World Food Programme
Programme Alimentaire Mondial
Programa Mundial de Alimentos
برنامج الأغذية العالمي

Executive Board
Second Regular Session

Rome, 7–11 November 2005

PROJECTS FOR EXECUTIVE BOARD APPROVAL

Agenda item 8

For approval

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Distribution: GENERAL
WFP/EB.2/2005/8-A
17 October 2005
ORIGINAL: ENGLISH

PILOT DEVELOPMENT PROJECT—ETHIOPIA DROUGHT INSURANCE 10486.0

Duration of project	12 months (1 January 2006–31 December 2006)

NOTE TO THE EXECUTIVE BOARD

This document is submitted for approval by the Executive Board.

The Secretariat invites members of the Board who may have questions of a technical nature with regard to this document to contact the WFP staff focal points indicated below, preferably well in advance of the Board's meeting.

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EXECUTIVE SUMMARY

The objective of this pilot development project is to contribute to an ex-ante risk-management system to protect the livelihoods of Ethiopians vulnerable to severe and catastrophic weather risks. The pilot uses a weather derivative to demonstrate the feasibility of establishing contingency funding for an effective aid response in the event of contractually specified severe and catastrophic shortfalls in precipitation.

The model covers 17 million people, living in 278 *woredas* (districts) in Ethiopia, which can be associated with 26 class 1 weather stations. The average income loss of this population is US$28 million per year, with a maximum loss of US$80 million in 1984 and a theoretical worst-case potential loss of US$154 million. This is the cost of the loss to the population, not the cost of the operation to transfer that value to them. For this pilot project, pastoralists will not be covered because of the difficulty in obtaining demographic and weather data for the areas in which they are concentrated.

The pilot project will put in place a small hedge with a US$2 million maximum premium for Ethiopia's 2006 agricultural season from March to October 2006, demonstrating the possibility of transferring the weather risks of least-developed countries and facilitating price discovery for Ethiopian drought risk in international financial markets. This pilot project is the first step in a process leading towards ex-ante risk management in developing countries involving governments, donors and private-sector international risk markets. The greater timeliness of event-specific contingency funding will make aid more efficient in saving livelihoods by protecting vulnerable populations against distressed productive asset depletion in response to severe and catastrophic weather shocks. The price discovery for Ethiopian weather risk in the international risk markets will enable Ethiopia to manage weather risk more effectively, especially with regard to future climate change.

DRAFT DECISION*

The Board approves "Pilot Development Project: Ethiopia Drought Insurance 10486.0" (WFP/EB.2/2005/8-A).

* This is a draft decision. For the final decision adopted by the Board, please refer to the Decisions and Recommendations document issued at the end of the session.

Context and Rationale

Improving Developing Country Risk Management

1. Beginning with an informal consultation in July, 2004, WFP has engaged the membership on the issue of weather-risk management in developing countries. In consultations in April 2005 and during EB.A/ 2005, the Secretariat presented a prototype weather-risk protection model for Ethiopia. At a subsequent consultation in September 2005, the membership endorsed a pilot project to be submitted for approval to EB.2/2005. The objective of this development pilot project is to contribute to ex-ante risk management system to protect the livelihoods of Ethiopians vulnerable to severe and catastrophic climate risks. The pilot uses a weather derivative to demonstrate the feasibility of establishing contingency funding for an effective aid response in the event of contractually specified severe and catastrophic shortfalls in precipitation.

2. The pilot project will (i) put in place an experimental hedge with a US$2 million maximum premium for Ethiopia's 2006 agricultural season (March-October), demonstrating the possibility of transferring the weather risks of least-developed countries (LDCs), and (ii) facilitate price discovery for Ethiopian drought risk in international financial markets. The pilot is the first step in a process towards ex-ante risk management in developing countries involving governments, donors and private-sector international risk markets.[1] The greater timeliness of event-specific contingency funding will make aid more efficient in saving livelihoods by protecting vulnerable populations against distressed productive asset depletion in response to severe and catastrophic weather shocks. Preventing asset depletion through timely aid reduces the costs of future food aid needed to save the lives of those left without productive assets and facing the indignity of destitution.

3. Determining the price of Ethiopian weather risk in the international risk markets — price discovery — will enable Ethiopia to manage climate risk more effectively, especially with regard to future climate change.[2] This pilot is therefore critical for risk management, especially in Africa. The population currently at risk because of drought is 250 million; it will rise to 400 million by 2030.[3] Current ex-post approaches risk significant loss of livelihoods, even in well-funded emergency responses, and may not be able to cope.

TABLE 1: POPULATION STATISTICS FOR ETHIOPIA AND SUB-SAHARAN AFRICA (MILLIONS)

	2005	2015	2030
Population (Ethiopia)	73	95	129
Population under 15 (Ethiopia)	31	38	43
Population at risk of drought (Ethiopia)	~ 22	~ 28	~ 37
Population at risk of drought (sub-Saharan Africa)	~ 250	~ 300	~ 400

[1] Hess, U. (ed.) 2005. An exhaustive review and roadmap for improved developing-country risk management, including discussion of the present pilot project on pp. 50–54.

[2] Sperling and Szekely, 2005.

[3] WFP. 2005. VAM Analysis, June. Rome.

4. New financial instruments and development research[4] are creating opportunities for better ex-ante risk management to enable developing countries to cope better with vulnerability to drought. In 2003, WFP's business process review (BPR) project began transferring risks associated with uneven resource flows away from beneficiary populations to the Working-Capital Facility (WCF), where these risks can be managed more effectively. Building on WFP's improved financial system and taking into account new development research, recognizing the *de facto* insurance function of WFP's emergency assistance[5] in Ethiopia, this pilot project exploits these new opportunities in order to create better tools to help poor populations manage weather shocks. It was developed in collaboration with the World Bank Commodity Risk Management Group (CRMG) and the International Taskforce for Commodity Risk Management.

5. In recognizing the challenge and the new opportunities, WFP's Business Planning Unit (OEDBP), the country office Ethiopia and the World Bank Agricultural and Rural Development (ARD) CRMG joined forces to develop risk-management solutions for developing countries focused on low-probability, high-consequence weather risk events as they relate to poor rural households. This combination of the World Bank's development research and financial expertise and WFP's operational experience and established food security infrastructure created the possibility for an effective pilot project. By managing WFP's exposure to implementing timely emergency operations in times of drought through secured financing, WFP can indirectly begin to manage the risks of its potential beneficiaries. If WFP – and as soon as possible the Government of Ethiopia – can transfer the costs of the most risky events from vulnerable farmers through insurance, the impacts will protect livelihoods as a result of timely assistance, and the safety net thus provided will encourage income growth and productivity.[6]

6. A critical part of this new approach is to connect LDCs to financial markets for weather events. There are numerous reasons why transferring risk out of developing countries to international markets is important. Natural disasters impede development, push households into poverty and drain the financial resources of developing countries. Many natural disasters are directly tied to extreme weather events, which have devastating impacts on agriculture. Of the 1.3 billion people in the world living on less than US$1 per day, nearly three quarters depend on rain-fed agriculture. In many countries, agricultural development will help to encourage overall economic development. There is a strong link between weather, the livelihoods of poor people and development – yet there are no effective ex-ante solutions for weather risks in developing countries.[7]

7. Developing countries, WFP, the World Bank and consequently the donor community are currently heavily exposed to natural disaster risk via ex-post actions such as emergency response, financial bailouts and debt forgiveness. None of these responses are adequate.

8. Subsistence farmers utilize various risk-coping and risk-management strategies, many of which are inefficient when faced with systematic covariant shocks such as weather events. Economic development literature is full of cases illustrating how poor risk-averse farmers

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[4] Dercon (ed.) 2005.

[5] World Bank, 2004, especially pp. 109-111 for the insurance role of WFP emergency food assistance. For an early recognition of this role see: United Nations, 1991, p. 79. Only recently have financial innovations created opportunities to pursue this early vision. See also Annex 4 of the *Porto Alegre Declaration* by the Governments of Brazil and Spain highlighting WFP's role as a *de facto* insurance provider for vulnerable populations.

[6] Hess (ed.), 2005, pp. 38–39.

[7] Ibid, pp. 25–35.

give up potentially higher incomes to reduce exposure to risk.[8] Individual households and society in general incur costs to smooth consumption across income shocks, at the expense of longer-term development.

9. The goal of this project is not be to replace the current emergency system but to strengthen it by providing a timely first line of response to protect vulnerable households' livelihoods more effectively and efficiently, specifically those not covered under the current safety-net programme and beyond the protracted relief budget capacity of WFP and others. Once the feasibility of establishing event-specific, contractually guaranteed contingency funding is demonstrated, country offices will be able to use these mechanisms to secure contingency funding on the basis of contingency plans designed to save livelihoods in the event of contractually specified shocks. These contingency plans, for which contingency funding would then be established, would aim to transfer resources to vulnerable households to reduce the probability of early depletion of assets and malnutrition and reduce future food aid requirements. From a financing perspective, the intervention also makes use of the currently underutilized potential of risk-management markets to complement public resources in responding to national emergencies.

10. Low-probability but high-impact weather risks are highly correlated geographically: a drought in Ethiopia often means a drought over the entire Horn of Africa, or even sub-Saharan Africa as in 1984, and require special financing and transfer to global markets where risks can be pooled and diversified and so more easily managed as part of international risk portfolios. A significant contribution of this pilot project is the introduction of index-based insurance and identifying ways in which it can be used for risk transfer at the macro-level. In particular, by using index insurance products it is possible to organize systems to take advantage of global markets and transfer out of developing countries the risks associated with low-probability, high-impact events.[9] Although an initial risk transfer will not be able to exploit the pricing advantages of a diversified risk portfolio, it is a necessary first step in constructing a more financially effective weather-risk portfolio for developing and least-developed countries.[10]

Context of Ethiopia[11]

11. Ethiopia is a low-income food-deficit country. Chronic food insecurity affects 10 percent of the population; even in normal rainfall years these households cannot meet their food needs and rely partly on food aid. As a consequence of the 2002 drought, the second most severe in recent history, a record 13 million Ethiopians required emergency assistance in 2003 at a cost of US$600 million. In the last ten years, an average 870,000 mt of food aid has been provided annually, primarily through emergency response. Millions of lives have been saved, but destitution has worsened, people's assets have been eroded and vulnerability has increased. In the absence of a firm baseline, accurate numbers are difficult to determine but the 2002 drought appears to have pushed as many as 1–2 million previously vulnerable people into destitution.[12]

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[8] Ibid, pp. 7–8.

[9] Shiller, 2003.

[10] World Bank, 2005. Includes discussion of the portfolio effect on LDC risk.

[11] PRRO Ethiopia 10362.0 "Enabling Livelihood Protection and Promotion" (WFP/EB.3/2004/8-B/4), para. 1–7.

[12] WFP 2005 and Bekele *et al*., 2004.

12. Household access to food is severely constrained. In chronically food-insecure areas, smallholders typically produce part of their annual cereal requirement and are dependent on the market and emergency assistance for the remainder. This project targets smallholders who are food secure in years of no or mild drought but who would require assistance in years of severe drought. There are few off-farm earning opportunities, and purchasing power is limited; households cope by disinvesting — for example selling productive assets and animals — and unsustainably exploiting common environmental resources or migrating in search of employment.[13]

13. Farmers have developed many risk-sharing and risk-smoothing strategies, but these fail in times of covariate shocks such as drought in areas that depend on rain-fed agriculture. Traditional coping mechanisms address idiosyncratic shocks well — for example family illness, accidents, livestock death and fire — but they have limited scope for shocks that affect entire risk-sharing communities.

14. Because of the extreme and covariant nature of the risks they face, and in the absence of risk-management instruments such as crop insurance,[14] risk-averse smallholder farmers naturally seek to minimize their exposure. For example, they will choose to minimize investments in their operations by opting for lower-value (lower-risk) and therefore lower-return crops, using little or no fertilizer and over-diversifying their income sources. These risk-management choices also keep farmers from taking advantage of profitable opportunities; they are a fundamental cause of continued poverty.[15]

15. If a smallholder can be sure that timely, sufficient and guaranteed assistance will be available in times of extreme covariant shock such as drought — a *de facto* risk-management opportunity — he or she may be encouraged to engage in more profitable income strategies such as purchasing better seeds or using more fertilizer, avoiding the financial risks of such activities should a major drought occur.

Government Policies and Intervention Approaches

16. In 2004, the Government of Ethiopia, donors, United Nations agencies and non-governmental organizations (NGOs) launched the New Coalition for Food Security, whose goal is to achieve food security for the 5–6 million people in Ethiopia categorized as "chronically food-insecure" through a productive safety net and to improve food security significantly for the additional 10 million people who are vulnerable.[16]

17. With the advent of the productive safety net, the Government has made a clear distinction between the safety-net programme, the aim of which is to change the vulnerability and risk profile of chronically food-insecure people, and emergency operations (EMOPs). Responses to chronic food shortages will be addressed through the productive safety-net programme coordinated by the Food Security Coordination Bureau (FSCB) created under the Ministry of Agriculture and Rural Development; responses to emergency food shortages will be addressed through the Disaster Prevention and Preparedness Commission (DPPC).[17]

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[13] World Bank, 2004.

[14] On the inappropriateness of traditional crop insurance for developing countries see Hess (ed.) 2005.

[15] Dercon, 2005.

[16] PRRO Ethiopia 10362.0 (WFP/EB.3/2004/8-B/4), p. 3.

[17] Government of Ethiopia, 2004.

18. While the safety net is attempting to address the food-insecure population, WFP and the World Bank CRMG have investigated the feasibility of insurance as a reliable, timely and cost-effective way of funding EMOPs. The aim is to address extreme emergency needs situations Response mechanisms are in place to deal with small—scale or local droughts, grain reserves are in place and a small contingency fund is built into the current PRRO in Ethiopia, but these mechanisms would be insufficient in the face of a severe country-wide drought on the scale of 2002-2003. Hence the aim of the pilot is to establish the feasibility of contingency funding to protect vulnerable populations who are not food insecure and so not included in the safety-net programme but who are at-risk to income and asset losses and consumption shocks resulting from severe natural disasters. An estimated additional 25-35 percent of the population is at risk in the event of an extreme drought. This insurance project is a financing tool for such high-impact, low-frequency droughts in Ethiopia.

19. Reducing poverty remains the core objective of Ethiopia's Sustainable Development and Poverty-Reduction Programme (SDPRP); food security and agricultural development are priorities. The Millennium Project will further support Ethiopia's poverty-reduction plans, working towards the Millennium Development Goals (MDGs) by 2015. This pilot project, which suggests a macro-level agricultural risk management approach for Ethiopia's rural at-risk population, is in line with the Government's current poverty-reduction strategy, which focuses on (i) agriculture-led rural-based growth, recognizing the importance of improving the environment for exports, private-sector growth and rural finance, and (ii) food security.[18]

PROJECT OBJECTIVES AND OUTPUTS

Overall Objective

20. The objective of this development pilot project is to contribute to the creation of an ex-ante risk-management system to protect the livelihoods of Ethiopians vulnerable to severe and catastrophic climate risks.

21. In terms of the major objectives of WFP, this project contributes to the following Strategic Priorities (SPs):

- SP 2: Protect livelihoods in crisis situations and enhance resilience to shocks. The project protects the livelihoods of normally food-secure but at-risk populations in Ethiopia from the effects of severe drought. By establishing the feasibility of contractually guaranteed contingency funding, the project contributes to a process that can create timely and appropriate funding to assist at-risk populations before they engage in negative coping mechanisms and can give this at-risk population the certainty they need to adopt better investment strategies, thus enabling development.

[18] Hess (ed.), 2005.

- SP 5: Help governments to establish and manage national food-assistance programmes. Weather-indexed insurance is a tool governments can use to manage the risk of severe drought. By quantifying, pricing and transferring the Ethiopia's weather risk, insurance can guarantee contingency funding for aid interventions in the event of severe drought. The index will also reinforce the current early-warning system by providing continuous information about the likelihood of a severe or catastrophic drought.

Objectives

22. The short-term objectives are to:
    - demonstrate the possibility of transferring LDC weather risks, especially Ethiopia's;
    - enable price discovery for Ethiopian weather risk in international financial markets;
    - set in motion a process for ex-ante risk management in Ethiopia and other developing countries; and
    - put in place a small derivative contract to hedge against the effects of severe drought for Ethiopia's 2006 agricultural season.

Outputs

23. The main outputs are:
    - quantification of Ethiopia's drought risk — rainfall index and coverage calculations;
    - a derivative contract based on a rainfall index — the legal contract stipulating the index and payout conditions; and
    - transfer of Ethiopia's 2006 drought risk to international reinsurers or retention by donors on the same terms.

PROJECT STRATEGY

24. The strategy to achieve the aim of the project consists of two steps complementary to WFP's traditional approach:
    i) quantification of the risk — an ex-ante needs assessment establishing income losses and needs resulting from defined weather variations; and
    ii) establishing the risk-transfer structure as the basis for an ex-ante experimental funding appeal; the pilot uses an index-based weather derivative contract to establish contingency funding for effective aid response in the event of contractually specified severe and catastrophic shortfalls in precipitation.

25. This is the first attempt to build such a risk-management system; the discussion below provides sufficient detail on the methods used. In this project, risk quantification is the basis for a national, macro-level hedge,[19] but its household-level design builds a basis for possible subsequent lower-level insurance schemes. If the small experimental hedge is triggered by a severe to catastrophic national drought in 2006, the resulting payout would

[19] Although the risk has been quantified at the national level, WFP is not implying responsibility for the entire Ethiopian population; this is shared with other partners and the Government, which coordinates aid efforts.

simply be a contribution to the WFP country office emergency response. Once the experimental hedge demonstrates the feasibility of creating contingency funding based on the mechanism described below, the Government, especially DPPC, the Ethiopia country office and other partners can consider creating contingency plans for 2007 and beyond to be funded through a similar mechanism.

Quantifying the Risk

26. A prerequisite for being able to manage risk financially — including pricing and decisions on retaining or transferring the risk to the global financial markets — is the definition of an independent, objective, verifiable and replicable index of livelihood losses, on which the weather derivative contract is based. Over 85 percent of Ethiopians make their living from predominantly rain-fed agriculture; more than 95 percent of agricultural production is by subsistence and smallholder farmers.[20] The livelihoods of the vast majority of Ethiopians is therefore critically dependent on the amount and distribution of rainfall and hence the success or failure of the two primary growing seasons, the *belg* (minor growing season, March/April–July) and the *meher* (main growing season, May–November).

27. Using the standards of the United Nations World Meteorological Organization (WMO), rainfall is one of the few independent, objective and early indicators[21] available to monitor production and therefore livelihood losses, although it is not the only critical factor. It is the only objective indicator with a long record — over 30 years of National Meteorological Services Agency (NMSA) data — available to quantify the risk, probability and magnitude of extreme drought events in Ethiopia. Rainfall is therefore the basis of the index and risk-transfer mechanism of this pilot. The rainfall index and the structure to be used to manage extreme and catastrophic drought risk financially, including transfer to the international weather market, are outlined below.

Methodology

28. This section summarizes the methodology used to develop the index and discusses its implications for national production and how it captures the evolution of extreme drought events in Ethiopia. Readers wishing to omit the technical aspects of the methodology can go directly to paragraph 80.

29. Quantifying the risk and magnitude of livelihood loss resulting from drought for rural populations living in the agriculturally productive regions of Ethiopia[22] requires five steps:

- assessment of the quality of rainfall data;
- spatial analysis to define the geographical coverage of the NMSA weather-station network and the micro-climates associated with selected stations;

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[20] Hunde, 2004.

[21] Other indicators include satellite-derived normalized difference vegetation indices, agricultural production, livestock production, crop assessment, crop and pasture diseases, fluctuations of market prices over time and by location, household income, access to markets and transport, access to water for irrigation and drinking, stunting, wasting, underweight indicators and HIV/AIDS statistics.

[22] The initial pilot programme does not consider the 15 percent of the population living in pastoral areas, which do not have a reliable or dense enough weather-monitoring network; the underlying data necessary to quantify livestock and pastoral losses as a result of drought are not available. However, should the programme continue beyond the first year pilot phase, further research could enable the project to consider these regions in the future.

- identification of the dominant crops grown in each micro-climate and how production can be indexed to rainfall amount and distribution;
- collection of information on economic exposure per household and the number of households at risk to drought-related agricultural income shocks in each micro-climate; and
- definition of a market-price inflation factor to ensure income losses are appropriately adjusted to compensate for reduced household purchasing power resulting from increased market prices associated with extreme drought.

Rainfall Data

30. NMSA in Addis Ababa controls and monitors 600 weather stations in Ethiopia. Of these, 17 are 24 hour synoptic (SYNOP) stations, which report every three hours to WMO Global Telecommunication System (GTS), when communication permits; an additional 50–60 stations report daily to the Addis Ababa office.[23] NMSA plans to increase its observation network to 2,500 stations, 200 of which will be Class 1. Historical data is available from the NMSA data centre in Addis Ababa; historical datasets for Class 1 stations were made available to the project team in soft copy in daily resolution. Years of civil war have limited historical data from some regions, however: several stations in the Tigray region, particularly in the north, have data missing for four to five years in the early 1990s;[24] other regions have one or two years of data missing in the early 1990s. Despite these gaps, most stations were established in the mid-1970s or earlier and there are several stations with complete 30-year or 50-year records.

31. In view of the constraints outlined above, the pilot project only uses Class 1 stations with good historical data. As the premium associated with weather-risk management strategies is based on a sound actuarial analysis of the underlying risk, the quality of historical and on-going weather data is paramount. To implement a successful weather-risk management programme, the data used to construct the underlying weather indices must adhere to strict quality requirements, including: [25]

- reliable daily collection and reporting procedures;
- daily quality control and cleaning;
- an independent source of data for verification such as GTS weather stations; and
- a long, clean and internally consistent historical record to allow for actuarial analysis of the weather risks involved – at least 30 years of daily data is ideally required.

[23] These are Class 1 stations: fully equipped meteorological observing stations recording pressure, temperature, relative humidity, wind speed and direction, rainfall, evaporation and soil temperature every three hours from 06.00 to 18.00.

[24] For example, Mekele station in Tigray region has data missing for 1989-1991 because of civil conflict. But these years were not extreme drought years.

[25] Hess and Syroka, 2005.

32. A preliminary study of the historical data identified 44 Class 1 stations well distributed around the country (see Figure 1; Table 2) which potentially meet the above criteria. To ensure that the data from these stations was of the required quality, WFP retained Earth Satellite Corporation (EarthSat) and Risk Management Solutions (RMS)[26] to perform data cleaning of precipitation data for the 44 locations and for 162 surrounding stations from the NMSA acquired by WFP. Data cleaning is a process in which raw weather data is analysed to identify missing values and values that are likely to be erroneous; once these have been identified they are replaced with values that represent a best estimate of the actual weather. The final dataset consisted of data for 42 of the 44 stations,[27] with no missing values in the cleaned data.[28] EarthSat/RMS described the quality of the final dataset as "excellent" when compared with similar precipitation datasets for other developing countries, and on a par with the quality of cleaned precipitation data available for some European countries.[29]

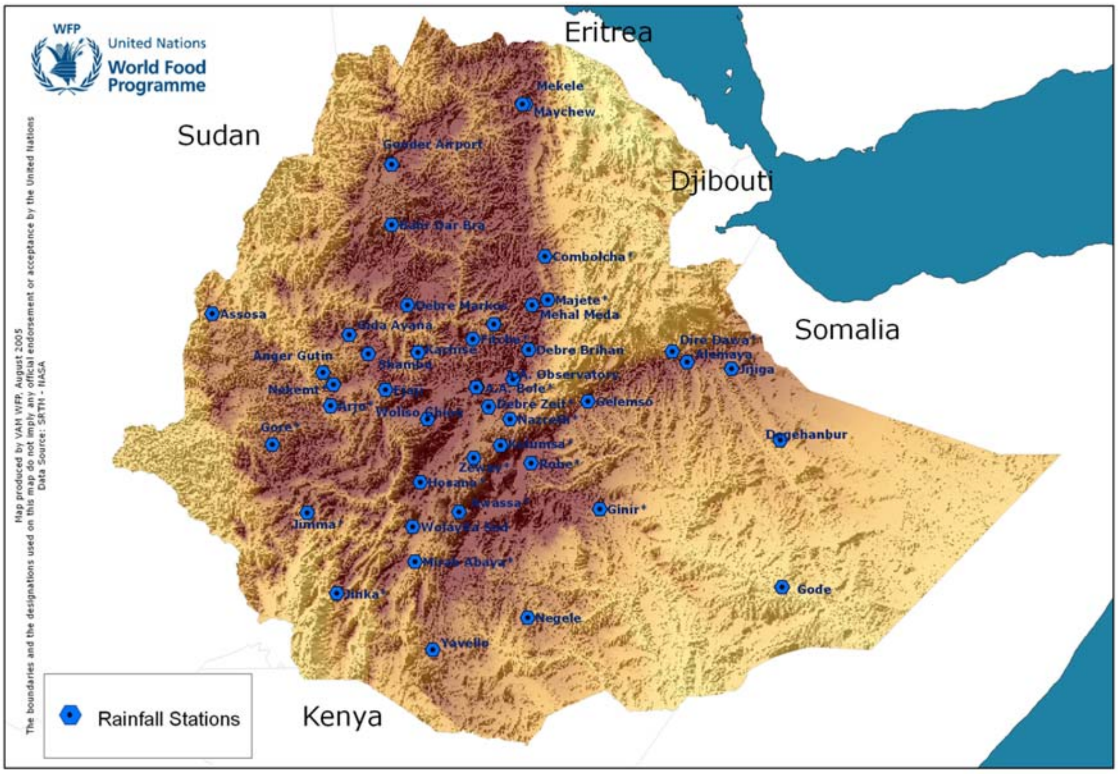
[26] EarthSat and RMS have been dealing with meteorological data since they were founded 30 and 15 years ago respectively. In particular, they have worked with the weather-derivatives industry in the last six years, supplying most of the data used. Most players in the weather market use data from EarthSat/RMS, which supply data for all countries in which weather derivatives are traded. To be able to supply official data, EarthSat has agreements with national meteorological services that allow them to obtain, clean and redistribute data. The EarthSat cleaned-data catalogue includes daily and hourly temperatures and precipitation for locations from Miami to Tokyo. The Chicago Mercantile Exchange (CME) weather-futures contracts in Europe, Japan and the United States are based entirely on data from EarthSat, which acquires it from national meteorological services, cleans it, and supplies it to CME so that it can settle contracts on a daily basis.

[27] EarthSat/RMS were unable to produce cleaned data for the remaining two stations, Degahebour and Gode in the southeast pastoral region of Somali, because of their remoteness and the poor quality of the data.

[28] The length of the cleaned record provided by EarthSat/RMS is a function of the number surrounding stations available at a particular time and the length of those historical records. Hence, not all station data can be cleaned from station establishment to date.

[29] EarthSat/RMS. 2005. 5

Figure 1: Location of the Class 1 Weather Stations Whose Data was Cleaned for the Insurance Project [30]



30 Refer to Table 2 for station names and details.

TABLE 2: ETHIOPIA WEATHER STATIONS SHORT-LISTED FOR THE INSURANCE PROJECT

Station code	Station name	Zone	Latitude (dec)	Longitude (dec)	Elevation (m)	Station establishment (year)	Cleaned: start date	Cleaned: end date	% daily missing from 1974**
0104030	Maychew	Southern	13.5000	39.5333	2 360	1975	1992-04-01	2004-06-30	49.47
0104031	Mekele Airport*	Mekele	13.5000	39.4833	2 070	1963	1992-01-01	2004-06-30	12.53
0301100	Gonder Airport*	North Gonder	12.5500	37.4167	1 967	1952	1980-01-01	2004-06-30	0.56
0304090	Combolcha*	South Wello	11.1000	39.8333	1 903	1958	1981-01-01	2004-06-30	0.14
0305020	Alem Ketema*	North Shewa	10.0333	39.0333	2 280	1973	1974-01-01	2004-06-30	0.00
0305050	Majete*	North Shewa	10.4167	39.8833	2 000	1962	1974-01-01	2004-06-30	0.00
0306080	Debre Markos*	West Gojam	10.3333	37.6667	2 515	1953	1974-01-01	2004-06-30	0.00
0306081	Mehal Meda	North Shewa	10.3333	39.6333	3 040	1980	1974-05-01	2004-06-30	1.08
0307042	Bahr Dar branch office*	West Gojam	11.6000	37.4167	1 770	1994	1986-01-01	2004-06-30	0.17
0402030	Gida Ayana	East Wellega	9.8667	36.7500	1850	1958	1981-01-01	2004-06-30	5.44
0402080	Kachise	W/Shewa	9.5833	37.8333	2 520	1955	1986-04-01	2004-06-30	30.94
0402100	Shambu	Eastern Wellega	9.5667	37.0500	2 430	1950	1987-02-01	2004-06-30	33.08
0402140	Anger Gutin	East Wellega	9.2667	36.3333	1 350	1972	1979-02-01	2004-06-30	9.10
0402141	Nekemt*	Eastern Wellega	9.0833	36.5000	2 080	1970	1980-01-01	2004-06-30	0.05
0403050	Arjo*	East Wellega	8.7500	36.4500	2 565	1955	1979-01-01	2004-06-30	0.91
0403110	Gore*	Illubabor	8.1500	35.5333	2 002	1952	1979-01-01	2004-06-30	0.59
0405050	Ejaji	West Shewa	9.0000	37.3167	1 900	1965	1983-05-01	2004-06-30	18.31
0405100	A.A. Bole*	3	9.0333	38.7667	2 354	1955	1954-01-01	2004-06-30	0.00
0405101	Shola Gebya*	North Shewa	9.1667	39.3333	2 500	1962	1962-03-01	2004-06-30	0.00
0405110	Fitche*	North Shewa	9.8000	38.7000	2 750	1954	1973-03-01	2004-06-30	0.00
0405120	A.A. Observatory	1	9.0333	38.7500	2 408	1944	1954-01-01	2004-06-30	0.00
0406100	Debre Brihan	North Shewa	9.6333	39.5833	2 750	1956	1975-01-01	2004-06-30	1.38
0407030	Nazreth*	Eastern Shewa	8.5500	39.2833	1 622	1963	1972-01-01	2004-06-30	0.00
0407090	Zeway*	Eastern Shewa	7.9333	38.7167	1 640	1968	1975-01-01	2004-06-30	0.00

TABLE 2: ETHIOPIA WEATHER STATIONS SHORT-LISTED FOR THE INSURANCE PROJECT									
Station code	**Station name**	**Zone**	**Latitude (dec)**	**Longitude (dec)**	**Elevation (m)**	**Station establishment (year)**	**Cleaned: start date**	**Cleaned: end date**	**% daily missing from 1974****
0408030	Gelemso	East Hararge	8.8167	40.5167	1 940	1962	2002-01-01	2004-06-30	33.87
0408060	Kulumsa*	Arsi	8.1333	39.1333	2 200	1963	1975-01-01	2004-06-30	0.00
0408140	Robe*	Arsi	7.8500	39.6167	2 400	1968	1980-01-01	2004-06-30	1.73
0410040	Jijiga	Jijiga	9.3333	42.7833	1 775	1968	2000-01-01	2004-06-30	47.03
0410060	Alemaya	East Hararge	9.4333	42.0833	2 125	1954	1997-01-01	2004-06-30	26.38
0410110	Dire Dawa*	Dire Dawa	9.6000	41.8500	1 260	1952	1980-01-01	2004-06-30	0.13
0411150	Ginir*	Bale	7.1333	40.7000	1 750	1959	1981-01-01	2004-06-30	0.83
0412051	Yavello	Borena	4.9167	38.0667	1 740	1980	1987-01-01	2004-06-30	31.70
0413010	Negele	Borena	5.4167	39.5667	1 544	1966	1993-01-01	2004-06-30	7.33
0504020	Degehabour	Degehabour	8.2167	43.5500	1 070	1968	1997-03-01	2004-06-30	> 20.30
0508040	Gode	Kebri Dehar	5.9000	43.5833	295	1967	1993-08-01	2004-06-30	29.97
0603030	Assosa	Assosa	10.2000	34.5833	1 600	1850	2000-01-01	2004-06-30	25.53
0701010	Woliso/Ghion	W/Shewa	8.5500	37.9833	2 000	1962	1983-05-01	2004-06-30	30.59
0701050	Debre Zeit*	Eastern Shewa	8.7333	38.9500	1 900	1951	1965-01-01	2004-06-30	0.00
0702040	Hosana*	Hadiya	7.5500	37.8667	2 200	1953	1972-03-01	2004-06-30	0.00
0704021	Awassa*	Sidama	7.0833	38.4833	1 750	1972	1972-08-01	2004-06-30	0.00
0707030	Jinka*	South Omo	5.8000	36.5500	1 480	1983	1979-01-01	2004-06-30	0.69
0708030	Wolayita Sodo*	Wolayita	6.8500	37.7500	1 800	1962	1972-01-01	2004-06-30	0.00
0708040	Mirab Abaya*	Norh Omo	6.3000	37.7833	1 260	1972	1972-03-01	2004-06-30	0.00
0709040	Jimma*	Jimma	7.0667	36.0833	1 725	1952	1980-01-01	2004-06-30	0.19

* Starred stations are part of the final 26.
** Up to June 2004, including cleaned data where available.

Spatial Analysis

33. The Vulnerability Analysis and Mapping (VAM) Unit used spatial analysis techniques to assign *woredas* (districts) and hence rural populations to the 42 rainfall stations listed in Table 1. The objective was to find *woredas* whose normalized difference vegetation index (NDVI) patterns correlated with rainfall recorded at each of the 42 stations. The geographic layers used to perform the analysis were:

- 42 geo-referenced rainfall stations (source: NMSA);
- NDVI for 36 decads[31] per year from 1998 to 2003 (Source: SPOT Vegetation, 1 km^2 resolution); and
- elevation (source: GTOPO30 USGS[32]).

34. Rainfall data for each station was analysed to retrieve the rainfall average per decad in 1984–2004, giving the rainfall "signature" for that location. To identify the area represented by a given rainfall station, NDVI averages for the 36 decads from 1998–-003 were classed into ten clusters representing geographical areas that exhibited similar NDVI patterns throughout the year. The clusters were created by an unsupervised classification using ERDAS Imagine software to identify the ten dominant classes of NVDI variability. For each cluster, the underlying NDVI "signature" was analysed and compared with the rainfall signatures of stations in these clusters. NDVI clusters, *woredas* and each rainfall station were then combined to calculate the area represented by each NDVI cluster for which the rainfall station was representative. The following criteria were used to assign the *woredas* to rainfall stations:

i) the NDVI classification for the *woreda* and the rainfall signatures exhibit a similar pattern, i.e. they fall within the same "micro-climate";

ii) the area of the *woreda* represented by the NDVI cluster is greater than 50 percent; and

iii) the *woredas* with more than 50 percent of area represented by the NDVI cluster must be contiguous to other such *woredas* to be considered as represented by the station.

35. For some stations in the higher-producing and *enset* (false banana) growing regions in the southwest, where extended and reliable rainfall seasons allow for multiple sowing seasons, NDVI was found not to be the best indicator for assigning *woredas* to weather stations – that is, the NDVI "signature" in these areas did not correspond well with the rainfall station signatures. In these cases, only criteria (ii) and (iii) were used. In all cases, however, the *woredas* assigned to the 42 weather stations by the methodology outlined above corresponded extremely well when a correlation analysis was performed on rainfall data using all Class 1 NMSA weather stations. Rainfall data from stations within the same NDVI cluster exhibited good temporal correlations with other stations in the same cluster and exhibited weaker correlations with those outside the cluster.

36. To identify which of the *woredas* associated with the 42 weather stations were predominantly agricultural, geographical masks were used to extract the season type for each *woreda*. Three masks were provided in Arc/Info Export Grid format from the United States Geological Survey (USGS)/Famine Early-Warning Systems Network (FEWS-

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[31] Each month is divided into three decads, or ten-day periods; the third, from the 21st to the end of the month, can have from 8 to 11 days. For example, decad 8 is 11–20 March; decad 36 is 21–31 December.

[32] http://edcdaac.usgs.gov/gtopo30/gtopo30.asp.

NET).[33] The first outlined the *belg* areas, the second outlined the predominantly *kiremt* (m*ajor rainfall season; meher* growing season) areas and the third outlined regions thought to be long-cycle cereal-growing areas (March/April–October/November). The long-cycle regions were mapped by USGS/FEWS-NET using climatological ratios of precipitation and potential evaporation, aided by reference to the Crop Production System Zones (CPSZ) of the Food and Agriculture Organization of the United Nations (FAO).[34]

37. Using information from the masks, only *woredas* and stations with an area greater than 50 percent falling in a *kiremt* zone were kept for the subsequent risk analysis; these areas were thus defined as agricultural. Of the remaining *woredas*, those with an area greater than 50 percent falling in the long-cycle zone were labelled long-cycle crop growing *woredas*, areas whose climate enables production of high-yield, slow-maturing long-cycle crops such as maize, sorghum and millet.[35] *Woredas* with an area less than 50 percent falling in the long-cycle zone were labelled short-cycle crop growing *woredas*, areas whose climate enables only production of low-yield short-cycle crops such as wheat, *teff* (a staple grain crop), barley and short-cycle variants of maize and sorghum.[36] Of the 42 stations initially considered, therefore, only 26 were finally selected for the pilot project (see Table 2). These are stations with the longest historical records and available cleaned data located in agricultural areas identified according to the criteria outlined above. In total, 278 *woredas*[37] were associated with these stations by the spatial analysis (see the Annex).

Water Requirement Satisfaction Index

38. The FAO Water Requirement Satisfaction Index (WRSI) establishes how production of the dominant crops grown in each micro-climate can be indexed to rainfall amount and distribution. A description follows of the WRSI model, its inputs and assumptions, and the staple crop baskets for the *woredas* associated with the final 26 stations selected for this project.

Model Description

39. There are two main rainfall periods: (i) the *kiremt*, associated with the *meher* main growing season accounting for 95 percent of national production, and (ii) the *belg*, the minor rainfall and growing season that accounts for 5 percent of national production, but whose rains are important in vulnerable areas and vital for pasture regeneration, water supply and planting of long-cycle crops. If *belg* rains are low or there is a gap between the end of the *belg* rains and the beginning of the *kiremt* rains, long-cycle crop yields will be affected. *Meher* crop production combines high-yield long-cycle crops planted in the *belg* and harvested after the end of the m*eher* in September, and lower-yield short-cycle varieties. The high-yield long-cycle crops contribute 50 percent of national cereal production; short-cycle *meher* crops account for 40-44 percent.[38]

[33] USGS at the National Centre for Earth Resources Observation and Science (EROS), Sioux Falls, SD, USA.

[34] FEWS-NET. 2003.

[35] Ibid

[36] Ibid.

[37] This number excluded urban *woredas* that fell in NDVI cluster groups.

[38] FEWS-NET. 2003.

40. The pilot project uses the USGS/FEWS-NET WRSI[39], a modified version of the FAO WRSI[40] to index long-cycle and short-cycle crop yield and therefore production to rainfall variability.[41] There are many more robust and data-intensive physically-based crop models available, but FEWS-NET adapted the FAO WRSI model for geospatial implementation in 2002[42] because of its limited data requirements and simplicity in operational use and made it an operational model, with some modifications in the algorithm.[43] This drought insurance project therefore also chose the WRSI model, which has been successfully tested against ground crop production data for Africa, including Ethiopia, to monitor crop performance.[44]

Model Inputs and Assumptions

41. The inputs and data sources required to calibrate the WRSI model for an area and a crop during a growing season include:

i) cumulative decad rainfall (mm) for the 26 rainfall stations for as many years as are available (Source: NMSA);

ii) average decad potential evapo-transpiration (PET) (mm) for the 26 rainfall stations (Source: FEWS NET[45]);

iii) the water-holding capacity (WHC) (mm) of the soil, averaged over the woredas associated with the 26 stations (Source: FAO);[46]

[39] Senay and Verdin 2003.

[40] Frere and Popov, 1986.

[41] A well-timed water supply is necessary for optimum crop production. WRSI is an indicator of crop performance based on water availability during the growing season, calculated using a crop water balance model. Studies by FAO have shown that WRSI can be related to crop production using a linear yield-reduction function specific to the crop in question (FAO. 1986). WRSI is defined as the ratio of seasonal actual evapo-transpiration experienced by a crop to the crop's seasonal water requirement; hence it monitors water deficits throughout the growing season, taking into account the phonological stages of a crop's evolution and the periods when water is most critical to growth. The WRSI model was initially developed for use with weather station data to monitor the supply and demand of water for a rain-fed crop during the growing season. The model currently is used by FEWS-NET as one of the operational remote-sensing products to monitor agricultural areas around the world for signs of drought on a near-real-time, spatial and continuous basis using a combination of satellite-derivative rainfall estimates and rain-gauge data from the GTS to compute WRSI values (Senay and Verdin, 2003).

[42] Verdin and Klaver, 2002.

[43] Senay and Verdin, 2003.

[44] Ibid. This paper gives an exhaustive description of the WRSI model and the inputs required to run the water-balance calculation. It was used as the reference template for this project. The WRSI values produced using this model form the backbone of the country-wide 26-station rainfall index described below constructed to monitor livelihood losses in agricultural areas of Ethiopia. The station-based WRSI values calculated by the project team compared well when tested against the operational USGS/FEWS NET WRSI model for Ethiopia from 1996–2003 for selected stations (Senay, G. Personal communication. 10 August 2005).

[45] USGS/FEWS NET calculates daily PET values for the globe at 1.0 degree resolution from six-hourly numerical meteorological model output using the Penman-Monteith equation (see Senay and Verdin, 2003 for more information). For this study, long-term decad average PET values were extracted from the FAO long-term average monthly data (1961-1990).

[46] FAO. 1988.

iv) crop coefficients (Kc) for each crop; Kc values define the water-use pattern and are defined for each of the critical phonological points of a crop's evolution; they are linearly interpolated between these points during each phonological stage during the growing season (Source: FAO);[47]

v) maximum crop root depth (m) and the allowable depletion fraction (Source: FAO);[48] and

vi) seasonal yield-response factors (Ky) for each crop to covert WRSI values to yield estimates (Source: FAO).[49]

42. The WRSI calculation requires start-of-season (SOS) and end-of-season (EOS) times and hence the length of growing period (LGP) for each crop considered (information from FAO,[50] confirmed by the Ministry of Agriculture and Rural Development) and a potential sowing window for the long-cycle and short-cycle crops (suggested by the Ministry of Agriculture and Rural Development). The SOS decad must be based on an objective and consistent criterion for identifying the sowing decad — the time during the potential sowing window when farmers choose to sow. There are several rainfall-accounting methods for identifying the SOS;[51] the method chosen for this project was the first decad in the sowing window where the ratio of cumulative rainfall recorded in PET is greater than 50 percent; once this ratio exceeds 50 percent, the soil favours germination.[52]

43. This method usually corresponds to the first decad in which cumulative rainfall exceeds 25 mm, a trigger often used in other rainfall accounting methods; however the criterion is less restrictive because it does not require a second criterion[53] and is therefore simpler to implement. In general, the potential sowing windows for long-cycle crops in identified long-cycle areas are (i) decad 8 to decad 15 (11 March–31 May), apart for some stations in the west of the country that have no *belg* rains but a reliable *kiremt* season and therefore plant long-cycle crops later and (ii) decad 16 to decad 21 (1 June – 31 July) for short-cycle crops.[54] In long-cycle growing regions, if no SOS condition is met during the potential sowing window, it is expected that farmers would not have planted, or would have unsuccessfully planted, long-cycle crops and would switch to short-cycle alternatives for a *meher* harvest. If the SOS condition is not met during the *kiremt* short-cycle growing season, the model automatically starts from decad 21; this has rarely occurred in the historical rainfall data. It is often assumed that if WRSI < 50 percent at the end of the growing season, a crop has failed;[55] but because the geographical areas associated with each weather station are large, it was decided that such a specific condition should not be applied in this case. All variations in WRSI were considered to distinguish relative rainfall variability from average in the areas associated with each station.

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[47] FAO. 1998.

[48] Ibid.

[49] FAO. 1986.

[50] FAO. 1998.

[51] Senay and Verdin. 2003; Hunde *et al.*, 2000.

[52] Senay, G. Personal communication. 1 June 2005.

[53] See for example Senay and Verdin, 2003.

[54] FEWS-NET. 2003.

[55] Senay and Verdin, 2003.

Staple Crop Baskets

44. This analysis only considers maize, *teff* and sorghum, the staple diet of most Ethiopians, and millet, wheat and barley; 600 g of cereal is required per day, with other foods, to meet adult minimum energy requirements of 2,100 kcal.[56] To identify which crops were grown and their relative importance to each region, production and area planting data collected annually from 1994 to 2002 and maintained by the Ministry of Agriculture and Rural Development were used for both growing seasons. For each *woreda* associated with one of the 26 selected weather stations, the total area devoted to all six cereal crops and to each of the six crops individually was calculated by finding the 1994-2002 average area planted. The ratio of the planted value of an individual crop to the total area planted with cereal was taken as the importance of that crop relative to the overall cereal production basket of the *woreda*. If an area reported maize and sorghum **planting**, yet fell within a region of short-cycle growing only, it was assumed that low-yield short-cycle variants of maize and sorghum were being grown.[57]

45. The data shows, for example, that *woredas* associated with Mekele weather station in the northern region of Tigray, an area with unreliable rainy seasons, prefer to plant safe short-cycle crops such as wheat, barley and *teff*; but *woredas* in the centre of the country such as those associated with Debrezeit weather station in Oromiya, an area with more reliable rainfall seasons, dedicate more of their land to long-cycle high-yield crops such as maize and sorghum. If the planted area of a *woreda* was unavailable in the ministry dataset, the zonal average was used. No urban *woredas* were considered in the analysis.

46. WRSI can be related to crop production or yield estimate by using the following linear yield-reduction function:[58]

$$\text{Actual Yield (AY)} = 1 - (1 - \text{WRSI}) * \text{Seasonal Ky} * \text{Maximum Yield} \quad (1)$$

47. Based on FAO/WFP Ethiopia production assessment reports and confirmed using ministry data, the following maximum yields were used for each of the six crops: long-cycle maize – 20 quintals (Q)/ha; long-cycle sorghum – 15 Q/ha; millet – 10 Q/ha; short-cycle maize and sorghum – 8 Q/ha; wheat and barley – 13 Q/ha; *teff* – 8 Q/ha.

48. A WRSI value and hence a yield estimate was calculated for each crop considered in the cereal production basket of a *woreda* using rainfall data from the rainfall station with which the *woreda* was associated. Staple crop per hectare for each *woreda* was then defined as the weighted sum of all the crops in the basket; the weights were given by the area-planted ratios defined above to capture the relative importance of each crop to overall production basket.

[56] Little *et al.*, 2004.

[57] FEWS-NET, 2003.

[58] FAO. 1986.

49. Production per hectare for the staple crop basket of each *woreda*, Y_w, is therefore defined as follows:

$$Y_w = \alpha_{Maize} AY_{Maize} + \alpha_{Sorghum} AY_{Sorghum} + \alpha_{Millet} AY_{Millet} + \alpha_{Teff} AY_{Teff} + \alpha_{Wheat} AY_{Wheat} + \alpha_{Barley} AY_{Barley} \quad (2)$$

and

$$\alpha_{Maize} + \alpha_{Sorghum} + \alpha_{Millet} + \alpha_{Teff} + \alpha_{Wheat} + \alpha_{Barley} = 1 \quad (3)$$

where α is the area ratio weight for each crop and AY is the actual yield estimated from the WRSI given by equation (1).

50. This was repeated for all *woredas* associated with one of the 26 weather stations. Indexing the staple crop production in this way established an objective indicator for household production per unit area cultivated for each *woreda*. It was assumed that on average most at-risk households farm the same amount of land throughout the agricultural regions of Ethiopia - approximately 1 ha per household;[59] but in terms of the livelihood-loss calculation in the following section, deviations in yield rather than production are considered to remove the potential variability in cultivated plot size. The WRSIs calculated for each weather station generally exhibit a positive correlation with Ministry of Agriculture and Rural Development yield data for the *woredas* associated with each station, particularly in lower-producing areas in the north and east, with correlation coefficients ranging from 20 percent to 90 percent for 1994-2002. The lower correlation coefficients were generally found in regions of higher production and better rainfall, which have not suffered from extreme drought-related losses in the past 30 years.

51. Several other factors are critical to production levels: incidence of pests, supply and quality of seeds and fertilizer, technology, management practices, and hail and frost, but these risks vary little from year to year or are idiosyncratic risks that effect individual farmers rather than whole communities. Water availability is the most critical exogenous factor for crop production, particular in rain-fed regions.

At-Risk Beneficiaries and Household Survey Data

52. The WRSI calculation measures the effects of rainfall deficits on crop productivity for a single unit of cultivated land. It estimates the impact of rainfall deficits on the population of at-risk or vulnerable households by calculating the impact on the income of an idealized representative household for each *woreda*. This impact is generalized to the *woreda* level on the basis of the population and the prevalence of at-risk households. The properties of these representative households are based on average household landholdings, the timing and type of crops being planted and the sources and magnitude of incomes of vulnerable households in each *woreda*. Constructing these representative households requires detailed understanding of the number and average characteristics of vulnerable households and how the characteristics vary among *woredas*; information on the demographics, income sources, asset holdings and farming choices of vulnerable households were collected and discussed

[59] Little *et al.*, 2004.

by a technical team of experts in local government, academia and development in Addis Ababa from April to June 2005.[60]

53. Data from the 2000 Welfare Monitoring Survey[61] (WMS) were analysed to estimate the demographic properties of at-risk households, including household size and income. To focus on at-risk households, it was agreed to consider only households owning livestock assets of between 2 and 6 tropical livestock units (TLUs)[62] and with annual incomes of less than Birr8,000 [63] in designing the representative households. Ownership of livestock strongly correlates with household ability to cope with income shocks[64] and therefore with the risk of falling into poverty and food insecurity when an income shock occurs. Households owning between 2 and 6 TLUs are not asset-poor, but tend to be highly vulnerable to rainfall shocks because of their dependence on rain-fed farming to generate income. This definition of vulnerability is consistent with research by Broadening Access and Strengthening Input Market Systems — Collaborative Research Programmes (BASIS-CRSP)[65] funded by the United States Agency for International Development (USAID), which finds that households with 4.5–6 TLUs, defined as poverty-vulnerable households, exhibited a 50 percent chance of falling into poverty because of drought during a six-year period.[66] Information on livestock ownership is commonly available in micro-economic household surveys and data sources.

54. Using this method of identifying at-risk households, WMS data were used to estimate the percentages of households in each *woreda* considered vulnerable. VAM population projections from the 1994 Central Statistical Authority census[67] were used to define current aggregate rural populations in each *woreda*. The proportion of vulnerable households was 37 percent, but there is an average 12 percent deviation among all *woredas*. In total approximately 16.8 million at risk beneficiaries were identified in all the *woredas* associated with the 26 weather stations using the WMS data. Nationwide, vulnerable households have an average of 5.05 members – 4.1 adult unit equivalents – and an annual income of approximately Birr3,500. The WMS information was collected in 1999-2000, but the technical team took it as representative of current average or normal rural conditions in the absence of drought. It was the only dataset available to the project team that offered consistent demographic information for the entire country. Where the properties of a representative household could not be estimated because of limitations in the scope of the *woreda*-level data, the average properties of at-risk households in the corresponding zone or region were used instead.

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[60] The Addis Ababa technical team was: Mathewos Hunde (Ministry of Agriculture and Rural Development), Workneh Negatu (Institute for Development Research [IRD], Addis Ababa University), Mark Ludwick, Kedir Shemsu and Mihret Bizuneh (WFP country office), Dula Shanko (Head of Data Management And Dissemination Department, NMSA), Girma Tedesse (Head of Natural Resource and Agricultural Statistics Department, Central statistical Authority [CSA]), Befekadu Kabeta (C/M Team Leader, Early Warning Department, DPPC.

[61] Central Statistical Authority, 2000.

[62] 1.0 TLU = 1 head of cattle; 0.5 TLU = 1 horse, donkey or mule; 1.4 TLU = 1 camel; 0.1 TLU =1 sheep or goat; 0.05 TLU =1 chicken. (Little et al., 2004)

[63] Birr8.85 = US$1.

[64] Little *et al*., 2004.

[65] BASIS-CRSP. (USAID grant number LAG-A-00-96-90016-00).

[66] Little *et al*., 2004.

[67] Central Statistical Authority, 1994.

55. Data from the Ethiopian Rural Household Survey[68] (ERHS) were used to determine the fraction of total incomes from agricultural production in vulnerable households. This value is important because the average level of agricultural income in a *woreda* serves as a baseline to quantify the amount of income loss resulting from a given drop in productivity. Although not as broad-based a survey as WMS, ERHS survey data were used to calculate this value because WMS responses seemed to display a systematic under-reporting of agricultural income, with agricultural income making up only a third of total household incomes among vulnerable households, with considerable variability among *woredas*. A common reason for under-reporting agricultural incomes in survey responses is that respondents do not include the value of food produced for their own consumption, which should certainly be included for the purposes of this project. The ERHS survey showed agricultural income averaging 68 percent of total household income among at-risk households for all villages in the survey.

56. This information allowed the project team to model the financial impact of production variations in the staple-crop basket on at-risk households in each *woreda* and to estimate the true number of vulnerable households. The following relationship was assumed between deviations in production per unit area, Y_w, measured by the staple-crop basket WRSI, and agricultural income losses per at-risk household in each *woreda*:

Drought-related agricultural income loss per at-risk household
= % deviation of Y_w from median * expected at-risk household agricultural income under normal (non-drought) conditions

$$= 0.68 * HI_w * \max(0, (Y_{median} - Y_w)/Y_{median}) \quad (4)$$

where HI_w is the expected household income from WMS, Y_w is the actual crop production per hectare of the staple-crop basket for that *woreda* as measured by the WRSI model, Y_{median} is the median crop production per hectare of the staple-crop basket for that *woreda* given 30 years of historical rainfall data.

Market Price Inflators

57. The final component necessary for quantifying the risk and magnitude of livelihood losses resulting from rainfall and hence production shocks is a market-price inflation factor to ensure that income losses — calculated above using average household income levels under normal conditions — are adjusted upwards to compensate for reduced household purchasing power resulting from increased market prices associated with extreme drought. This was done by referring to price data and reports from 2002, Ethiopia’s last extreme drought year. In December 2002, FAO and WFP noted: “In October 2002, average prices of maize, wheat, barley and sorghum were respectively 85 percent, 50 percent, 32 percent and 25 percent higher than at the same time last year. Consumers and producers alike are suffering from such severe price volatility.”[69]

58. Price information from the Ethiopian Grain Trade Enterprise[70] show that prices increased in markets throughout the country: from November 2001 to November 2002,

[68] These 1989–1999 data from 15 villages in Amhara, Oromiya and the Southern Ethiopian People's Association have been made available by the Economics Department, Addis Ababa University, the Centre for the Study of African Economies, University of Oxford and the International Food Policy Research Institute IFPRI). Funding for data collection was provided by the Economic and Social Research Council (ESRC), the Swedish International Development Agency (SIDA) and USAID; preparation of the public release version was supported by the World Bank.

[69] FAO/WFP, 2002.

[70] http://www.egtemis.com/priceone.asp

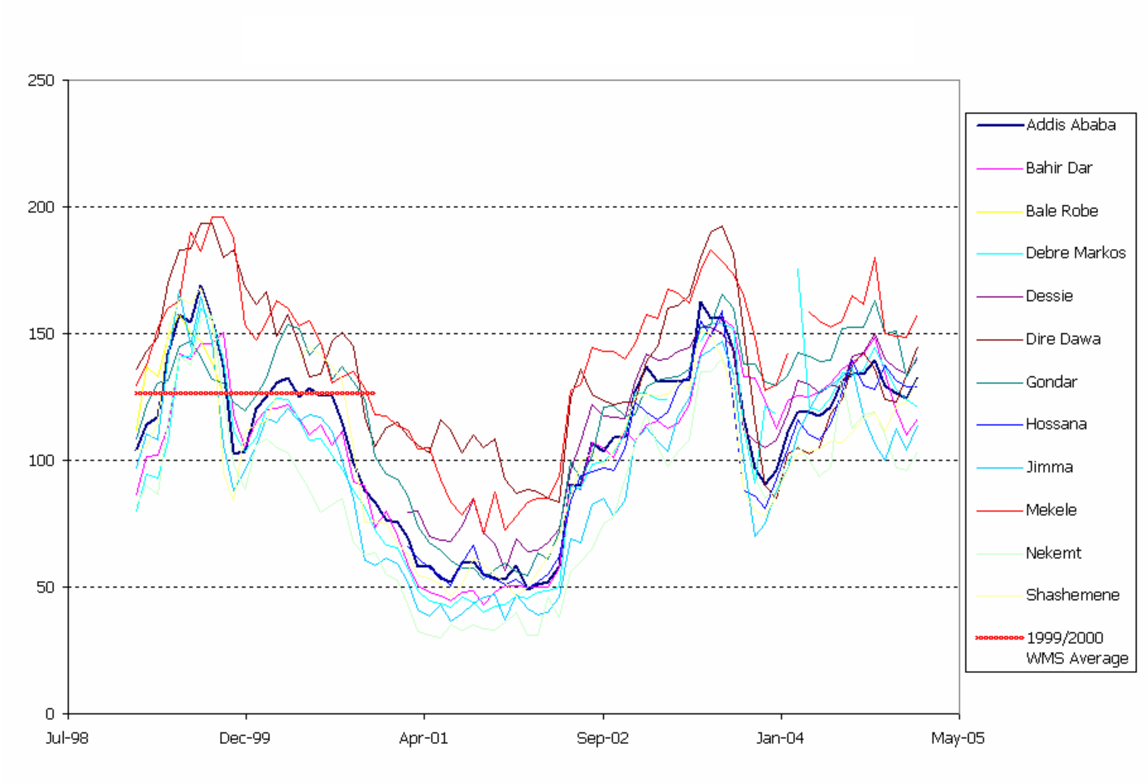
maize prices had increased on average by 200 percent, sorghum by 146 percent and *teff* by 115 percent. A simple price-inflation factor, *p*, was calculated for each *woreda* by considering the staple-crop basket for the *woreda* and multiplying the proportion of each crop in the basket by the approximate price increase observed for it in 2002:

$$p_w = 2\ \alpha_{Maize} + 1.25\ \alpha_{Sorghum} + 1.15\ \alpha_{Millet} + 1.15\ \alpha_{Teff} + 1.5\ \alpha_{Wheat} + 1.5\ \alpha_{Barley} \quad (5)$$

[71]

where α is the area-ratio weight for each crop. Prices have continued to rise in Ethiopia since late 2002, as seen by the maize price record for 1999–2005[72] shown in Figure 2: inter-annual price fluctuations characterized by higher prices in 1999–2000 and a low in 2001–2002 rising to 1999–2000 levels in 2004–2005 are evident in the other commodity price records. The WMS survey data used to establish the agricultural income at-risk baseline for this project was collected in 1999 and 2000; in absolute terms, that period is comparable to today's levels with regard to a beneficiary's purchasing power for a given income (see *At-Risk Beneficiaries and Household Survey Data* for more details). The role of the price inflation factor is therefore to compensate for the relative increase in commodity prices that would be expected above this baseline if another catastrophic drought occurred in 2006.

Figure 2: Maize Wholesale Prices (Birr) in Markets across Ethiopia



[71] For simplicity, barley was considered to be the same as wheat in the analysis, because their crop characteristics and coefficients are very similar.

[72] Price data taken from the Ethiopian Grain Trade website at http://www.egtemis.com/priceone.asp This price may already have factored in the food aid in Ethiopia at this time. Estimating the expected price rise in the event of a drought is extremely difficult and dependent on many external factors in addition to the rainfall failure. Understanding the complex nature of market price responses to drought should be addressed further in future work.

Index Definition

59. To summarize the five preceding sections, the final index of livelihood losses for at-risk beneficiaries in all *woredas* associated with the 26 weather stations in the project is therefore defined as follows:

Index = sum of livelihood losses at each of the 26 weather stations

(6a)

livelihood losses at a weather station = sum of livelihood losses in each associated *woreda*

(6b)

$$\text{livelihood losses in a } woreda = p_w * N_w * HAI_w * \max(0, (X_w * Y_{median} - Y_w)/Y_{median})$$

(6c)

where p_w is the price inflation factor, N_w is the number of at-risk households in each *woreda*, HAI_w[73] is the expected household agricultural income, Y_w is the actual crop production per hectare of the staple-crop basket for that *woreda* measured by WRSI, Y_{median} is the median crop production per hectare of the staple-crop basket for that *woreda* given 30 years of historical rainfall data and X_w is the *woreda*-specific income-loss trigger level adjustment factor.

60. At-risk households have often established their own coping and risk-sharing strategies to withstand small or moderate droughts, so an index of livelihood losses needs to capture only severe income-loss events that render the risk-coping strategies ineffective. In this index design, this risk-retention is characterised in terms of the income-loss trigger level adjustment factor, which is defined in terms of a *woreda*'s staple-crop basket production capability with respect to national or 26-station average staple-crop basket baseline production. *Woredas* in lower-producing areas should have a higher income-loss trigger level closer to the median than those in more food-secure regions. This is because it would take a more severe drought and production shock for these areas to experience local food shortfalls resulting in asset losses. The staple-crop basket production figure for all 278 *woredas* associated with the 26 stations was found to be 12.2 Q/ha, with a standard deviation of 3.3 Q/ha. This is not the actual average cereal production per household, but the relative difference between the 12.2 Q/ha average and each *woreda*'s median production per hectare can be taken as an indicator of the *woredas*' relative vulnerability to production shocks.

61. The *woreda*-specific income-loss trigger level adjustment factor is therefore defined as follows:

$$X_w = \min(1, 12.2 / Y_{median})$$

(7)

which means that *woredas* in the lowest-producing regions have an income-loss trigger level set at the median production level Y_{median}, zero risk retention. This implies that even in slightly below-average production years, a household in these areas may enter into asset-depletion or require external support to cope, as did *woredas* associated with Mekele

[73] $HAI_w = 0.68 * HI_w$, as defined in equation 4.

station in Tigray. *Woredas* in highproducing areas have trigger levels set up to 30 percent away from the median, implying risk-retention in income deviations of up to 30 percent from expected levels before a household requires external support, such as in those associated with Arjo weather station in East Wellega. Hence historically some of these high-producing stations, in particular Arjo, Gore, Hosana and Awassa, do not actually contribute to the livelihood losses index defined in equation 6 and therefore do not need to be included in the final index basket for the risk-transfer transaction; but their importance for national production has to be taken into account when considering *woreda*-specific triggers for the stations that are included.[74]

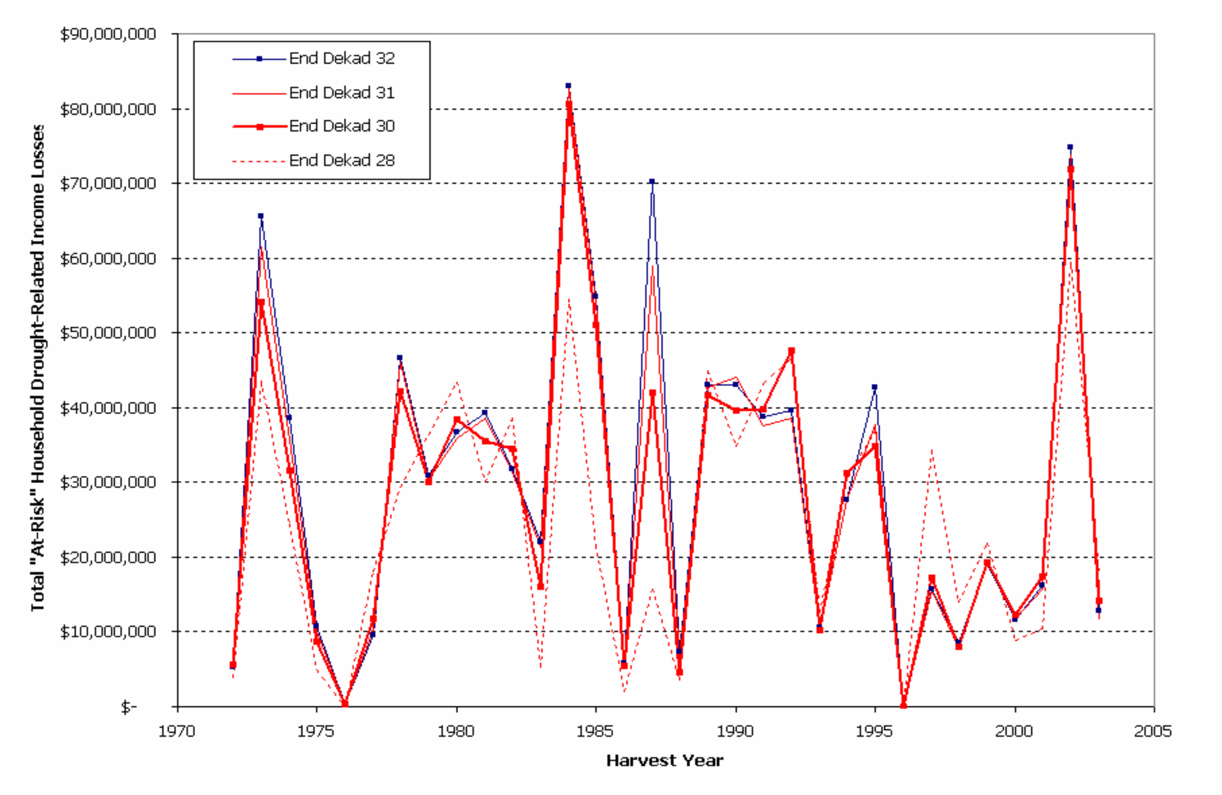
62. Figure 3 shows the livelihood-loss index calculated using 1972-2003 rainfall data for the 26 stations.[75] Average loss per year is US$30.4 million, with a standard deviation of US$23 million, a minimum loss of US$8,000 in 1996 and a maximum of US$83.1 million in 1984. The complete livelihood-loss index finishes at the end of the year (decad 36) because it follows all potentially late-sowed *meher* crops to maturity; in practice, however, its value does not change from the middle of November onwards (decad 32), when most have harvested. Figure 3 shows how the index changes as it is observed before decad 32.

63. The underlying WRSI and production estimates — coefficient of variation = 3 percent — are not as volatile as the income loss index for the 26 station average. The higher coefficient of variation for the index results from the definition of the index: the loss index is (i) a one-sided measure and (ii) the number of at-risk beneficiaries per station used to construct the loss index is a fixed number rather than a number that varies proportionally with rainfall. Property (ii) implies that if there is an attachment event at a station, the entire at-risk population associated with that station experience a loss, resulting in digital additions to the index and hence increased volatility. This approach was chosen for two reasons: (i) the data to calibrate such a model does not currently exist at consistent national level and (ii) the project copied an individual-insurance contract approach; in a traditional insurance programme, a fixed number of farmers (in this case the entire population at risk) would buy an insurance contract before the growing season, and would all require a payout if the contract triggered.

[74] FEWS-NET, 2005. This suggests potential problems in these areas because of a decreasing trend in April/May rains, critical for long-cycle crops, which as been observed in western high-producing areas. In Awassa, for example, WRSI shows that rains have become more unreliable in recent years, although not to levels that could significantly impact production. Hence these stations may become important in future, even though they have not yet contributed to the livelihood-loss index.

[75] For ease of calculation, *woredas* associated with each weather station were first averaged into 26 groups, with a representative long-cycle and short-cycle staple crop basket per group, a group-specific income-loss adjustment trigger *X*, a price inflation factor *p*, the number of at-risk households and agricultural income exposed to drought per group. The index was calculated by using equation 6(a). Some resolution was lost, but little difference was found between the final two indices, which correlate at 99 percent; the second method was much less data-intensive and quicker, however. This is important when taking the contract to the market for pricing: the easier the index is to calculate, the more market participants will be willing to price the deal, facilitating a more competitive price.

Figure 3[76]: Livelihood-Loss[77] Index Calculated Using Historical Rainfall Data for the 26 Stations



Index Discussion

64. Historically, the index exhibits considerable annual variability; in particular, it picks up the droughts of 1973, 1984, 1985, 1987 and 2002, the most extreme in Ethiopia's recent history. At today's values in such conditions the rural population would experience income losses of US$50–80 million. This corresponds to losses per at-risk household ranging from zero to more than Birr 2,000, depending of the severity of the rainfall deficits measured at each station; in general, losses of approximately Birr1,000 per household occur at stations affected in extreme drought years, roughly a third of annual expected at-risk household income.

65. The index is constructed from a weighted sum of negative production deviations in individual staple-crop baskets throughout the agricultural regions; the weighting is essentially the number of at-risk households in each of the 278 *woredas*. The index can therefore be interpreted as a proxy for total cereal crop production: years where agricultural income losses are high are years where staple crop production is low; hence such years should correspond to years when national cereal production is below average.[78] In the following correlation analysis, the income-loss trigger level adjustment factors X are set to 1 for all stations; that is, all below-median deviations in production are considered in the index total.

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[76] Cleaned data were used where possible. For stations with missing years after 1972, the 30-year average was used to fill in the missing decads; the missing years were not extreme drought years in Ethiopia.

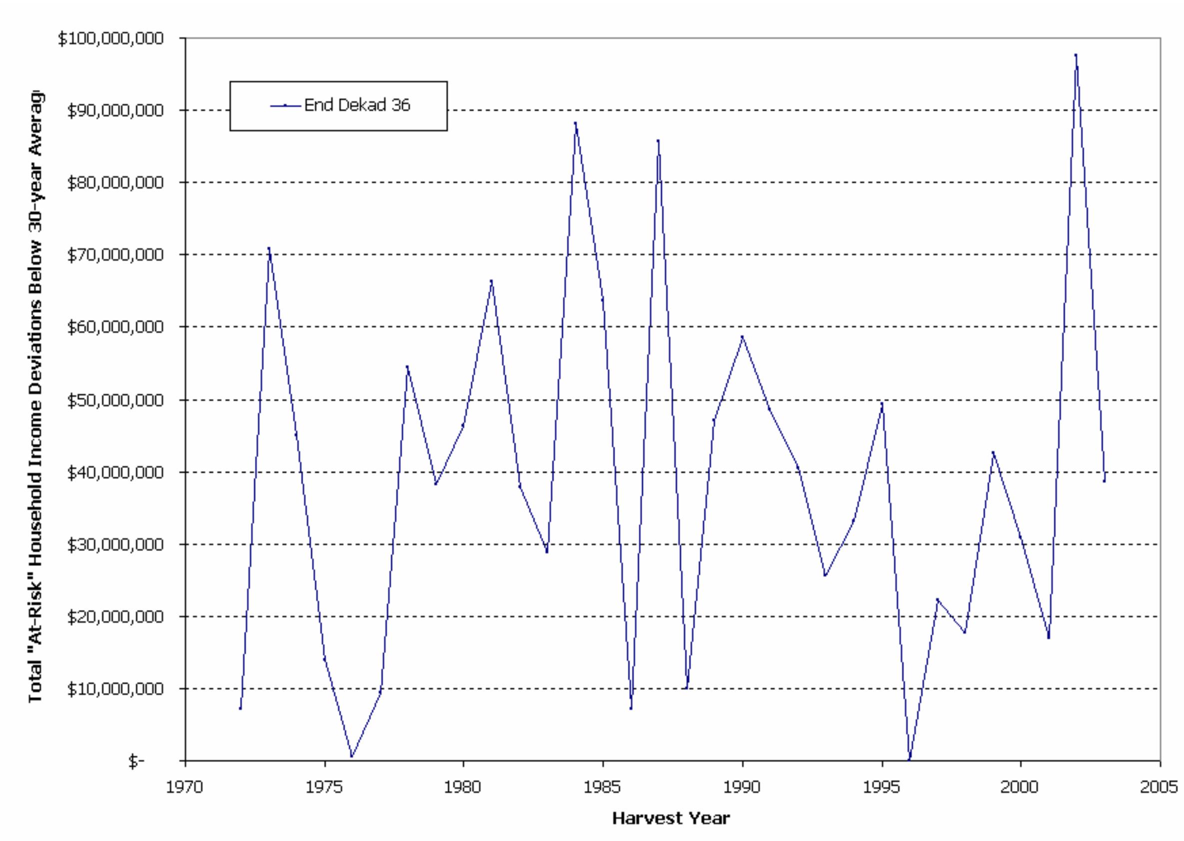
[77] An exchange rate of US$1 = Birr8.85 was used.

[78] Senay and Verdin, 2003. Their GIS-based WRSI model output correlated with national cereal production with a correlation coefficient of 92 percent.

66. The correlation coefficient between (i) annual variations in FAO/WFP national cereal and pulse production estimates in 1999–2003 and (ii) annual variations in the index at X=1 in 1999–2003 is –87 percent. The correlation coefficient between (i) annual variations in national cereal crop yields using data collected by the Ministry of Agriculture and Rural Development and (ii) annual variations in the index at X=1 from 1995-2003 is –75 percent. For completeness, the correlation with WFP beneficiary numbers for 1994–2004, corresponding to the 1993–2003 rainfall seasons, is 81 percent. These correlation coefficients may be artificially high because of the strong index correspondence to 2002, an extremely low-production year.

67. The index shown in Figure 3 captures recent extreme droughts, in particular 1984, 1987 and 2002. These droughts evolved differently: the 2002 drought was the most widespread and affected the largest number of weather stations and hence a larger proportion of the population; of the 278 *woredas* covered by the index, 124 would have experienced income loss from negative-rainfall shock, which, multiplied by the at-risk populations in these *woredas*, corresponds to 7.7 million at-risk beneficiaries affected in the areas covered. Figure 3 shows, however, that losses in 2002 were less than in 1984, when according to the index approximately 7.4 million at-risk beneficiaries would have experienced loss; hence the 1984 drought did not affect as large a proportion of the country, but in areas where there were losses they were greater than in 2002. The many small losses of the 2002 drought are seen if the *woreda*-specific income-loss trigger level adjustment factors are set to 1 for all *woredas* (see Figure 4). The greatest aggregate production losses were in the 2002 drought, which is visible in decads before decad 32.

Figure 4: Setting Income-Loss Trigger Level Adjustment Factors *X* = *1* for all Stations



68. In contrast, the 1987 drought developed later: the *belg* was excellent but it was followed by a late and poor *meher*, so farmers sowed short-cycle crops later than normal; but the rains did not extend into October/November to bring them to maturity. Long-cycle crops planted in the *belg* were stressed by the gap between *belg* and *kiremt* rains despite the good start. Ministry of Agriculture and Rural Development data show, however, that the areas affected in 1987 now grow mainly short-cycle *teff*, wheat and barley; their long-cycle choice is sorghum. These long-cycle crops therefore do not contribute greatly to the cereal basket today, and so do not contribute to the index. The 2002 drought is visible earlier than the 1987 drought, because 2002 was a problem of sporadic rains throughout the year rather than a late and poor *meher*.

69. The *belg* and *kiremt* rains failed in 1984 as they had in 2002. But according to the index long-cycle sowing occurred much later in 1984 than in 2002, so the drought is just evident by decad 28, whereas it is much clearer in 2002; the problem only becomes clear at the early cessation of the rains in mid-September, when the late-sowed crops still needed several decads of rainfall to mature.

70. It should be noted that events of a greater severity than 1984 or 2002 are possible; the fact that they have not happened in the past 30 years does not mean they will not happen in the future, particularly with regard to climate change. For reference and illustration, the income losses that would be predicted by the index if a 1984 severity drought occurred with a 2002 geographical distribution are US$98 million; the losses from a combination of the 1984 and 2002 events, taking the largest index deviations for each of the 26 stations in either of the two years, would be $118 million. Assuming worst-case rainfall deviation for each station from 1972–2003, the number jumps to US$154 million.

Pricing the Risk

71. The pilot uses a 26-station index as the basis of a weather derivative contract to establish contingency funding for aid response in contractually specified severe and catastrophic shortfalls in precipitation. To balance expediency with accuracy, the end of the contract calculation period is set at 31 October 2006, or decad 30 (see Figure 3). The two main characteristics of a weather derivative are the trigger level of the contract – the attachment level of the deal – and the limit, or maximum payout in a worst-case drought scenario. Every loss above the trigger level as recorded by the index results in a payout to WFP up to the limit. The trigger level should be set at a point that enables the project to provide financing in extreme and catastrophic drought. For a calculation period ending at decad 30, the 30-year average index value at decad 30 is US$28 million, with a standard deviation of US$20 million and a maximum of US$80.6 million in 1984.

⇒ *Example 1*

72. The settlement calculation using a US$60 million trigger – a trigger level approximately 1.5 standard deviations from the average – and US$20 million as the limit will therefore be given by:

$$\text{Payout (US\$)} = \min(\ \max(\ 0, \text{Index} - \text{US\$60 million}), \text{US\$20 million}\ ) \qquad (8)$$

73. In 1984 such a contract would have paid the maximum US$20 million; in 2002 it would have paid US$11.8 million. Two payouts in 32 years imply a return frequency of one in 15 years, in other words a contract that provides protection for events that occur on average

every 15 years. A linear regression can be used to estimate the national production total that a trigger level represents. For example, using the FAO/WFP 1999–2003 national cereal and pulses production estimates, the following relationship can be derived:

National cereal and pulse production (mt) = -5.896 x 10^{-8} x 60,000,000 + 13.257 = 9.7 million mt (9)

with an r^2 value of 92 percent and a standard error of 530,000 mt. Such a trigger level would correspond to years when the number of at-risk beneficiaries in the areas covered in the index would exceed 7 million.

⇒ *Example 2*

74. Consider the settlement calculation using a US$65 million trigger – approximately 1.8 standard deviations from the average – and US$20 million as the limit:

Payout ($US) = min (max (0, Index - US$65 million) , US$20 million)

In 1984, such a contract would have paid the maximum US$15.6 million; in 2002, it would have paid US$6.8 million. Two payouts in 32 years implies a return frequency of 1 in 15 years, but the expected loss of the contract would be less than that above because the payouts would have been smaller than in the previous example. The national cereal and pulse production total that this trigger level represents is therefore:

National cereal and pulse production (mt) = -5.896 x 10-8 x 65,000,000 + 13.257 = 9.43 million mt

with a standard error of 0.53 million mt. Such a trigger level would correspond to years where the number of at-risk beneficiaries needing assistance in the areas covered by the index would reach 7.5 million. Such a contract with a lower expected loss would obviously be less expensive than the first example, because it covers much more extreme risk.

⇒ *Example 3*

75. Consider the settlement calculation using a US$55 million trigger – approximately 1.3 standard deviations from the average - and US$20 million as the limit:

Payout (US$) = min (max (0, index - US$55 million) , US$20 million)

76. In 1984 such a contract would have paid the maximum US$20 million; in 2002 it would have paid US$16.8 million. It is clear that the expected loss of the contract would be greater than in the previous examples, because the payouts would have been larger. The national cereal and pulse production total represented by this trigger is therefore:

National cereal and pulse production (mt) = $-5.896 \times 10^{-8} \times 55{,}000{,}000 + 13.257$
= 10.0 million mt

with a standard error of 530,000 mt. Such a trigger level would correspond to years where the number of at-risk beneficiaries in the areas covered in the index would exceed 6.5 million. Such a contract with a higher expected loss would obviously be more expensive than the first two examples, because it covers lower levels of risk with a higher probability of occurrence.

⇒ *Example 4*

77. Consider the settlement calculation using a US$50 million trigger – approximately 1.0 standard deviations from the average - and US$30 million as the limit:

Payout (US$) = min (max (0, Index - US$50 million) , US$30 million)

In 1984 such a contract would have paid the maximum US$30 million; in 2002 it would have paid US$21.8 million, with smaller payouts of US$4.2 million in 1973 and US$1.05 million in 1985. Four payouts in 32 years implies a higher return frequency of one in eight years, in other words a contract that provides protection for events that occur on average every eight years. The national cereal and pulse production total that this trigger level represents is therefore:

National cereal and pulse production (mt) = $-5.896 \times 10^{-8} \times 50{,}000{,}000 + 13.257$
= 10.3 million mt

with a standard error of 530,000 mt. Such a contract with a higher attachment frequency and greater limit would obviously be more expensive than Examples 1 and 2. At this lower trigger level, it is difficult to estimate the number of at-risk beneficiaries, because of the variability between the number of beneficiaries affected and the financial extent of their losses; in other words there are several years when the number of beneficiaries affected exceeded the 6 million, but the losses they experienced would not have been great enough to trigger a payout.

⇒ *Example 5*

78. Consider the settlement calculation using a US$45 million trigger — approximately 0.8 standard deviations from the average — and US$30 million as the limit:

Payout (US$) = min (max (0, Index – US$45 million) , US$30 million)

In 1984 such a contract would have paid the maximum US$30 million; in 2002 it would have paid US$26.8 million, in 1973 US$9.2 million, in 1985 US$6.05 million and in 1992 a small payout of US$2.7 million. Five payouts in 32 years implies a return frequency of one in six or seven years, in other words a contract that provides protection for events that occur on average every six to seven years. The national cereal and pulse production total that this trigger level represents is therefore:

National cereal and pulse production (mt) = $-5.896 \times 10^{-8} \times 45{,}000{,}000 + 13.257$
= 10.6 million mt

with a standard error of 530,000 mt. Such a contract would obviously be even more expensive than Examples 1, 2, and 3. But reducing the trigger level to US$45 million would pick up some elements of basis risk (see Project Risk Assessment) with a payout in decad 30 for 1992; there would have been no payout in 1992 if the contract had ended in decad 32. It is difficult to estimate the number of affected at-risk households at lower trigger levels.

79. With the contract end-date at decad 30, a payout in 1987 would not have occurred in any of the examples, another example of basis risk; but the 1987 drought developed late in year with a good *belg*. In pricing this contract in the international markets, WFP will seek to establish prices at three trigger levels: (i) US$55 million, (ii) US$60 million and (iii) US$65 million. In all three cases, payouts would have occurred in 2002 and 1984, the two most extreme events when the *belg* and *meher* seasons were poor. These trigger levels are beyond 1.0 standard deviation from the average and therefore correspond to the lower-frequency but higher-loss events that this project seeks to protect against.

Transferring the Risk

80. The risk will be transferred using a weather-derivative contract tendered out in a competitive tender. International Swaps and Derivatives Association (ISDA)[79] documentation specifies that payments must be made within five days of the end of the contract period in standardized over-the-counter weather derivative contracts.

81. On the basis of the results of this tender, the project team will consult with donors who contributed to the premium funding to ascertain whether the premium price is acceptable or whether donors would prefer to retain the risk by establishing a contingency fund to be made accessible to WFP on the same contractual basis as the derivative contract. The premium price demanded by the market in response to WFP's tender is the current cost of Ethiopian weather risk as constructed in the model above. Only the Government and donors contributing to the project will be provided with the information on price. Discovery of this price is important information for the construction of a development portfolio for Ethiopia.

82. Only contributions specifically directed to this project will be used by the project. WFP will be the counterparty to the risk transfer. A possible payout resulting from the 2006 pilot transaction will be made available to the Government and implemented in consultation with WFP through the established channels.

Capacity-Building

83. The project is working with the Government and local partners to enhance capacity in support of weather-based index insurance, especially in terms of quantification of risk and weather-index creation and monitoring and contingency planning for livelihood preservation. In March 2005, the team held a workshop in Addis Ababa attended by representatives from WFP, the World Bank, DPPC, NMSA, the Ministry of Agriculture and Rural Development and the University of Addis Ababa; a follow-up workshop will explain the construction of the final index and the coverage calculations and initiate joint

[79] www. isda.org

monitoring of index performance during the pilot project. Even in the absence of a financial contract linked to it, the index provides a valuable early-warning function and an objective indication of the resultant losses and assistance needed per *woreda* in the area covered. At the end of the pilot, a session will be held with partners in Addis Ababa to determine the usefulness of the project for early warning during 2006, assess the potential cost-benefit relation of a future contingency plan linked to contingency funding, and identify improvements to the index.

84. NMSA is an important partner, because daily rainfall data from the 26 meteorological stations is vital for monitoring the index and payout calculations. To guarantee real-time rainfall reporting, capacity-building is included in the project budget, especially for information technology. A strengthened reporting and communication network for NMSA will last beyond the pilot and will assist others involved in food security.

85. The project will demonstrate to the Government, donors and the re-insurance market how weather indexed insurance can work in Ethiopia and provide a proven index and methodology on which to base future contracts and projects.

Partnerships

86. A core team has been established at Headquarters, which will be assisted by the World Bank CRMG. It will monitor the index as the agricultural season progresses and develop risk-management applications for other countries. The country office is supported by a national staff member who will work with the VAM unit to monitor the performance of the index in relation to events and help to build consensus with NMSA, DPPC, FSCB, the Ministry of Agriculture, the World Bank country team, FEWS-NET, FAO, and IFPRI.

87. The contract is written on an index based on NMSA data, so NMSA is critical in ensuring that high quality daily rainfall data from all stations is available promptly and reliably. An independent third expert to be determined will verify the NMSA data if the index crosses the threshold at decad 30. Any settlement from the weather-derivative contract will be calculated using this verified data.

Project Risk Assessment

88. A major concern with index-based weather-risk management products is basis risk — the potential mismatch between contract payouts and the actual loss.[80] Most index-based insurance mechanisms to monitor and calculate losses are not as accurate as the actual loss adjustment associated with traditional insurance products and claim-settlement procedures, which in Ethiopia would correspond to a physical crop and needs assessment of the entire country that would take several months. However, these shortcomings are arguably outweighed by the inherent advantages of index-based solutions, particularly for a country such as Ethiopia. The two main advantages that this approach offers are (i) timeliness, the possibility of ex-ante assessment obviating the need for time-consuming physical assessment to release a payout, and (ii) an objective independent measure for calculating losses, which facilitates potential risk transfer to the international markets.[81] A potential basis risk outcome can be partly quantified by using historical data; it is shown above that the index designed for this pilot project correlates well with recorded needs and production data. Basis risk can also be minimized by focusing on protection for extreme and catastrophic years rather than years with average variations in weather. The important

[80] Hess (ed.) 2005.

[81] Ibid.

point, as in all risk management strategies, is the efficacy of the hedge and the effective reduction the insured party's exposure to the risk in question. In this case, WFP's exposure to extreme and catastrophic drought would have been reduced by substantial payouts in 1984 and 2002.

89. The index is based on only 26 rainfall stations in agricultural regions, not enough to cover the entire country sufficiently; lack of data prevented inclusion of pastoral regions in the current index. Given the local nature of rainfall, a station may not be representative of the patterns in an associated *woreda* in any given year, particularly in years that are not extreme in terms of rainfall deviations. However, if a country-wide drought affecting the *belg* and *kiremt* impacts production, it will be detected by the 26 stations. Satellite-based data such as rainfall estimates or NDVI could form a better basis for an underlying index, but such data are not often used in the weather market because they are short and inconsistent; the first generation of earth-observing satellites was launched in 1979, but calibrating older low-resolution data to data from current satellites is not straightforward. Furthermore, NDVI is not a fully objective indicator for risk transfer, because it depends on farming practices and other man-made factors.

90. The index only considers the impact of rainfall deficits on crop production, not other meteorological risk factors such as excessive rainfall. Little information exists on the effects of surplus water on crop yields; the team is not aware of a simple tested model such as WRSI for excess rainfall. Excess rainfall or hail are usually localized and do not affect an entire country. The index does not cover other large-scale risks such as pests, civil war, market-price shocks or input-supply shocks that can significantly impact production. Given the time constraints of this first pilot,[82] the index does not take into account the success of belg production, which accounts for 5 percent of national annual production,[83] though it does take into account the performance of long-cycle crops planted in the *belg*. The current model is based on optimal farming practices and decision processes, assuming, for example that if there is no successful sowing during the *belg*, farmers will replant short-cycle crops such as wheat, barley or *teff* for the *meher*. This is why the 1999 *belg* drought in the area associated with Combolcha weather station and other areas in the northwest does not contribute significantly to the index. There was no SOS trigger that year implying failed long-cycle sorghum sowing in those regions, but the model assumes that farmers replanted with higher-yielding short-cycle crops such as wheat and barley. The subsequent *kiremt* was strong, hence farmers following this strategy would have harvested short-cycle crops in October 1999 with little impact on their overall cereal production. Such limitations of the index developed for this pilot can be overcome: the index must be enhanced with the involvement and support of stakeholders and experts if the project evolves beyond the pilot and particularly if the index and risk-management strategy are modified to address sub-national risk.

91. Data risk — the risk of inaccurate, untimely or unreported data — is a considerable issue for this project. Accordingly, part of its aim is to strengthen capacity at NMSA and engage a third party for data verification if the index crosses the trigger threshold.

92. Support for capacity-building for local partners is required throughout the project: community participatory planning, adequate technical standards and strengthened

[82] To prevent seasonal weather forecasts from having a negative impact on the pricing of a weather derivative, significant pricing advantages can be gained by entering into a derivative contract as early as possible before the calculation period start date. To capture fully national *belg* production, the index would have to start at the beginning of January 2006. The current index starts on 11 March 2006.

[83] FEWS-NET, 2003.

administrative, programming and budgeting skills are all necessary to develop and implement contingency plans.

Next Steps and Exit Strategy

93. Should this pilot project demonstrate the feasibility of creating contingency funding based on the mechanism described, the country office, the Government and partners can consider creating contingency plans for 2007 and beyond to be funded through contingency funding based on this approach, subject to consultation with and approval by the Board. At that stage the payout given in the price-inflation-adjusted beneficiary-loss terms above would have to be scaled up to include the cost of value transfers to capture the true cost of a response.

94. In earlier phases of drought insurance for Ethiopia, WFP will be the counter-party to any commercial transaction with the international weather market; it is expected that donors will pay for the premium associated with this risk transfer. As soon as possible, once it has developed the necessary expertise, the objective is for the Government to go directly to the market and take responsibility for this programme.

ANNEX I

PROJECT COST BREAKDOWN	
	Value (US$)
WFP COSTS	
A. Direct operational costs	
Other direct operational costs	
Derivative contract premium	2 000 000
Daily rainfall data	100 000
Verification of rainfall data	4 000
Total other direct operational costs	**2 104 000**
Total direct operational costs	**2 104 000**
B. Direct support costs (see Annex II for details)	
Total direct support costs	**51 016**
TOTAL WFP COSTS*	**2 155 016**

* Indirect support costs at 7 percent of US$150,851 are not included in the total.

ANNEX II

DIRECT SUPPORT REQUIREMENTS (US$)	
Staff	
National consultants	20 000
Staff duty travel	2 500
Subtotal	**22 500**
Office expenses and other recurrent costs	
Rental of facility	466
Utilities (general)	150
Office supplies	25
Communication and IT services	265
Equipment repair and maintenance	25
Vehicle maintenance and running costs	275
Other office expenses	50
Subtotal	**1 256**
Equipment and other fixed costs	
Furniture, tools and equipment	2735
Vehicles	17 475
TC/IT equipment	7 050
Subtotal	**27 260**
TOTAL DIRECT SUPPORT COSTS	**51 016**

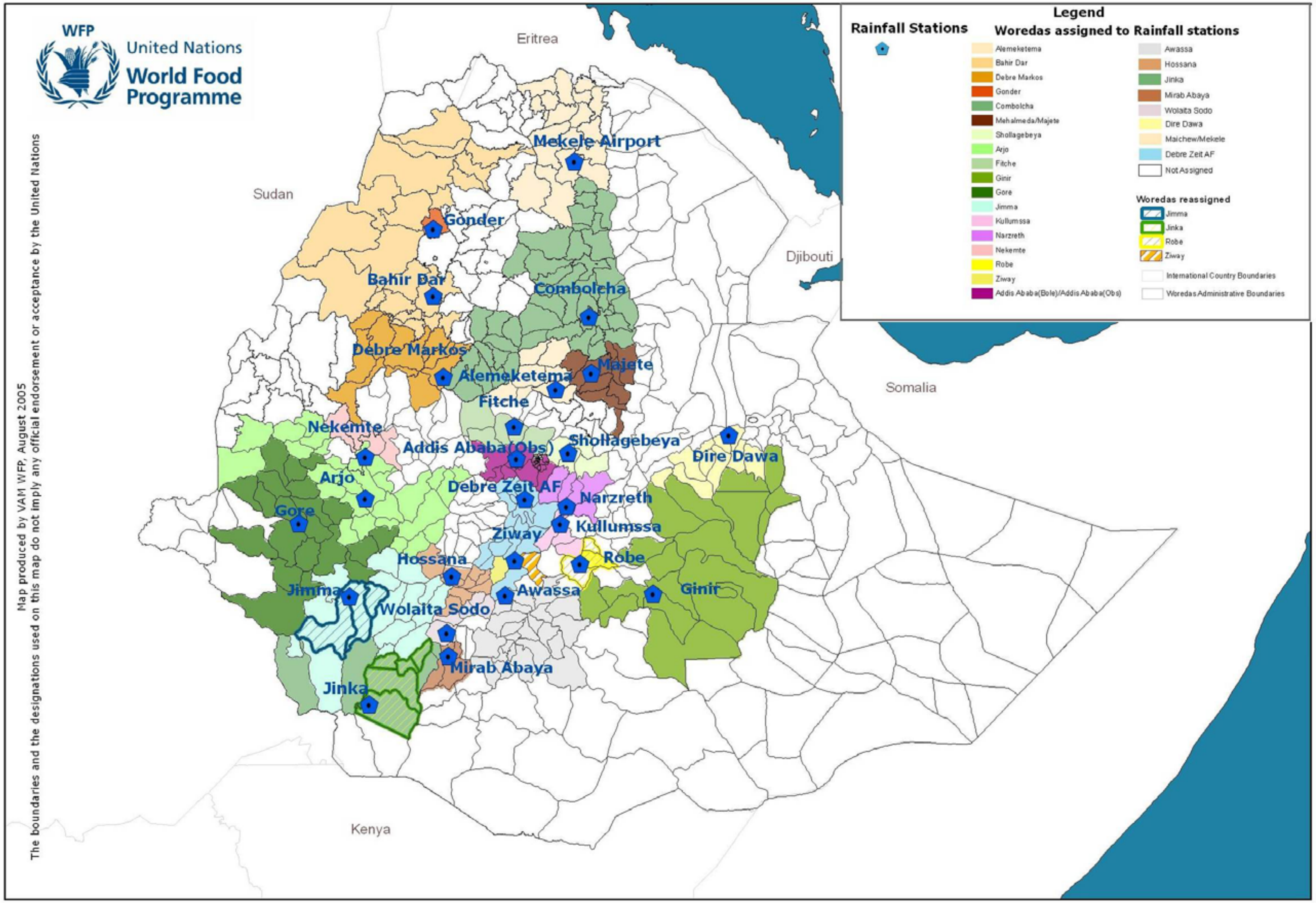
ANNEX III: LOGICAL FRAMEWORK SUMMARY: PILOT DEVELOPMENT PROJECT — ETHIOPIA DROUGHT INSURANCE 10486.0

Hierarchy of results	Performance indicators	Assumptions and risks
Overall goal		
Contribute to creation of ex-ante weather risk management system.	Establishment of Government-led agricultural weather-risk management system providing protection for smallholders.	The World Bank will lead policy discourse with the Government. The Government will build capacity to hedge country's weather risks. International capital markets will engage on Ethiopian weather risk. Donors will provide reliable support to the Government to meet capacity-building and financial challenges.
Outcome 1 Demonstrate feasibility of transferring LDC weather risks.	Market transaction at acceptable premium for Ethiopian weather risk.	Market players reject or charge excessive premium for newly introduced risk.
Outcome 2 Price discovery for Ethiopian weather risk.	Competitive tender establishes market price for Ethiopian weather risk.	Markets willing to take Ethiopian risk. Pricing information accepted by Government and stakeholders for development portfolio considerations.
Outcome 3 Setting in motion a process for ex ante risk-management in developing countries.	The Government builds ex ante risk management system, which is copied by other developing countries vulnerable to weather shocks, especially drought.	Demonstration provides incentive for other countries to engage in the process. The Government, with assistance from WFP and the World Bank, invests further in ex ante weather-risk management.
Outcome 4 Small weather hedge for 2006 agricultural season.	Weather derivative is in place no later than end November 2005.	Donor support for experimental transaction. Acceptable premium cost or risk retention by donor.

ANNEX III: LOGICAL FRAMEWORK SUMMARY: PILOT DEVELOPMENT PROJECT — ETHIOPIA DROUGHT INSURANCE 10486.0

Hierarchy of results	Performance indicators	Assumptions and risks
Output 1.1 Quantification of Ethiopia's drought risk.	Credible index-based on correlation of rainfall and losses.	Data available. Basis risk manageable.
Output 2.1 Derivative contract based on a rainfall index.	Contract made available to market players for transaction.	Reliable data flow from Ethiopia. Third party verification agreement.
Output 2.2 Transfer of the risk to international markets or donor risk retention.	Transaction on contract.	Willing counterparty at acceptable price.

ANNEX IV: Map of *Woredas* Associated with Stations Used in the Index



The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the World Food Programme (WFP) concerning the legal status of any country, territory, city or area or of its frontiers or boundaries.

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ACRONYMS USED IN THE DOCUMENT

ARD	agricultural and rural development
BASIS-CRSP	Broadening Access and Strengthening Input Market Systems – Collaborative Research Support Programmes
BPR	business process review
CME	Chicago Mercantile Exchange
CPSZ	Crop Production System Zones
CRMG	Commodity Risk Management Group
CSA	Central Statistical Authority
DOC	direct operational costs
DPPC	Disaster Prevention and Preparedness Commission
DSC	direct support costs
EMOP	emergency operation
EOS	end of season
ERHS	Ethiopian Rural Household Survey
EROS	Earth Resources Observation and Science
ESRC	Economic and Social Research Council
FAO	Food And Agriculture Organization Of The United Nations
FEWS	Famine Early-Warning System
FSCB	The Food Security Coordination Bureau
GIS	geographical information system
GDP	gross domestic product
GTS	global telecommunications system
IFPRI	International Food And Policy Research Institute
IMTR	Institute for Meteorological Training and Research
IRD	Institute for Development Research
ISC	indirect support costs
Kc	crop coefficient
Ky	yield-response factor
LDC	least developed country
LGP	length of growing period
MDG	Millennium Development Goal
NDVI	normalized difference vegetation index
NMSA	National Meteorological Services Agency

NGO	non-governmental organization
ODK	East and Central Africa Regional Bureau
ODOC	other direct operational costs
OEDBP	Office Of The Executive Director, Business Planning
OEDSP	Special Project Branch
PET	potential evapo-transpiration
RBM	results-based management
RMS	Risk Management Solutions
SIDA	Swedish International Development Agency
SOS	start of season
SP	Strategic Priority
SDPRP	Sustainable Development and Poverty Reduction Programme
TLU	Tropical Livestock Unit
USAID	United States Agency For International Development
USGS	United States Geological Survey
VAM	vulnerability analysis and mapping
VARG	Vulnerability and Adaptation Resource Group
WCF	working-capital facility
WHC	water-holding capacity
WMO	United Nations World Meteorological Organization
WMS	Welfare Monitoring Survey
WRSI	Water Requirement Satisfaction Index