastrophic events that everyone agrees will create significant problems for many crops that are growing at the same time. Attempting to cover all of the weather risk should not be the goal in developing a sustainable index insurance market. Paying for poor weather events that occur too frequently will be cost prohibitive. In a feasibility study, it will be critical to learn more about the most extreme weather events that are of the most concern. These events likely affect many crops at the same time as well as pastoral conditions and the well-being of livestock. Saving and lending should be used for the minor risks events and insurance should be used for the major risk events. This issue requires some significant attention given the small number of quality weather stations in Mali. If there is strong correlation in the most extreme years, then it is more likely that a catastrophe insurance product could be introduced with the existing infrastructure. Adding weather stations to provide contracts for small events could quickly become too costly.

Index is a Good Proxy for Loss

If index insurance is to provide effective risk protection, the underlying index must be highly correlated with losses experienced by policyholders. Farm interviews as well as third-party data are used to establish the relationship of an indexed event with production outcomes. Farm interviews show that farmers are aware that precipitation shortfalls during critical growth periods negatively affect yields and are able to recognize when certain management practices might have compounded losses, such as lack of fertilizer applications at appropriate intervals. Some losses, however, cannot be readily captured by the relationship between and the index and yields such as, for example, when erratic rainfall during the early growing season force replanting of the crop which then goes on to generate near-average yields. The additional cost and effort of replanting are true economics costs not necessarily born out in yield data. In this case, the relationship between rainfall during crop emergence and establishment may be a good proxy for economic loss experienced by the farmer. Further investigation would be needed during full feasibility to establish the index thresholds at which these losses begin to accrue. During the prefeasibility mission, efforts were made to obtain both time series rainfall data from the synoptic stations at Bougouni and Sikasso as well as yield data from their surrounding cercles to statistically test correlation between various critical period rainfall indexes and yield outcomes, in particular, the flowering and kernel/seed development phases when water stress is most strong on yields.

Index Data Characteristics

Three primary prefeasibility questions surround the desirable characteristics of the type, source, and methods of a weather variable used for an index insurance product:

1. Event is observable and easily measured with a transparent, objective, and reliable source of data for the index measurement
2. Measurement of weather variable should involve a third party
3. Reliable, historic data exist to price the risk

Rainfall measurements are among the most commonly used for weather index insurance for a number of important reasons. Among the many agro-meteorological variables that can be collected, precipitation measurements are likely the ones with the longest history of observation and the greatest density of observations over a given area. Weather station configuration, standards for measurement, and professionalism in meteorological services are generally well-established.

In Mali, weather station operation is controlled by the Direction Nationale de la Météorologie du Mali (Météo-Mali), a government agency that should meet the test of being a reliable third-party observer with no financial stake in weather insurance outcomes. Météo-Mali requires payment for the use of weather variables in excess of simple handling charges which are used to cover some operating costs, in particular since certain donor funding to support operations has ended. Overall, Météo-Mali appears to be professional and interested in new developments. Determining the likely cost of obtaining historic data and maintaining an active reporting of data must be part of the feasibility assessment. High data cost could negate the potential for developing these products in Mali.

Météo-Mali administers approximately 74 rainfall stations in the main agricultural regions south of Bamako. In this region there are four synoptic stations that collect not only precipitation information but also observations on evaporation, air and soil temperatures, and daylight hours. Observations are made every three hours. Synoptic stations usually have automated rainfall equipment, as was observed on a site visit to the Bougouni city weather station, as well as standard manual rain gauges. Though the automated equipment was in disrepair, the station manager indicated that it would be repaired before the start of the rainy season. Other station categories are agro-climate stations and rainfall stations, both of which collect precipitation measures but differ in the timing of collection. Agro-climate stations make observations three times a day while rainfall stations take observations twice a day.

Operationally, recorded rainfall observations are reported the same or following day to the meteorological center in Bamako. At the end of each month, the meteorological center checks the quality and validates the data, which can take approximately 15 days to complete. Data series length from synoptic stations is the longest among recording sites with approximately 58 years of observations, easily meeting the minimum requirements needed to develop the statistics for insurance pricing purposes. In addition, no missing observations of the rainfall data obtained from the Bougouni and Sikasso stations were indicated.

However, not all the reported stations are currently operational. An inventory of weather stations obtained from Météo-Mali (Appendix C) indicates that approximately only 8 stations are currently reporting. The historical record shows good coverage for the decades 1960–80. However, data reporting becomes more intermittent afterwards which raises an important question of whether the density of reporting stations is sufficient to keep basis risk to a minimal acceptable level and to enable cross-check verification between stations if required. Typically a nearby station is used as a means to provide some backup in the event the core station experiences problems. Nearby stations are also used to check the validity of the core station. Historic data are needed to establish the correlation between the core station and a nearby station for these systems to work. Figure 10 shows the locations of those weather gauging stations currently operational in the south overlaid with rings having a radius of 20 km from the weather station. If one assumes that anything beyond 20 km from the station will have too much basis risk, Figure 10 demonstrates that very little of the cropping area could effectively be insured with weather station data.

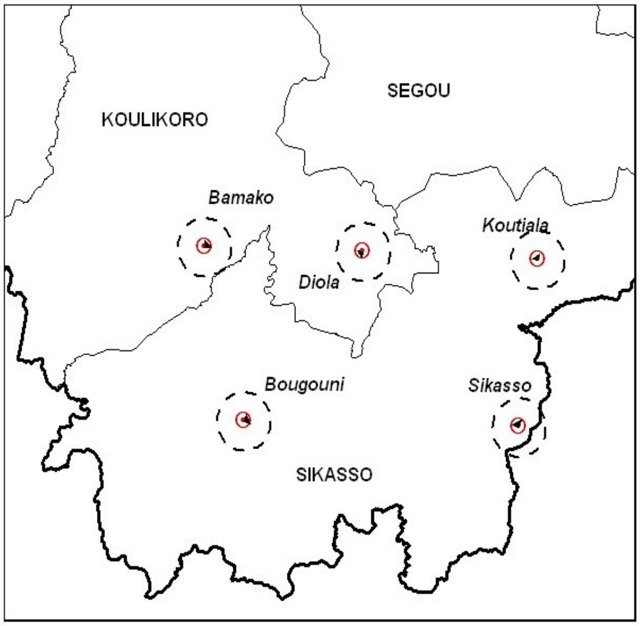


Figure 10: Distribution of weather stations

Enabling and Supportive Regulatory Environment

While a rainfall index product could be developed as a derivative, it is well-established that this is the wrong course in most developing countries. Developing countries are in a much stronger position to regulate insurance markets. Most developing countries have limited or no capacity to regulate derivative markets. During the prefeasibility study the office of the insurance regulator, the Division des Assurances, Direction Nationale du Trésor et de la Compatabilité Publique, was visited to introduce the idea and concept of index insurance and to initiate an open dialogue to gauge, in part, the regulator's willingness to actively review and potentially make revisions in the regulatory structure that may be necessary to facilitate the development of index insurance. In many cases, well-constructed index insurance contracts can be developed within the existing legal and regulatory framework. The Malian regulator was receptive to this innovation and further discussions.

The standard procedure for new product development starts by a domestic insurance company making a request to the insurance regulator with a complete dossier describing the proposed product. In the case of index-based insurance, this dossier should include: 1) a sample contract that fits with the local legal and regulatory framework; 2) a risk assessment and potentially some clear evidence that the insurer can obtain *ex ante* risk financing if the exposure is too great for their capacity (this can involve a reinsurance contract); and 3) a basic actuarial document to show the basis for payment and the methods used to develop premium rates. Given this information, the insurance division can perform their review and make a recommendation to the Minister of Finance. Should the proposal win approval from the minister, it is then submitted to a supranational insurance supervisory body that meets every quarter where it is again reviewed against insurance law for approval.

This supranational regulatory authority, the Commission Régionale de Contrôle des Assurances (CRCA) was created as a component of a 14 West African francophone country treaty establishing the Conférence

Interafricaine des Marchés d'Assurances (CIMA) having the objective to rationalize and aid in the development of insurance markets. The insurance legislation known as the CIMA Code covers both life and non-life insurance business and came into effect in 1995. CIMA authorities are meant to collaborate with national insurance regulators to, among other items, advise member governments, and supervise insurance markets.

Members of the Division des Assurances, including the interim director, appeared at first to be surprised that they were being consulted at this early stage of prefeasibility. There evidently is little tradition of interaction between insurance companies and the Division in advance of the submittal of a request. However, while they suggested that the association of insurance companies would be helpful in understanding the process, they also welcomed the opportunity for a higher level of interaction and education with respect to index insurance. A positive sign of their interest was the attendance of a representative of the Division at the closing workshop of the in-country prefeasibility work. Our experience in other countries reinforces the need to engage the regulator at an early stage.

Acceptance of the Concept by Potential Users

At an early stage, it is difficult to make an assessment of potential users. However, some insights can be gained by considering how potential users currently cope with the events that are being examined. If it is clear that the current systems are costly and inefficient, then it may be possible to infer that demand for index insurance may emerge. Farming households who suffer production or expense setbacks from weather risk that affect their ability to repay production credit loans are seen to delay repayment until other household activities can generate funds needed for repayment. This often involves small-scale commercialization activities (buying and selling of agricultural products) but during an extreme weather event this strategy may also be at risk given that poor crop yields will limit these opportunities. Some households have prior experience with insurance and understand the idea of paying a premium for the potential of an indemnity when things go wrong. Life insurance experience seems to be the most common experience. Given this prior exposure, farmers were asked directly about their preferences for two types of insurance products, one that would indemnify extra production costs from a need to replant, or one that would indemnify potentially large yield losses determined during the flowering stage. Farmers chose the second time period, clearly associating a great deal of value to a catastrophe product. Again, this time period for extremely low levels of rain is likely to affect many crops and other livelihoods strategies as well.

The reaction of MFIs and other lending institutions were more cautious with respect to what might be their response to some form of weather insurance product for agriculture. However, both MFIs and other lenders acknowledged that they view agriculture to be a high-risk sector and that insurance might be helpful. There was some agreement that while agricultural risk linked to weather is one constraint in the rural financial system, there are other factors at play as well. For example, one lender (BNDA) focused much attention on governance issues and difficulties in making a serious credit rating of potential clients or groups of clients. Kafo Jiginew, the largest MFI lender to agriculture, reported that specific spikes in loan non-performance, as much as 15 percent in some locations, were largely due to weather risk and specifically, poor rainfall at the beginning of the rainy season. The year 2005 was specifically mentioned since loan non-performance reached 12 percent across all regions where it operates. Normal loan non-performance rates fall between 3–5 percent. Kafo draws on two different *ad hoc* funds to help cope with the impact of disaster events but claims that these are insufficient compared to the size of agricultural risk.

Soro Yiriwaso managers raised the point that while risk in agricultural lending does exist, they are not necessarily convinced there is established proof that insurance will help improve their ability to raise additional capital to meet the growing demand for agricultural loan products. Soro is a relative newcomer to agricultural lending and so far has not had a serious problem with loan default in its agricultural portfolio.

What is evident from the limited interviews with agricultural lenders is that the value of a weather insurance product for agriculture cannot be effectively and properly valued without a greater emphasis on risk assessment and risk management of their current portfolios. Certainly, risk is acknowledged and incorporated into lending interest rates, into required collateral deposits, and through reserving requirements. But without a more thorough understanding of the weather-related components of risk premiums applied to lending, and with consideration of other choices for risk management, risk transfer may be premature.

Analysis of a Rainfall Index

The analysis of a weather index as a good proxy for correlated losses took the following approach:

- Investigation of spatial correlation of the index.
- Rainfall pattern identification to determine if farmers concerns about drought and rainfall manifestations can be matched.
- Determination of whether particular rainfall events recorded in the data series have high correspondence to the negative variation from aggregate mean yields identified in the data and identified as problematic by farmers. This uses an aggregate crop yield index and assumes that the rainfall event affects many production activities at the same time such that most crop diversification strategies are minimally effective.
  - Prototype contract simulation
  - Correlation analysis
  - Given that maize is identified as the crop whose performance is of most concern among farmers, and given their preference for a type of insurance that would protect against significant yield losses associated with water stress during the reproductive stages, the analysis will try to identify a particular critical window that best captures the impact of rainfall only against maize yields. This represents a crop specific index that, while having limited value for other agricultural activities, could be easily adapted to use by value chain participants of maize.

Correlation across Space

During the mission, data from two synoptic weather stations, Bougouni and Sikasso, were purchased. Bougouni is approximately 200 km directly west of Sikasso and about 125 km southeast of Bamako. These two stations are in the core area for cereal production. A simple correlation of the daily average rainfall between the two stations is 0.87 percent which is surprisingly strong given their distance apart, however they do sit roughly in the same rainfall isohydral (refer to Figure 10). The correlation of cumulative monthly rainfall between Bougouni and Sikasso is strongest in the months of May and June, 52 and 65 percent respectively. In July, it drops off to 27 percent and in August, it is 20 percent. The early months demonstrate reasonably strong correlation in rainfall.

Rainfall Pattern Identification

Daily rainfall data from 1950 to 2007 from Bougouni and Sikasso gauging stations were organized on a 20-day moving average process and superimposed over the normal annual rainfall distributions. The moving average process is used to help readily identify precipitation shortfalls over a length of time that would imply potentially serious drought stress. Figures 11–14 provide examples of years where several different types of abnormal rainfall patterns emerge that might signal production problems. Four general patterns of deviation can be identified:

- Figure 11 (1971) demonstrates a situation where rainfall levels are nearly normal during the height of the rainy season but are quite below average during the beginning and end of the season. Early season shortfalls might imply slow emergence and vegetative growth with an occasional need to replant crops that fail to germinate while the late season shortfalls would contribute to failures of cereals to reach physiological maturity. In looking at the national-level yield data, the impact of this pattern appears to be primarily on maize.

- Figure 12 (1983) demonstrates the situation where rainfall is below normal in an almost uniform fashion that becomes more deficient until late into the growing season. Such a pattern would suggest difficulties in crop establishment as well as potential moisture stress during the reproductive stages when yield potential is determined. The spikes evident at Bougouni station could suggest potential problems if the lows occur during sensitive moisture stress periods or, on the high side, heavy rain might wash soils or cause water logging. National-level yield data show only a small impact on crop yields, suggesting that the timing of rainfall may have as much or more influence on yields than rainfall amount.

- Figure 13 (1984) demonstrates the situation where rainfall begins and ends close to normal but fails to reach potential during the normal height of the rainy season. The impact here would be manifest through moisture stress during the reproductive and early filling stages for cereals. This year was mentioned by farmers as being difficult but yield shortfalls are only recorded for the millet crop.

- Figure 14 (2002), while demonstrating the pattern where rainfall at the height of the rainy season is below normal, also shows a pattern where the start of the rainy season appears to be significantly delayed and somewhat below normal levels. Such a pattern might imply a failure of seed germination and a need to replant. Farmers identified 2002 as a problem year in that the early season dryness caused poor seed germination resulting in a need to replant by many. National-level data also reveal serious yield reductions.

  Interestingly, in none of the years 1950–2007 was there observed a single 20-day period with zero rainfall during the main growing season. This tells us that, unlike some areas in Africa, rainfall is reasonably frequent, even during those years when production problems are encountered. Figure 15 shows the average number of monthly rain days for selected locations in the south of Mali. That the pattern generated by the rain days follows the general rainfall distribution indicates that rainfall is distributed across a number of discrete events, and less likely to be concentrated in only a few single rainfall occurrences. In fact, during the main part of the rainy season, it rains nearly every other day, on average. What is important is that when drought is indicated in this kind of environment it must also be linked in some manner to soil profiles or other mechanisms that prevent available moisture from being effectively captured.

Exploration of Correspondence for Catastrophic Loss

A simple rainfall deficit contract model was developed to identify correspondence between abnormal rainfall events and yield shortfalls. The rainfall model consisted of creating a percentage basis linear payout function on aggregate rainfall for each of the months May through September where the trigger is based on multiples of the standard deviation. The trigger, calculated for each of the five months, was applied to observed aggregate rainfall for each month to arrive at the percentage payout. This was calculated for each of the five months for both Bougouni and Sikasso stations. These monthly results were then summed by station but constrained not to exceed 100 percent. The aggregate rainfall index was then determined by taking the average of the two stations. This index shows those years when monthly aggregate rainfall was below some standard deviation of the norm and can be compared with a yield index to check for correspondence. In fact, this procedure just aggregates ten monthly rainfall contracts, each having the possibility of generating an indemnity payment.

Next, the yield index was created by recording only the negative average percentage shortfalls of each of the major crops maize, millet, and sorghum. Maize was allotted twice the weight in the calculation to capture the importance that farmers placed on the performance of this crop. This index was calculated for the entire national-level yield data, 1961–2007, and for the Sikasso region data, 1998–2007.

As a starting point, there should be, at least, correspondence between rainfall shortfalls and yield shortfalls, though it is possible for there to be more rainfall shortfalls than negative yield impacts. However, the results show a mixed correspondence. Figure 16 juxtaposes the national- and regional-yield index shortfalls alongside the rainfall deficit contract results. What is noticeable is that a good degree of correspondence in the decades of 1960 through mid-1980s does exist, though there are a number of years when the yield index shows some problem wherein the rainfall index contract would not pay. Since 1983, there is virtually no recognizable pattern with few instances where both the rainfall and yield index indicate potential payments during the same year. No improvement is found when comparing rainfall with the regional yield index either, which is particularly disturbing since both rainfall stations are contained in the Sikasso region from where the yield data originate.

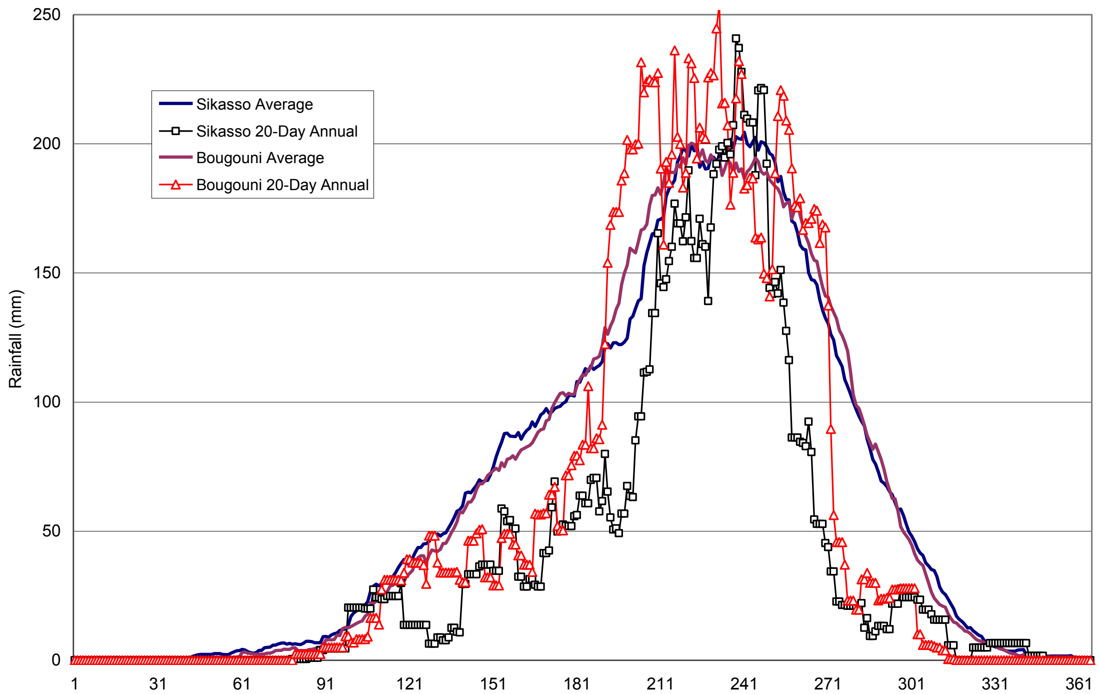


Figure 11: Daily annual average and 20-day moving average, 1971

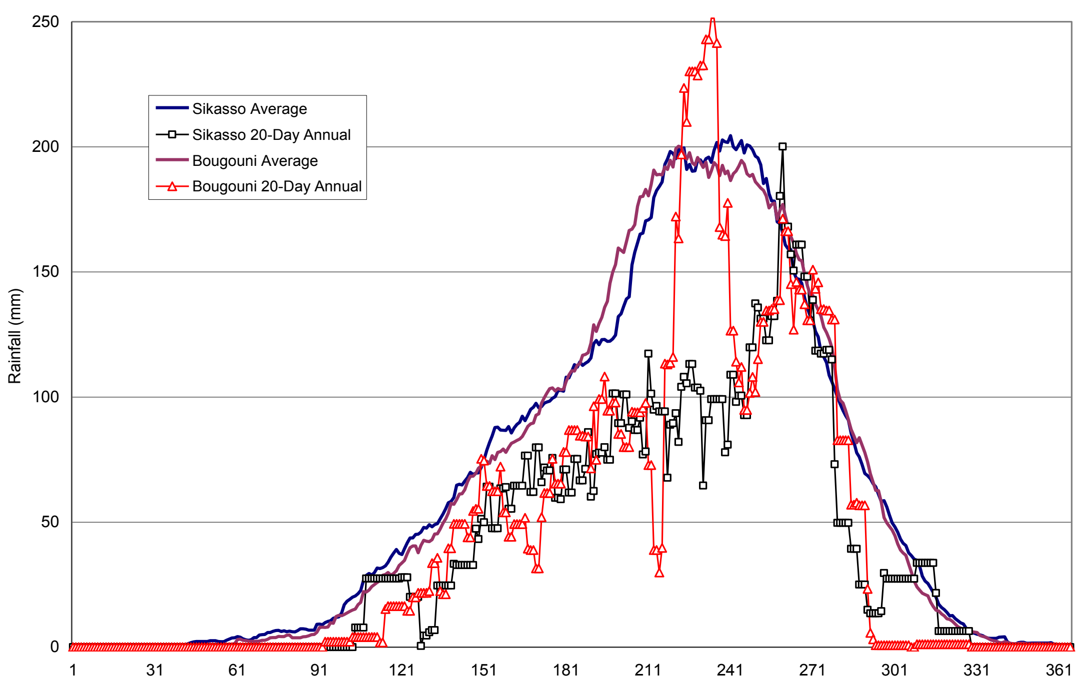


Figure 12: Daily annual average and 20-day moving average, 1983

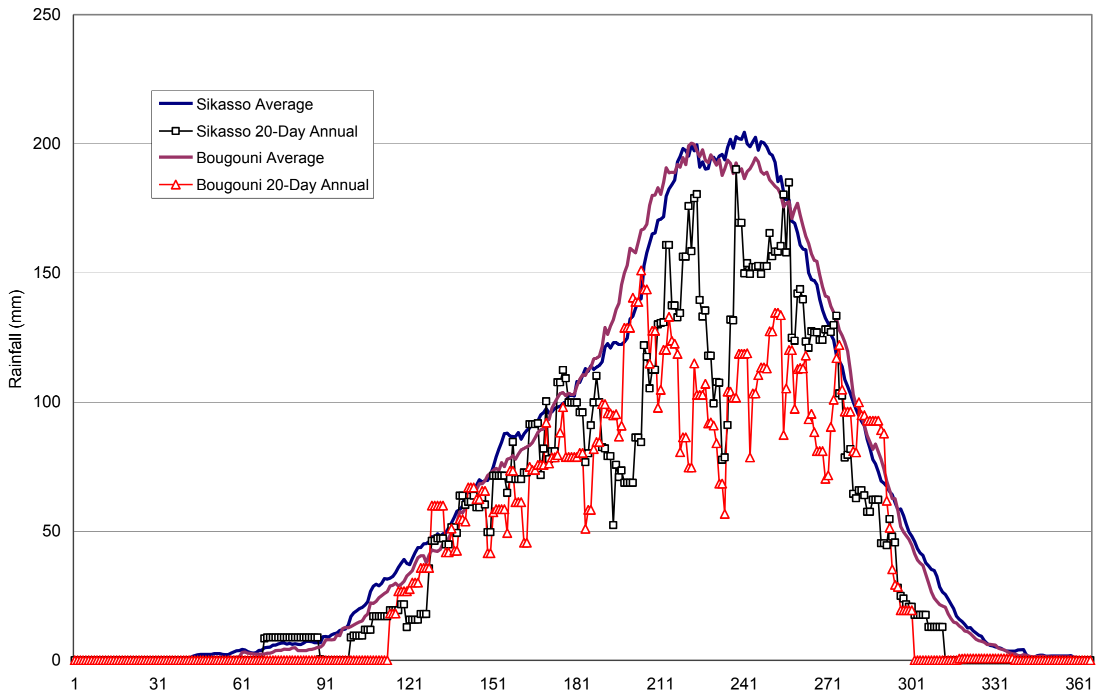


Figure 13: Daily annual average and 20-day moving average, 1984

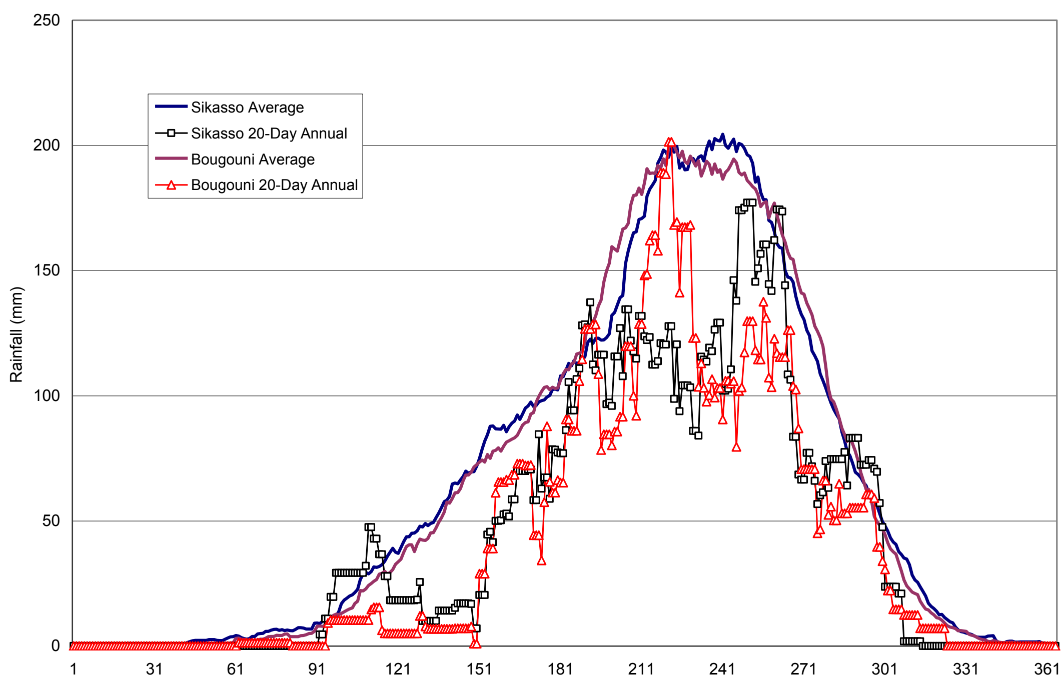


Figure 14: Daily annual average and 20-day moving average, 2002

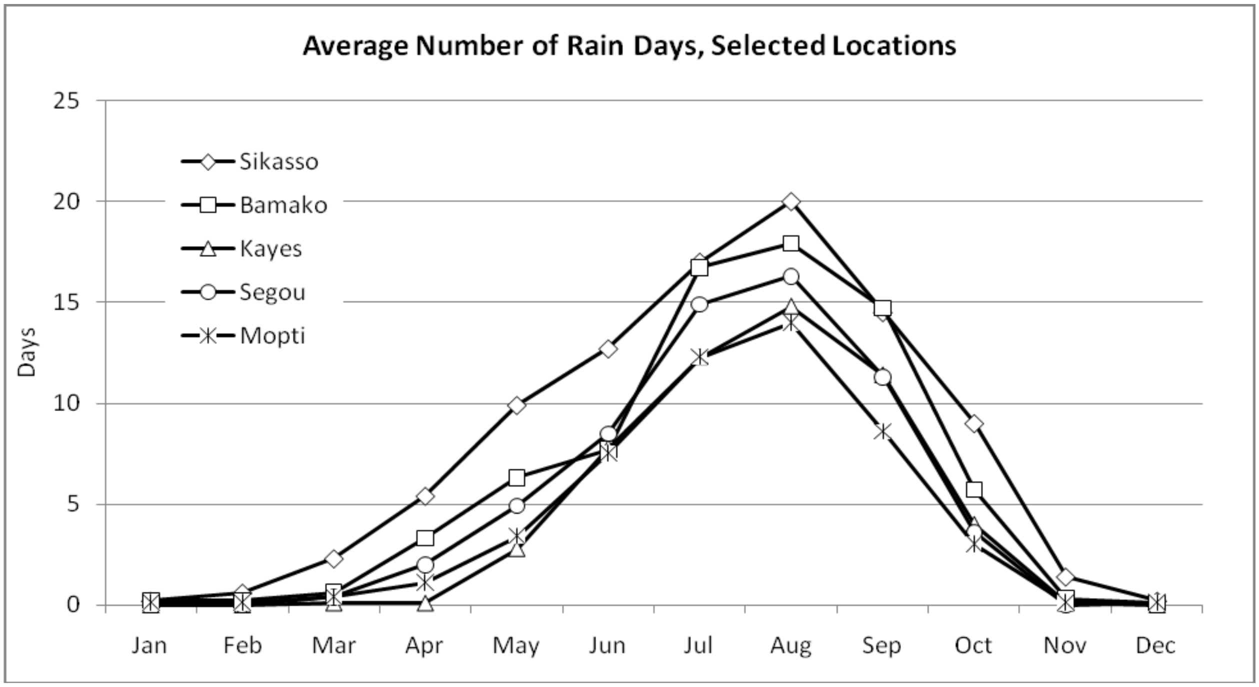


Figure 15: Average monthly rain days, 1950–2000

In thinking about an explanation for this result, it is helpful to consider some history and agronomics. One of the last severe region-wide droughts peaked in 1984 with a group of three years experiencing deficit rainfall, as shown in Figure 16. While Bougouni station still recorded a reasonable amount of rainfall, drought was still felt locally as indicated by farmers and in other areas, particularly to the north, where severe drought conditions were experienced. We hypothesize that multiple drought years tended to worsen soil degradation trends that were already underway and which, during this period, reached a threshold where much of the soil organic matter was depleted, reducing water infiltration and retention properties, thus limiting the ability of the soil to act as a moisture reservoir and buffer. This hypothesis, we believe, can help explain some of the randomness of yield outcomes to rainfall outcomes experienced in subsequent years, and explain in part why drought and flood are both mentioned as agricultural risks.

Correlation Analysis of Proxy for Loss

To further study the issue of whether a rainfall-based index could serve as a good proxy for loss and to explore the hypothesis that soil degradation is responsible for seemingly erratic yield outcomes, a correlation analysis was conducted with the previously calculated aggregate yield index and crop-specific, negative-yield deviations from the norm against aggregate rainfall for the months of July, August, and September, for each of the two weather stations. These months span the range of time during the cropping season, most frequently mentioned of concern to farmers. Furthermore, the correlations were developed for different time periods to search for indications of abrupt changes in soil fertility and moisture retention properties. The correlation results, however, find very few strong relationships, no recognizable pattern between crops and time periods, and no relationships that are strictly significant.

REFLECTIONS AND NEXT STEPS FOR A FULL FEASIBILITY

Potential for Developing a Weather Index that Matches Crop Yields

Our analysis of the weather data from the two available stations is extensive. What is clear is that the Sikasso region of Mali normally receives a large amount of rainfall, and during the months of July and August, it rains, on average, about every other day. The analysis we perform suggests that there are few periods where there is very low rainfall in any 20-day period during the growing season. However, given that drought is clearly mentioned as a major problem, we test available data to search for any possible relationships between rainfall shortfalls and yield shortfalls. To identify what might be possible, we organize a monthly rainfall deficit contract for each month between April and August for both available weather stations. Even with this data, which represent 10 monthly contracts with the possibility to receive payments, there is very little correlation: neither with national-yield shortfalls nor with a more limited, regional-yield series for maize, sorghum, and millet. These two stations are in the midst of an area responsible for roughly half of the national maize production and 40 percent of sorghum production.

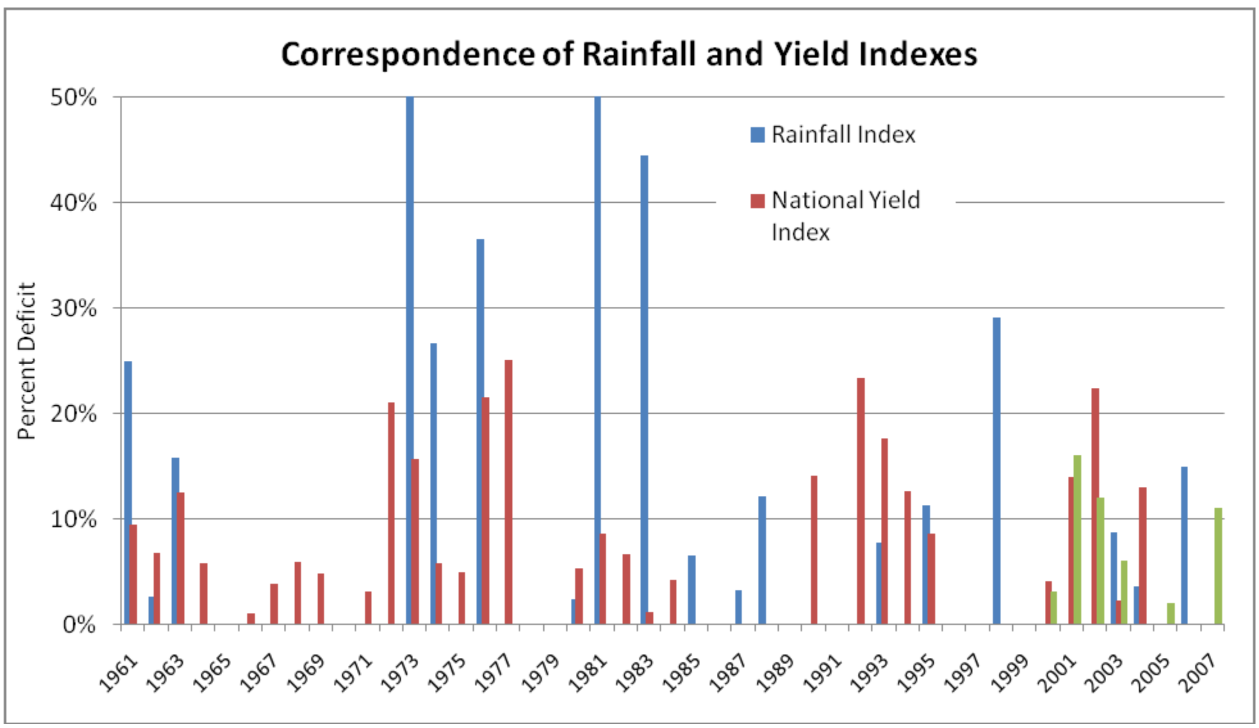


Figure 16: Correspondence of rainfall and yield indexes, 1.5*(standard deviation)

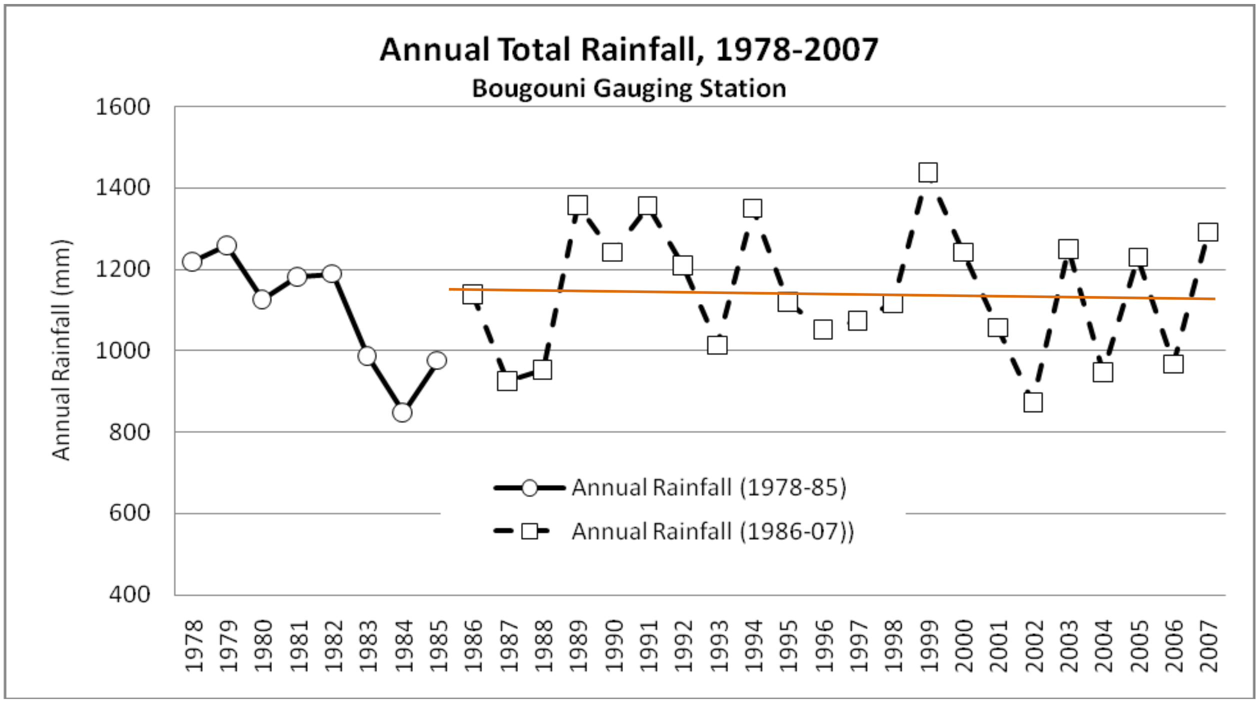


Figure 17: Annual total rainfall, Bougouni gauging station, 1978–2007

One important reason for these confounding results is that crop yields are strongly conditioned on soil quality. We have learned that soil erosion, soil nutrient mining, and loss of soil organic matter resulting in poor water infiltration are of serious concern across large parts of Mali. Limited water infiltration essentially means that the moisture-holding capacity of the soils is low and therefore prone to surface erosion since rain is largely running off the land. This explains why some farmers cited the occasional flood, especially in the month of August when rainfall is highest, as a concern. High sensitivity to rainfall timing and rainfall intensity also helps to explain why it has been difficult to find a correspondence between various rainfall windows and crop yields. The reason is, if intensity of rainfall is a key explanatory variable (either because it creates flooding or because the intensity affects the saturation of rain creating more sensitivity to drought conditions even when there is rainfall) then the pre-requisite of strong spatial correlation may be absent. Rather than having a strong spatial correlation a variable like intensity of rainfall is more likely to be idiosyncratic.

To test this further, we examine the correlation between crop yields when they are below normal and rainfall levels for different months and different time periods. These tests are limited by having only two rainfall stations worth of data and only national crop yields for maize, sorghum, and millet. The correlation results do not reveal any patterns or strong and significant relationships.

While this does not lead to the conclusion that a rainfall drought insurance contract cannot be properly designed, it does raise the specter that it will need to be a complex contract that focuses on very narrow periods of rainfall. Potentially, with enough data resources, in combination with agronomic modeling that takes into account soil characteristics, it could be possible to fit a rainfall index to the yield data for specific crops. This, however, raises other important considerations related to basis risk that result from frequent “over-fitting” and other factors such as the assumption of uniform management practices that underlie many agronomic models. Complex models also increase the difficulty in transferring the basic skills needed to manage the index to local entities once technical assistance has departed. Furthermore, complex models also make it more difficult for smallholders to understand the insurance contract. The current lack of operational rainfall gauging infrastructure also means that it will be difficult to design a product that can serve a meaningful percentage of the farming population. The basic conclusion regarding developing rainfall-based weather index insurance for Mali is that it will be quite challenging.

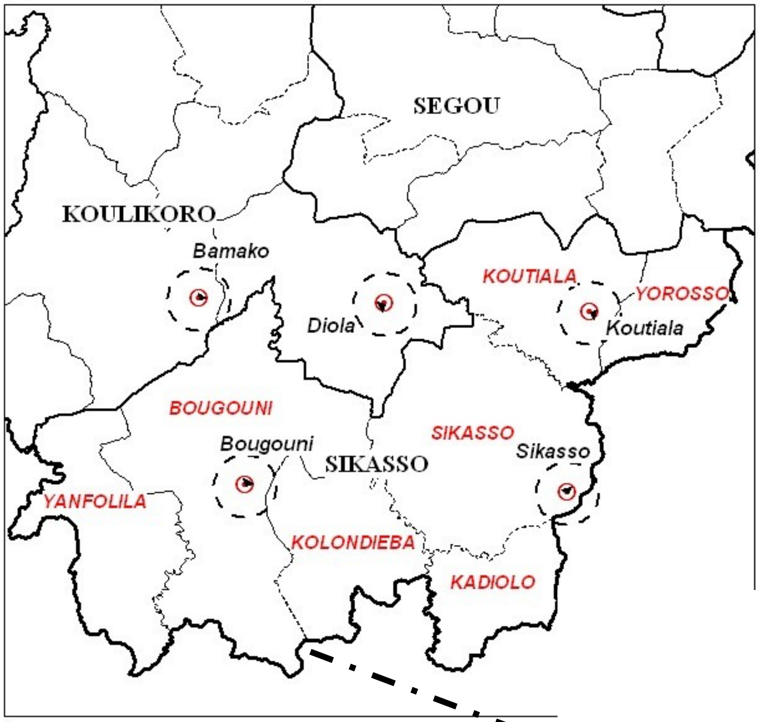
Potential of Other Index Approaches

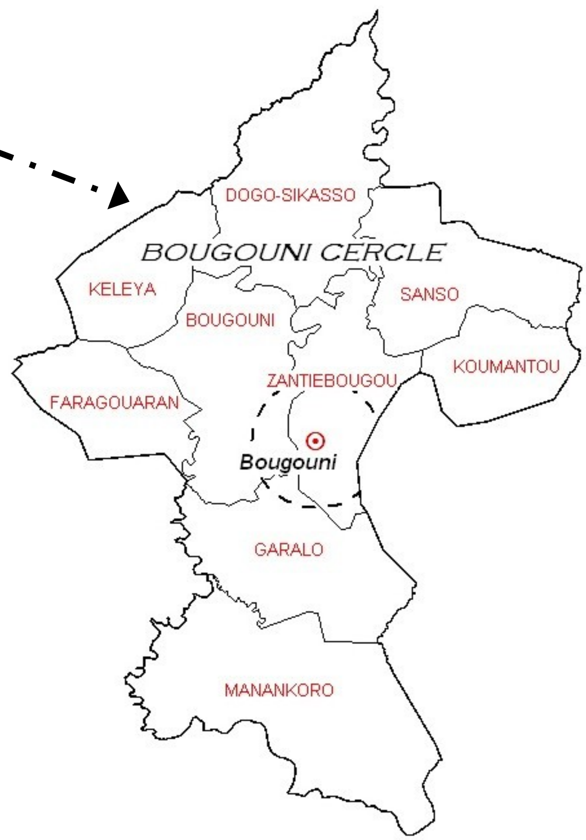
During the mission there were discussions regarding area-yield estimates developed on the basis of the cercle or, ideally, smaller administrative unit. The process for estimating these yields involves field cuttings, which is a standard process. The administrative areas where yield estimates are made may be small enough that there could be the potential to design an area-yield insurance product. One reason why area-yield contracts are interesting is because the yield estimates may be able to capture many of the complex weather events and other interactions, such as those occurring with soils, that a rainfall index alone fails to detect. If yield data have been estimated for 20 or more years, and if the quality and methods used are deemed to be acceptable and consistent, developing an area-yield contract may be possible. An area-yield insurance product could be suitable for individual farmers as well as MFIs and other agricultural lenders. Area-yield contracts, like weather index contracts, can also preserve and even enhance incentives for farmers to improve their management knowledge and practices. Nonetheless, without some significant steps to insure the ongoing integrity of area-yield estimates, reinsurers and insurers may have underwriting concerns about using area yield. Regretfully, initial guarantees to provide some of these data were not fulfilled by officials at the national agricultural statistics office, making it difficult to gain a good sense of the quality and cover of the data. However, a subsequent feasibility mission has reported that regional yield estimates are available for only the past 15 years and that district (cercle) level estimates are generally shorter and display less continuity (PlaNet Guarantee, 2009). Additionally, it does not appear that reliable subsector level (Appendix A) yield estimates are possible which are preferred to minimize yield level basis risk.

A second type of index approach that could be considered is one based on satellite remote sensing. One index that has applicability to drought detection is the Normalized Difference Vegetation Index (NDVI). The NDVI is based on the principle that vegetation that is actively growing and photosynthesizing absorbs certain wavelengths while reflecting others. A time series of NDVI values can be used to establish an average or normal value for vegetative health at a defined period in time. Subsequent values of the index can be compared to the norm to detect below-average plant growth, which is most commonly associated with moisture availability; however, significant cloud cover can also generate a low NDVI value. Using NDVI as a proxy index for drought must be well investigated. For example, depending on local weather characteristics, a low NDVI value could be detecting a prior season's drought that impacts plant growth rather than current rainfall deficits. NDVI will detect both agricultural crops as well as native vegetation but not distinguish between the two. In Mali where mixed systems are common, the impact of rainfall shortfalls, especially where timing is important, could understate the impact on agricultural plant growth. An index based on remote sensing is most appropriate for risk aggregators, such as agricultural lenders, rather than individual farmers. While attractive in principle, remote sensing indexes still require significant start-up costs, calibration of index values with yields, and finally a correspondence to some measure of insurable interest on the part of risk aggregators. In general, remote sensing indexes of this type are best for detecting pervasive drought events rather than identifying localized and mild drought.

Obtaining the combination of area yields and satellite data could provide the opportunity for further analysis that would be the first step before a full-blown feasibility analysis is undertaken (Appendix D). Data are critical to the development and maintenance of any weather insurance product. Until it can be demonstrated that consistent and logically coherent data are available it is be unwise to invest much further resources in trying to develop a weather insurance market in Mali.

APPENDIX A: GEOGRAPHIC ORIENTATION OF BOUGOUNI CERCLE





Bougouni cercle is an administrative sector of Sikasso Region. Bougouni cercle is composed of 9 subsectors. The dashed circles indicate 20 km radii around operational rainfall gauging stations.

APPENDIX B: MALAWI AND ETHIOPIA INDEX-BASED RISK TRANSFER

Malawi: Weather Insurance Pilot for Farmers

Drought is the most frequent weather disaster in Malawi. In terms of the number of individuals affected, all six of the most severe natural disasters in Malawi were droughts. On average over 3.5 million individuals are affected when drought occurs in Malawi (UN/ISDR, 2008). Largely due to drought risk, crops tend to have low yields associated with low access to credit, poorly functioning input markets, and low uptake of technology (Hess and Syroka, 2005).

Malawi has 22 government-managed weather stations that are of sufficient quality to develop a drought insurance product. The Malawi Meteorological Service has been a willing partner in providing historical and ongoing data to make payments in this World Bank project. Of the 22 government-managed stations, 13 were used for the initial risk assessment. Stations having long histories (about 40 years) of data with very few missing values were selected. These stations were also dispersed throughout the country to assess the weather risk in disparate regions. Drought was defined as 75 percent of cumulative average rainfall over the rainy season (October–April). On average, drought occurs at two weather stations each year when measured in this way. This is roughly a 1-in-6-year event, which should be insurable. The historical data reveal localized, regional, and national drought occurring in Malawi (Hess and Syroka, 2005; Kimball, 2006).

Groundnut farmers in Malawi wanting to plant with certified groundnut seed were unable to obtain credit because of the high default risk in the event of a drought (Alderman and Haque, 2007). A drought in 2004–2005 led to high default rates ranging from 30 percent to 50 percent for agricultural loans. Malawi has neither land tenure nor a national identification system, reducing opportunities for contract enforcement for the bank. Many lenders refused to offer credit for agriculture after the 2004–2005 event (Mapfumo, 2007). A pilot was launched in the 2005–2006 growing season linking the Insurance Association of Malawi; the smallholder farmers union, National Smallholder Farmers' Association of Malawi (NASFAM); and two lenders (Alderman and Haque, 2007). (Figure B1 illustrates the relationships of key stakeholders for this program.) The two lenders provided loans to smallholders who agreed to purchase index insurance. The loan covered the costs of seed and insurance premiums (Opportunity International, 2005). These products were presented as a bundled packet, which results in lower delivery costs than using an insurance sales agent.

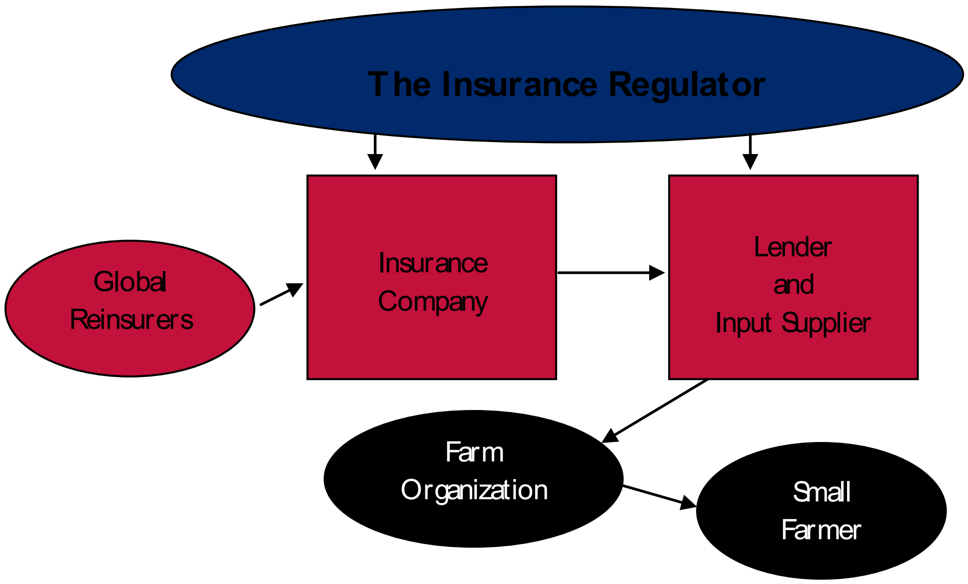


Figure B1: Key stakeholders for Malawi-type weather insurance

Farmers purchasing the index insurance agree to sell their yields to NASFAM. NASFAM acts as a delivery channel for the loan and insurance payouts and deducts the price of the loan from its payments to farmers for their yields. Insurance policies only cover the cost of seed for which farmers borrow from the bank, paying premiums at 6–7 percent of loan values. In the event of a payout, NASFAM deducts the amount from the farmer's loan and passes the payout on to the bank. NASFAM deducts the leftover loan liability from farmers' yield proceeds. In the event of a total payout, indemnities equal the value of the loan, and NASFAM does not deduct any amount from yield proceeds for loan payments (Opportunity International, 2005).

Malawi yield data are limited and may be unreliable, and thus, alternative methods for structuring the rainfall insurance payout were pursued after the first year of the pilot (2005). The Malawi product used the FAO Water Requirement Satisfaction Index (WRSI) to establish the contract structure for drought insurance for groundnut. WRSI is the ratio of water availability for a crop to water requirements for a crop during a season. WRSI is weighted based on water needs during critical stages of development. Other, more robust crop growth models are available that mimic the physiological growth process of groundnut; however, given the limited data available, WRSI was chosen for this project (Syroka, 2005). WRSI requires several data inputs:

1. Historical dekadal (10-day) rainfall data for a weather station;
2. Average dekadal potential for the weather station;
3. Water-holding capacity of the soil;
4. Water use patterns for the insured crop in the region (these are defined for the critical stages and interpolated between these stages);
5. Maximum crop root depth;

6. Seasonal-yield response factors for each crop, which allow WRSI to be converted into yield estimates; and
7. Start- and end-of-season time periods, and thus, the length of the growing period.

Thus, the project designed the contract based on WRSI modeling of the effects of rainfall on groundnut crop yields. The benefit of using WRSI is that the only input variable expected to vary is rainfall — all other model inputs are expected to remain constant. Thus, it can isolate the effects of rainfall on models of crop yields (Syroka, 2005). However, the drawback of WRSI is that it assumes constant soil quality (e.g., constant water-holding capacity), which can differ dramatically within a region, especially in Africa.

Contracts are divided into three phases, with emphasis on rainfall levels during the first two phases. The contracts were structured so that payouts would begin when rainfall levels were such that the expected decline in yields was 16 percent or 23 percent of optimal yield levels, depending on the region. Average yields in the pilot regions are between 88 and 96 percent of optimal yields. Thus, while the contracts are described as insuring against catastrophe risks, they are designed to protect against moderate declines in rainfall. The findings of this project concluded that rainfall at 65 percent of optimal levels was associated with total crop failure. Thus, payout limits were based on this amount and ranged from 58 to 68 percent, (Syroka, 2005).

The product has been piloted in four areas, and to keep basis risk at an acceptable level, households must be within 20 km of a weather station to participate (Syroka, 2005). For the 2005–2006 period, 892 farmers purchased weather insurance for a total sum insured of USD 35,000. In the 2006–2007 growing season farmer uptake increased to 1,710 groundnut farmers and a rainfall-based insurance contract was also purchased by some 826 farmers for maize production. Client uptake of the rainfall index insurance product may have been inhibited by the good 2006 groundnut crop. No claims were paid and there was no demonstration effect. However, farmers report yields for using hybrid seed rose by 140 percent (Mapfumo, 2007).

During the 2006–2007, the lenders learned that some farmers purchasing the weather insurance were side-selling their crops to avoid repaying the loan. Thus, while weather index insurance was creating access to the higher-yield seed and protecting the lender from drought risk, coordination in the groundnut value chain was insufficient to support this product. Value chains for other commodities including tobacco and paprika are more strongly integrated in Malawi. Tobacco in Malawi is sold through an auction, and farmers create forward contracts with tobacco processors to sell their tobacco crop. This structure reduces opportunities for side-selling, and so in the 2007–2008 season, the weather index insurance product was tailored to protect tobacco against drought. Instead of selling insurance to individual farmers, the index insurance products were designed to protect a portfolio of loans between a lender and a tobacco processing company. The insurance products were associated with individual farmers so that if payouts occurred for a particular weather station, the tobacco company would repay the loans of the appropriate farmers. Tobacco has the added benefit of being grown by more farmers in Malawi than groundnut, and expansion of this insurance pilot was planned for the 2008–2009 season (CRMG 2008).

In sum, Malawi is an innovative and interesting case that seems to have facilitated valuable linkages within the value chain. It is an infant program in a single country and questions regarding its international scalability and sustainability remain, yet valuable lessons can be learned from its development and implementation.

Ethiopia: Index-based Food Security Weather Insurance

Ethiopia contains approximately 22 million farmers (CIA, 2008a). The entire Ethiopian economy and food security for rural households can be threatened by low rainfall levels that damage agricultural production. The first prototype weather insurance for Ethiopia food security was designed by Skees et al. (2004). In 2006, the World Food Programme (WFP) purchased a weather index contract that was structured as a derivative to provide contingent financing in the case of extreme drought during the March to October agricultural season. The value insured was USD 7 million. The WFP purchased the contract from Axa Re (now Paris Re) for a premium of USD 930,000 (Alderman and Haque, 2007). Payments were triggered when the cumulative rainfall from March to October was significantly below the 30-year average, indicative of widespread crop failure and potential famine. In the case of a triggering event, the payment made to the WFP would be transferred to the Ethiopian government for distribution to vulnerable households according to the government's existing cash-for-work poverty support program using community-based targeting methods. The contract was expected to benefit up to 63,000 households in 60 districts with maximum payments of about USD 100 (WFP, 2006). The pilot was discontinued after 2006.

Daily rainfall data from 26 weather stations were collected by the Ethiopian meteorological agency and served as the basis for this contract. These data were submitted to an independent agency for validation. These represent the best weather stations in Ethiopia in terms of having complete and long historical datasets. They are over half of the 44 stations in Ethiopia for which historical data with few missing observations are available and roughly a fifth of the 120 official stations in Ethiopia. Few weather stations with good historical data exist in the pastoral regions; consequently, these regions were excluded from the pilot (Alderman and Haque, 2007).

Ethiopia is dependent on agriculture, which employs 80 percent of its labor force and accounts for roughly 50 percent of GDP (CIA, 2008a). The vast majority of crops in Ethiopia are rainfed and, as a result, household income is highly correlated with rainfall. Drought is the most common and most devastating disaster risk in Ethiopia. Significant droughts occurred in 2000, 2002, and 2003. In data from 1900 to 2006, drought accounts for eight of the ten worst natural disasters on record (famine accounts for the other two), all 10 of which have occurred since the early 1980s. On average, almost 4 million people are negatively affected and roughly 26,000 people perish when drought occurs in Ethiopia (UN/ISDR, 2008).

While drought risk affects stakeholders at all levels, roughly seven percent of the Ethiopian population have food insecurity problems regardless of weather conditions. In drought years, the number of food-insecure households can easily double. Households have very limited access to credit. In Ethiopia, land is held publicly so it cannot be used as collateral, which has been a major impediment to lending. To address this, local governments sometimes provide loan guarantees for farmers. Thus, local governments are greatly exposed to the risk of natural disasters adversely affecting loan repayments for agriculture. Finally, at the macro level, safety net programs in Ethiopia are almost entirely funded by donor organizations. Because of the chronic food insecurity problems, food aid in Ethiopia is a constant. When drought occurs, donor programs (e.g., the WFP) require large and rapid increases in funding to provide relief to households entering the ranks of the food insecure. Drought relief efforts can often divert resources from other donor organization programs that are aimed at sustainable development. Thus, the risk assessment of drought in Ethiopia revealed that households, lenders, and donor organizations were all experiencing significant consequences associated with drought risk.

Rainfall data for the risk assessment were provided by the Famine Early Warning System Network (FEWS NET) in the form of daily Collaborative Historical African Rainfall Model (CHARM) data for 80 zones in Ethiopia for 43 years (1960–2003). CHARM uses interpolated weather station, satellite, and land elevation data to create a grid of rainfall in Africa. CHARM results in an improved estimate of rainfall over simple interpolated weather station data; however, compared to the interpolated weather station values, CHARM tends to underestimate extreme rainfall events — the most important events for insuring against drought at refined local levels. Additionally, specificity of CHARM is somewhat limited, especially in areas of complex topography, so it is best used for understanding rainfall patterns over large regions (Funk et al., 2003).

Though basis risk may be too high for households to directly utilize index insurance based on CHARM data, these data can be effectively used for understanding drought risk in Ethiopia. Average rainfall declined over the 43 years of weather data, indicating drought risk is increasing. Ethiopia comprises five distinct regions based on rainfall patterns. In general, Ethiopia receives 60 to 90 percent of rainfall in the rainy season (June–September), called *kiremt*. However, many areas also receive a springtime rain, called *belg*. Farmers in these regions can alter crop choices based on the timing and intensity of these rains. For example, they may choose to plant two seasons of short-cycle crops such as wheat and teff, or if the rains are late, farmers may choose to plant a single, long-cycle crop such as maize that is planted in belg but harvested in kiremt.

In designing a weather insurance product, the initial work highlighted the importance of early payouts that can be structured with weather index insurance — even in the middle of the rainy season — given clear evidence that drought will be a problem. Because drought is a slow onset event, timely payments are critical because they can provide payments as the disaster emerges — before stakeholders are truly experiencing crisis. Thus, the early work suggested indemnities be determined on a monthly basis during the rainy season and that consideration be given to defining several points for payouts during the season.

To emphasize the need for early payments, consider the case of drought in northern Kenya. In this region, drought is associated with famine, with famine measured as the prevalence of at least 20 percent of children severely wasted (Chantarat et al., 2007). Low mid-upper arm circumference (MUAC) is a common estimate of child (aged 6 to 59 months) wasting and is predictive of infant mortality (Mei and Grummer-Strawn, 1997). Beyond infant mortality, childhood malnutrition, especially in the first 2 to 3 years of life, is associated with life-long stunted growth and cognitive and social-emotional deficits that result in lower education completion, less learning per year of education, and lower economic potential (Grantham-McGregor et al., 2007). Children experiencing even a single famine during the first year of life continued to show lower cognitive and social-emotional deficits thirty years later (Galler and Barrett, 2001). Thus, protecting households from famine can be very important and provides a clear rationale for well-functioning food aid safety nets. However, the protection must come sooner than it does with current systems.

Currently, food aid procurement requires months, challenging its ability to protect households from even slow onset events. For example, the average time from the formal request for U.S. food aid to delivery is 5 months (Barrett and Maxwell, 2005). Because malnutrition can be so detrimental to lifelong developmental outcomes, mechanisms that expedite the food aid process can potentially have significant effects on household well-being and economic development.

Chantarat et al. (2007) show that that rainfall estimates can be used to insure against famine in this region as a component of a safety net program. Rather than designing the contract to make payments based on indirect estimates of household well-being such as crop yields, they suggest designing rainfall insurance contracts that makes timely payments based on early indicators of drought and at levels that prevent famine (i.e., prevent severe child wasting from reduced consumption).

Appendix C: Inventory of Weather Stations for Mali

```
Inventaire de PLUVIOMETRIE POUR MALI
=================|=========|==========|==========|==========|==========|========|=====
STATION     <1951|  1950   |   1960   |   1970   |   1980   |   1990   |  2000  >2007
                 |123456789|0123456789|0123456789|0123456789|0123456789|01234567|
-----------------|---------|----------|----------|----------|----------|--------|-----
BADJILA          |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx x|          |        |
BAGUINEDA       X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxx xxxxxx|xxxx    |
BAMAKO  ZOO  IF X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x         |     x  x |        |
BAMAKO SENOU    X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx|
BAMAKO VILLE     |   xxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx|
BAMAKO-AERO (FE X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx  |          |        |
BANBA MANANKORO  |         |       xxx|xxxxxxxxxx|xxxxxxxxx |          |        |
BANKOUMANA       |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx  | xxxxxxxxx|xxxx xx |
BAROUELI        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x xxxxxxxx|xx   xx |
BELEKO          X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx      |
BLA              |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxx xxxxx| x      |
BONKOURA         |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxx   |          |        |
BOUGOUNI        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx|
CINZANA          |         | xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x       |
DEMBELA          |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x         |        |
DIOILA          X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx xxxxxxx|xxxxxxxx|
DOGO  BOUGOUNI   |         |  xxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx  xxxxxx|xx      |
DOUNFING        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx        |          |        |
DOUSSOUDIANA     |         |          |          |          |    xxxxxx|xx      |
FAKOLA           |         |      xxxx|xxxxxxxxxx|xxxxxxxxxx|xxx x     |        |
FALADYE         X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx  |          |  x     |
FANA             |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxx xxxxxx|xxx     |
FARAKO           |         |        xx|xxxxxxxxxx|xxxxxxxxxx|xx  x     |        |
FERENTOUMOU     X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x         |        |
FILAMENA         |         |    xxxxxx|xxxxxxxxxx|xxxxxxxxxx|x   xxxxxx|xxxxxxx |
FOUROU           |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x         |        |
GARALO           |         |   xxxxxxx|xxxxxxxxxx|xxxxxxxx  | x        |        |
GOUALALA        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx xxxxxxx|xx      |
IFAC-CNRF-SRFM   |         |    xxxxxx|xxxxxxxxxx|xxxxxxxx  |   xxxxxx |        |
KABALABOUGOU     |         |          |          |          |   xxxxxx |  xx    |
KADIANA          |         |       xxx|xxxxxxxxxx|xxxxxxxxxx|x   xxx   | x      |
KADIOLO         X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxx xxxxxx|xx x    |
KALANA          X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx| xxxxxxxxx|x       |
KANGABA         X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxx    |
KARANGASSO      X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxx xxx|          |    x   |
KATI-HAUT        |       xx|x xxxxxxxx|xxxxxx    | xx   x   |  x xxxxx | xx xxxx|
KATIBOUGOU      X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx xxxxxxx|xxxxxxx |
KIGNAN          X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx xxxxxxx|xxxx    |
KLELA            |         | xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx      |
KOLOMBADA        |         |          |     x    |  xxxxxxx |x       x |        |
KOLONDIEBA       |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x       |
KOLONI           |         |    xxxxxx|xxxxxxxxxx|xxxxxxxxxx| xx       |        |
KONODIMINI       |         | xxxxxxxxx|xxxxxxxxxx|xxxxxx x  |          |        |
KONSEGUELA      X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxx    | x  xxxxxx|xx      |
KOULIKORO       X|         |          |          |      xxx |       x  |  x     |
KOULOUBA        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx        |x         |        |
KOUMANTOU        |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x xxxxxxx |        |
KOUTIALA        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx|
LOBOUGOULA       |         |   xxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x  xx     |        |
LONGOROLA        |         |          |          |xxxxxxxxx |          |        |
LOULOUNI         |         |   xxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x         |        |
M'PESOBA        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xx x  x   |    xxxxxx|xx xxxxx|
MADINA-DIASSA    |         |        xx|xxxxxxxxxx|xxxxxxxxx |  x xxx   |        |
MANANKORO        |         |   xxxxxxx|xxxxxxxxxx|xxxxxxxxxx| xx xxxxxx|xx      |
MASSIGUI         |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxx   |          |        |
MISSENI          |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxx | xxxxxxxxx|xx      |
N'TARLA  I.R.C.  |         |        xx|xxxxxxxxxx|xxxxxxxxx | xx xxxxxx|xxxxxxx |
NANGUILA         |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx  |      x   |        |
NEGALA          X|xxxxxxxxx|xxxxxxxxxx|x  x      |xxxx      |          |        |
NEGUEBOUGOU      |xxxxxxxxx|x         |          |          |         x|xx      |
NEGUELA          |         |       xxx|x  xxxxxxx|          |          |        |
NIENA           X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x         |        |
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NIENEBALE       X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxx |x         |        |
NIENTJILA        |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx  |          |        |
NYAMINA         X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxx  xx|          |        |
OUELESSEBOUGOU  X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x    xxx x|  x     |
SAMANKO I PAR    |         |          |          |   xxxxxxx|x    x    |        |
SAMANKO II CE    |         |        xx|xxxxxxxxxx|xxxxxxxxxx|x  xxxx   |        |
SANANDO          |         |xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxx     |        |
SANTIGUILA      X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx  |x   xx    |        |
SANZANA          |         |          |          |xxxxxxx x |          |        |
SELINGUE         |         |          |          |       x x|xx xxxxxxx|xxxxxxx |
SIKASSO         X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxx|
SOTUBA          X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|x  xx  xxx|xxxxxxxx|
SOUROUKOULA      |         |          |xxx       |          |          |        |
TIBI             |         |    xxxxxx|xxxxxxxxxx|xxxxxxxx  |          |        |
TIEROUALA        |         |          |          |xxxxxxxxxx|xxx       |        |
YANFOLILA       X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxx |xxxxxxxxxx|xxx     |
YANGASSO        X|xxxxxxxxx|xxxxxxxxxx|xxxxxxxxxx|xxxxxxxxx | xx    x  |        |
YOROBOUGOULA     |         |        xx|xxxxxxxxxx|xxxxxxxx  |xx  xxxxxx|        |
ZANGASSO         |         |      xxxx|xxxxxxxxxx|xxxxxxx   |x   xxxxxx|x       |
ZANTIEBOUGOU     |         |      xxxx|xxxxxxxxxx|xxxxxxxx  | x  xxxxxx|x       |
ZETA             |         |      xxxx|xxxxxxxxxx|xxxxxxxx  |xx  xxxxxx| xxxxxxx|
=================|=========|==========|==========|==========|==========|========|=====
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Source: Direction Nationale de la Météorologie du Mali

APPENDIX D: MARKET DEVELOPMENT AND ELEMENTS OF A FULL FEASIBILITY ACTIVITY

Figure D1: Market development / implementation model

Weather Risk Assessment

The risk assessment identifies the major risks affecting rural households and, by extension, microfinance lending to agriculture, to assess the economic impacts of those risks and ascertain whether these risks can be effectively transferred using index insurance.

The following are some of the primary questions that are addressed in this assessment:

Are there one or more extreme weather events that are known to directly undermine the welfare of rural households or to impede the delivery of critical services to rural areas?

Events likely to meet this condition include well-defined extreme weather events such as droughts, excessive rainfalls, floods, freezes, excessive temperatures, deficit sunlight, and cyclones.

How widespread are the economic impacts of this weather event?

For weather index insurance to be cost effective, the extreme event must affect a geographic region that encompasses significant economic activity. This condition effectively excludes from consideration events that are localized in their impact in any one occurrence, such as hail or tornadoes. This condition also effectively excludes weather events that occur non-uniformly over space due to significant microclimatic variation, which is not uncommon in mountainous regions.

What is the nature of the economic impacts of this weather event?

Does the extreme event destroy private property such as homes, crops, livestock, irrigation facilities, storage structures, or other capital equipment? Does it destroy public infrastructures on which rural households are dependent, such as roads, bridges, railroad systems, public irrigation systems, and water reservoirs? Thorough documentation of the economic impacts of the extreme event is not required for the feasibility study. However, some statistical or strong anecdotal evidence of widespread economic damages should be provided to justify proceeding to the pilot program.

How frequent is the weather event?

For index insurance to be cost effective, the extreme event must occur frequently enough to be recognized by individuals as a significant risk. However, the event should not occur too frequently, for then the premium rates would be prohibitively high. As a rule of thumb, the event, on average, should occur at least once every 15 years, but not more than once every 7 years.

Index and Data Assessment

If index insurance is to be successfully implemented, an appropriate index must be identified and adequate historical data on the index must be available. In identifying whether an appropriate index exists, the following questions should be considered:

Does a variable (i.e., index) exist that is highly correlated to the losses caused by the extreme event?

Potential variables that could serve as an index include standard weather variables compiled by the meteorological service such as rainfall and temperature; satellite or radar imagery for flood or vegetative cover, and El Niño Southern Oscillation (ENSO) indexes; government-compiled statistics directly related to losses, such as regional crop yield, livestock mortality, and epidemiological statistics; and other environmental variables such as river flow and reservoir levels.

How many years of reliable data are available for the candidate index and how dispersed are the geographical locations at which it is measured?

An insurer must have reliable data from which to establish premiums for index insurance. Ideally, insurers prefer at least 30 years of data that conform to international standards. Insurers may be willing to work with less data, provided that supplementary data exist, such as measurements from other nearby geographical locations.

Can the index be measured objectively using consistent, secure, and transparent methods?

To sell index insurance, an insurer must have confidence that the underlying index will be measured securely, consistently, and in accordance with internationally accepted protocols; for example, an index compiled and published by a disinterested international organization that reports based on data from government meteorological stations. Meteorological variables compiled locally and on site, however, may not be useful as indexes if the agency responsible for compilation and publication of statistics is deemed by the insurer to be susceptible to corruption or if the measurement stations are not secure or do not conform to international standards (such as those established by the World Meteorological Organization).

Institutional Assessment

An assessment of existing institutions and mechanisms for managing risk is necessary to understand where improvements may be needed. The institutional assessment examines the current roles of the government, private sector (insurance and banking), and donor organizations in risk management. The existing mechanisms may influence the design of index insurance, as a new product may need to account for or complement existing mechanisms and strategies. The responsibilities and experiences of existing institutions will also influence design of index insurance as regards financing, delivery mechanisms, regulations, etc. The following questions should be considered for the institutional assessment:

How are risks currently being handled by financial, insurance, or government institutions? What weaknesses, if any, exist in the ability of these institutions to provide risk management services to rural households?

The cost of extreme weather events is likely already being internalized somewhere in the country's political and economic systems. In particular, it is important to understand how existing government programs may be absorbing these costs. In many lower income countries, state-supported banks often change the terms of an outstanding loan for those affected by a natural disaster. Such policies have numerous negative consequences as they are both fiscally costly and they do nothing to improve incentives for improved risk management practices. Furthermore, these types of programs are generally not transparent and they are difficult to uncover when working in a lower income country. Understanding them is extremely important as they can potentially crowd out any real demand for index insurance.

Does the country have well-established legal and regulatory framework for its banks, insurers, and security exchanges, and which regulatory agency is likely to have authority over the index insurance?

As with any insurance product, index insurance must conform to the laws and regulatory requirements of the country. Sometimes this is not easy with index insurance, since index insurance contracts are relatively novel instruments that can be considered either to be insurance products or derivative securities. Lack of clarity regarding the regulatory status of index insurance creates a business risk for insurers and reinsurers, potentially undermining their interest in participating in a pilot demonstration project. As part of the feasibility study, a prototype version of the index insurance contract should be presented to various regulatory agencies for preliminary review, in an effort to anticipate possible regulatory issues associated with the sale of the contract. Early indications regarding which regulatory agency will have oversight over the index insurance contract and the recent experience of the agency with similar financial products, if any, should help fashion strategies for the design of a successful pilot demonstration program.

Do banks, MFIs, and/or insurers operate successfully in the target regions and could they serve as financial intermediaries for the sale of the index insurance contract?

The insurer that writes the index insurance is highly unlikely to want to market or distribute the product directly to individuals — this is not the insurer's strength. The insurer will likely wish to establish a partnership with a local financial intermediary that is capable of aggregating individual risks and providing local services. This could be a local insurer with an established marketing base and experience dealing with the country's regulatory agencies, and, ideally, international reinsurers. This could also be a bank or an MFI, or a collection of such institutions, who implicitly act as insurers for individuals or who otherwise bear the consequences of catastrophic weather events, say, by experiencing widespread defaults. Although it is not essential that a commitment of a local partner be secured during the feasibility study, identifying possible partners and testing their general interest in cooperating is prudent.

Preliminary Demand Assessment

During a formal feasibility stage, demand assessment can be evaluated through research as well as discussion groups with potential users. This should also involve concept testing to obtain feedback on the product design. Is the time period the preferred one? Are the thresholds the ones of the most concern? What misunderstandings emerge that may help focus the educational efforts?

What are the expected benefits and constraints affecting demand for insurance at the MFI level?

What is the latest thinking and attitude of financial service providers and local banks toward insurance? How would insurance shift their portfolio diversification and rural/ag-lending expansion strategies? How will select product designs and delivery mechanisms have to be adjusted to accommodate insurance (e.g. unlike loan contracts, insurance contracts need to be made prior to the ability to predict weather risk). How can MFIs pass on the potential benefits of portfolio-level insurance to clients?

Who is likely to benefit from index insurance and what are their general financial and economic characteristics?

To assess the potential success of index insurance, a potential target sector must be identified and its financial and economic characteristics must be understood. In particular, one should know the typical size of the farm/rural household; typical sources of income (on-farm vs. off-farm income) and how these sources are affected by catastrophic weather events; and the use of credit (possibly through MFIs). Clearly, the potential benefits of index insurance increase if household income is relatively low and highly exposed to the extreme weather event indexed by the index insurance.

How do the potential beneficiaries of index insurance currently manage income risk from catastrophic events and, in particular, do programs or financial products currently exist that may compete with or complement index insurance?

To assess the potential success of index insurance, one must evaluate existing mechanisms and institutions for risk management and identify weaknesses or gaps. Some program, such as disaster assistance programs, could be enhanced by the introduction of index insurance. Alternatively, other programs may interfere with attempts to introduce index insurance. Examples of competing products and programs include other insurance products that may be offered by private insurers or the government; implicit insurance coverage offered by banks in the form of easy debt forgiveness policies; public programs operated in nearby areas by USAID or other international agencies; and established government practices of free disaster assistance in times of extreme weather events.

Do the potential beneficiaries of index insurance have experience using formal financial services?

Are the potential beneficiaries of index insurance receptive to the idea of hedging or risk sharing using formal financial contracts? Do they have experience with formal financial services, including savings deposits or consumer or business loans? Do cultural norms undermine the use of financial risk-sharing arrangements? Clearly, chances of success for the index insurance pilot program are higher if the potential beneficiaries of index insurance have acquired experience with formal financial transactions.

What about risk tolerance and willingness to pay among potential users?

Under some conditions focus groups or field surveys may be used to gauge risk tolerance and willingness to pay. Such activity should be conducted only if the potential users have some prior knowledge of insurance products. In many cases, no such knowledge exists and the best way to determine demand is with a pilot project that actually offers index insurance in the marketplace.

GLOSSARY

***Ad hoc* Disaster Response**	Disaster relief arranged in the aftermath of a disaster. There are a variety of approaches used (for example, direct cash, and debt forgiveness). *Ad hoc* disaster responses are generally inefficient and not reliable for decision makers as they are subject to budget availability and *ad hoc* rules for who receives the assistance after the disaster.
Adverse Selection	Occurs when potential insurance purchasers know more about their risk exposure than the insurer, leading to participation by high-risk individuals and non-participation by low-risk individuals. Insurers react either by charging higher premiums or not insuring at all, as in the case of floods.
Agricultural Risk	Risks that cause loss or decline to agricultural production or income such as adverse weather and commodity price shocks.
Basis Risk	The risk that the with index insurance, the index measurements will not match individual losses. Some households that experience loss will not be covered and the risk that households that experience no loss will receive indemnity payments. As the geographical area that is covered by the index increases, basis risk will increase as well.
Capacity	The maximum amount of insurance or reinsurance that the insurer, reinsurer, or insurance market will accept.
Catastrophe	A severe, usually sudden, disaster which results in heavy losses.
Claim	An insurer's application for indemnity payment after a covered loss has occurred.
Correlated Loss/Correlated Risk	A risk or combination of risks affecting many individuals or households in the same area at the same time such as drought, which can damage agricultural production over an entire region, or a fall in a commodity price, which simultaneously affects all producers of the commodity within the same market.

Crop Insurance	Provides financial compensation for production or revenue losses resulting from specified or multiple perils, e.g., hail, windstorm, fire, flood. While most crop insurance pays for the loss of physical production or yield, coverage is often available for loss of the productive asset such as tree crops.
Default	Failure to fulfill the obligations of a contract.
Derivative	A financial instrument, traded on or off an exchange, the price of which is directly dependent upon, "derived" from the value of one or more underlying instruments, for example, debt instruments, commodities, or any agreed upon pricing index. Derivatives involve the trading of rights or obligations based on the underlying product, but do not directly transfer property. The derivative itself is merely a contract between two or more parties. Its value is determined by fluctuations in the underlying asset. They can be used to hedge risk or to lock in a fixed rate of return. Derivatives are generally used to hedge risk, but can also be used for speculative purposes.
Drought	One of the most commonly requested perils by farmers, but it is also one of the most difficult perils to insure because of problems of its definition, isolation, and measurement of effects on crop production. In contrast to most weather perils, drought is a progressive phenomenon, in terms of an accumulating soil moisture deficit for plant growth, and its impact on crop production and yields is often extremely difficult to predict, then measure and isolate from other non insured causes.
El Niño	A warming of sea surface temperatures in the equatorial Pacific Ocean associated with dramatic changes in the weather patterns of the region and worldwide.

El Niño Southern Oscillation (ENSO)	ENSO is an oceanic-atmospheric process that results from interaction between the temperature of the equatorial Pacific Ocean and the atmosphere. Changes in the ocean impact the atmosphere and climate patterns around the globe. In turn, changes in the atmosphere impact the ocean temperatures and currents. The system oscillates between warmer than average (El Niño) and cooler than average (La Niña) conditions.
***Ex ante* Risk Financing**	The process of managing the financial consequences of risk *prior to* a potential risk event through instruments such as insurance contracts, CAT bonds, reinsurance, or options contracts. In the context of this paper, we use risk financing to describe the methods insurers must use to manage correlated risk in their insurance portfolio.
Exposure	The possibility of financial loss based on the probability of an event occurring. In regard to insurance, the amount (sum insured), exposed to the insured peril(s) at any one time. In crop insurance, exposure may increase then decrease during the coverage period, following the growth stages of the crop from planting to completion of harvest.
Financial Intermediary	An institution such as an insurance company, bank, or microfinance institution that serves as a middle man or acts as a go-between for sellers and buyers of financial services such as credit or insurance.
Financial Risk	Risk that income will not reach expected levels or the invested value in a crop will be lost due to adverse changes in weather and price. Many agricultural production cycles stretch over long periods of time, and farmers must anticipate expenses that can only be recouped once the product is marketed, leading to cash flow problems that can be made even more severe by a lack of access to credit or the high cost of borrowing in rural areas.

Indemnity	The amount payable by the insurer to the insured, either in the form of cash, repair, replacement, or reinstatement in the event of an insured loss. This amount is measured by the extent of the insured's pecuniary loss. It is set at a figure equal to but not more than the actual value of the subject matter insured just before the loss, subject to the adequacy of the sum insured. This means for many crops that an escalating indemnity level is established, as the growing season progresses.
Index Insurance	Index insurance makes indemnity payments based not on an assessment of the policyholder's individual loss, but rather on measures of an index that is correlated with losses and serves as a proxy for actual losses. Two types of agricultural index insurance products are products based on area yields (where the area is some unit of geographical aggregation larger than the farm) and products based on measurable weather events. *See also* ***Weather Index Insurance.***
Insurance	A financial mechanism which aims at reducing the uncertainty of loss by pooling a large number of uncertainties so that the burden of loss is distributed. Generally each policyholder pays a contribution to a fund in the form of a premium, commensurate with the risk he introduces. The insurer uses these funds to pay the losses (indemnities) suffered by any of the insured.
Insurance Agent	The person who solicits, negotiates or implements insurance contracts on behalf of the insurer.
Insurance Policy	A formal document including all clauses, riders, endorsements which expresses the terms, exceptions, and conditions of the contract of insurance between the insurer and the insured. It is not the contract itself but evidence of the contract.

Loss Adjustment	Determination of the extent of damage resulting from occurrence of an insured peril and settlement of the claim. Loss adjustment is carried out by the appointed loss adjuster who works on behalf of the insurer.
Macro Level	The economic level at which countries and large donor agencies working with these countries experience risk of weather-induced humanitarian crisis or economic instability caused by price volatility.
Moral Hazard	A change of behavior that increases the chance of loss because of the existence of insurance. Examples of moral hazard can range from poor management or carelessness to fraud specifically targeted at creating losses and collecting on the insurance.
Premium	The monetary sum payable by the insured to the insurer for the period (or term) of insurance granted by the policy.
Premium Rate	The price per unit of insurance. Normally expressed as a percent of the sum insured.
Reinsurance	When the total exposure of a risk or group of risks presents the potential for losses beyond the limit which is prudent for an insurance company to carry, the insurance company may purchase reinsurance, i.e., insurance of the insurance. Reinsurance has many advantages including (i) leveling the results of the insurance company over a period of time; (ii) limiting the exposure of individual risks and restricting losses paid out by the insurance company; (iii)may increase an insurance company's solvency margin (percent of capital and reserves to net premium income), hence the company's financial strength. (iv) The reinsurer participates in the profits of the insurance company, but also contributes to the losses, the net result being a more stable loss ratio over the period of insurance.

Reinsurer	A company that sells reinsurance. Commercial reinsurers often operate on a global scale where they are able to pool a diverse portfolio of large risks to reduce their overall risk exposure. *See also* ***Reinsurance.***
Risk Assessment	The qualitative and quantitative evaluation of risk. The process includes describing potential adverse effects, evaluating the magnitude of each risk, estimating potential exposure to the risk, estimating the range of likely effects given the likely exposures, and attempting to describe the probabilities associated with various events.
Risk Financing	The process of managing the financial consequences of risk through instruments such as insurance contracts, CAT bonds, reinsurance, or options contracts.
Risk Management	Systematic decision making process for the identification and evaluation of potential hazards and exposure to loss faced by an organization or individual (for example, making a risk assessment). The process also involves selection and implementation of the most appropriate techniques for treating such hazards and exposures. *See also* ***Risk Mitigation, Risk Transfer.***
Risk Mitigation	Risk management actions taken before an event to reduce exposure to, severity of, or probability of loss from the event. Risk mitigation can be physical (for example building a flood wall) or financial (for example, risk transfer).
Risk Transfer	The process of shifting the burden of financial loss or responsibility for risk financing to another party through insurance, reinsurance, futures exchange transactions, legislation, or other means. Risk transfer is an *ex ante* risk management strategy used to mitigate the financial impact of potential risks.

Shock	An unexpected traumatic event such as death in the family or loss of land and livestock which can be caused by catastrophic weather events or other unexpected phenomenon. Price shocks occur when the price of commodity changes dramatically due to changes in local or global supply and demand, affecting the livelihood of households dependent on this commodity either for income or caloric intake. Economic shocks can occur at the micro, meso and macro levels and can have long-term consequences for the economic well-being of actors at each level.
Stakeholder	Individual who has a vested interest in the topic being discussed. For example, insurers, reinsurers, insurance regulators, delivery agents, households, etc., involved in an insurance program are stakeholders.
Traditional Agricultural Insurance	Insurance in agriculture has historically underwritten a particular crop on a particular plot of land. This insurance is priced by using historical farm yield data. In the event of a loss from an insured event, a trained claims agent will visit the plot of land and assess the amount of damage accrued. One of the most common forms of traditional agricultural insurance is multiple peril crop insurance.
Underwrite	Process of selecting and rating risks for insurance purposes.
Weather Index Insurance	Contingent claims contracts for which payouts are determined by an objective weather parameter that is highly correlated with farm-level yields or revenue outcomes, such as rainfall levels, temperature, or soil moisture. *See also* ***Index Insurance.***
Weather Risk	The risk of physical damage and/or financial loss from adverse weather events such as hurricanes, flooding, or drought. When weather risks are correlated, the losses are greater due to their wider geographical impact. See also ***Correlated Risk.***

Yield Loss/Yield Risk	A risk unique to agricultural producers; unlike most other entrepreneurs, agricultural producers cannot predict the amount of output that the production process will yield due to external factors such as weather, pests, and diseases.

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