Index-based Crop Insurance in Senegal

Promoting Access to Agricultural Insurance for Small Farmers

April 2009

THE WORLD BANK
Sustainable Development, Africa Region
Finance and Private Sector Development

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Acknowledgements

This report was authored by a team co-led by Olivier Mahul (Finance and Private Sector Development, World Bank) and El Hadj Adama Touré (Sustainable Development, Africa Region, World Bank). The team comprised multidisciplinary Specialists with responsibility for specific aspects of the report, namely, William Dick, Commodity Risk Management Group, World Bank (weather index based crop insurance product development); Bertrand Muller, research fellow CERAAS/CIRAD (agro-meteorological modeling and weather index based crop insurance product design); Mamadou Ndiaye, agronomist (data collection and stakeholder consultation for weather index based crop insurance); Charles Stutley, insurance underwriter (agricultural risk assessment and Area-Yield Crop Insurance); Wally Seck, agricultural economist (data collection and stakeholder consultation); Joana Syroka, Commodity Risk Management Group, World Bank (weather index based crop insurance product design and pricing); Ligia Vado (research assistant); Elisabeth Mekonnen , language program Assistant; and Anta Tall diallo. Program assistant.

The team thanks for their support the Departement of Insuarnce (Direction des Assurances, DA), the Department of Economic and Financial Cooperation (Direction de la Coopération Economique et Financière, DCEF), in the Ministry of Economy and Finance, the Senegal Association for Grassroots Developement Promotion (Association Sénégalaise pour la Promotion du Développement à la Base, ASPRODEB), the Senegalese Federation of Insurance Companies (Fédération Sénégalaise des Sociétés d'Assurance , FSSA), the Department of Agricultural Statistics (Direction de la Statistique et de la Prévision, DAPS), in the Ministry of Agriculture, the National Agricultural Credit Bank (Caisse Nationale du Crédit Agricole, CNCA), the Regional Research Center for Draught Adaptation (Centre d'Etude Régional pour l'Amélioration de l'Adaptation a la Sécheresse, CERAAS), and the Ecology Monistoring Center (Centre de Suive Ecologique, CSE). The team also thanks the local stakeholders met during the field visit conducted in Gossas, Kafrine and Nioro on January 14-18, 2008; the participants of the workshop on "Index-based Crop Insurance in Senegal" organized in Dakar on May 7, 2008; and the participants of the workshop on "Index-based Crop Insurance in Senegal" organized in Dakar on March 18, 2009.

The authors are grateful to the peer reviewers Xavier Gine (Development Research Group, World Bank) and Nathan Belete (Sustainable Development, South Asia Region, World Bank). This report has been prepared under the overall guidance of Madani M. Tall, then Counrty Director for Senegal, Karen Mcconnell Brooks, Sector Manager, Agriculture and Rural Development in the Africa Region for Stephen Mink (Sustainable Development, World Bank) and Rodney Lester (Department of Macroeconomics, East Asia, World Bank). For their relentless support, the team would also like to thanks the Country Management Unit and the Agriculture and Rural Development team in Washing ton and Dakar Country Office, namely Habib Fetini, Country Dircetor, McDonald Benjamin, Country Program Coordinator, Francoise Perrot, Sr. Operations Officer, jean Philippe Tre, Sr. Agricultural economist, and Manievel Sene, Rural Development Specialist.

Funding support for this study was provided mainly by The World Bank and the Trust Fund for Environmentally and Socially Sustainable Development (TFESSD). Additional support was also provided by the Government of Switzerland and the Government of The Netherlands.

Executive Summary

Context

1. The Government of Senegal (GoS) recognizes that the modernization of the agricultural sector can be hampered by the occurrence of natural disasters, such as droughts. The Government has adopted a post-disaster assistance approach to help farmers deal with the negative impacts of natural disasters, mainly based on the *Fonds de Calamité*, aimed at protecting farmers against natural disasters, and the *Fonds de Garantie*, which offers partial credit guarantees for non-performing loans.

2. In addition, the GoS has undertaken a series of studies to examine the feasibility of agricultural insurance. The most recent study, commissioned in 2005, recommended the establishment of a specialized National Agricultural Insurance Company of Senegal (CNAAS) to underwrite crop and livestock insurance. The study suggested the development of Area-Yield Crop Insurance, where the indemnity payments depend on an aggregate yield index of a given geographical area (e.g. *département*), and drought index insurance, where the insurance indemnity is based on a weather index (in this case, cumulative rainfall over a given period reported at a pre-defined weather station). While this report provided a useful overview of the range of crop and livestock insurance products that might be developed in Senegal, it did not fully address the technical, financial, operational and institutional challenges related to its implementation.

3. In this context, the Ministry of Finance (MoF) requested the World Bank to conduct a feasibility study on index-based crop insurance in Senegal and to provide recommendations for its future development. This feasibility study aims to provide an overall framework for the development of sustainable market-based crop insurance in Senegal and includes the following components: (i) Review of the GoS proposal for agricultural insurance, including the provisional business plan of the proposed agricultural insurance company, CNAAS; (ii) Formal crop risk assessment; (iii) Area-Yield Crop Insurance product design and pricing; and (iv) Weather index based crop insurance pilot design.

Key Findings

4. ***There is no tradition of crop or livestock insurance in Senegal***. The private commercial insurers do not have any direct experience in the planning, contract design, underwriting, claims adjusting, rating and risk financing for this class of business. Neither do they have a rural branch-office network with which to market and underwrite agricultural crop and livestock insurance products and programs for small-scale Senegalese farmers. They also lack trained local staff to perform field-level inspections and loss assessments. This poses major challenges for the introduction of agricultural insurance in Senegal.

5. ***Senegalese farmers have very limited knowledge or awareness of the role and potential benefits of crop insurance***. In the absence of agricultural insurance, farmers currently have limited knowledge of the role of crop insurance. During field visits some farmers highlighted the fact that crop insurance is only one of many potential risk management instruments. For many

farmers crop insurance is of secondary importance compared to access to seasonal credit and timely supply of improved seeds and fertilizers.

6. ***A specialized agricultural insurance company has been established***. The Government of Senegal decided to establish the National Agricultural Insurance Company of Senegal (CNAAS) with public and private sector shareholding. Shareholders are the Government of Senegal, domestic insurance companies, farmer organizations, and a regional reinsurer. The insurance company was licensed by the CIMA in December 2008 and established by the Minsitry of Finance through the Decree of February 10, 2009.

7. ***The business plan of the specialized agricultural insurance company CNAAS lays out the operational and institutional structure of the CNAAS and lists potential insurance products to be offered. It needs, however, some further operational, legal, technical and financial refinements***. The business plan aims to underwrite a national-level crop and livestock portfolio. It proposes an Area-Yield Crop Insurance scheme with *départements* as insured unit, with a 50 percent coverage level, and in due course simplified rainfall index based crop insurance. It also aims to underwrite individual animal All Risk Mortality cover. The terms and conditions of the proposed agricultural products and their rating are broadly described in the proposed business plan. A provisional risk financing and reinsurance plan is discussed, but it would benefit from a detailed catastrophe risk assessment of the insurance portfolio.

8. ***There is currently no legal and regulatory framework for agricultural index-based insurance***. The current CIMA code does not allow index-based insurance. The implementation of index-based insurance would thus require an authorization from the regional insurance regulatory body CIMA.

9. ***The fiscal implications of the proposed agricultural insurance could be significant***. The Government of Senegal has taken a 35 percent share of the new agricultural insurance company, with FCFA 495 million (approximately USD1.1 million). The Government would also provide 50 percent insurance premium subsidies, which under the provisional business plan represent USD 2.7 million the first year of implementation. The business plan does not discuss the eligibility criteria to access premium subsidies and how this subsidy program would complement or substitute the current post-disaster relief program *Fonds de Calamités*.

10. ***Departmental crop yields are highly variable due to marginal rainfall and the semi-arid climate in much of Senegal, and there is a major drought exposure.*** *Département*-level average crop yields are highly variable, mainly on account of the drought exposure, both spatially between *départements* and temporally between years. Northern Senegal experiences annual rainfall of less than 400 mm, and crop production is very marginal and featured by low average yields and high crop losses in drought years. Rainfall increases from North to South and crop production and yields are more stable in the Centre and South of Senegal and the planning of any national crop insurance program should take these regional variations in risk exposure into account. A national Area-Yield Crop Insurance Program prviding a coverage level of 70 percent has a 1-in-100 year probable maximum loss of 29 percent of total liability. This represents a very major potential loss which needs to be structured into any future crop insurance and reinsurance program through the CNAAS.

11. ***The crop yield data collection system in Senegal is well developed, although it should be further enhanced.*** Senegal has a well developed system of annual farm production and yield estimation surveys termed the “Permanent System for Agricultural Statistics” (SPSA). SPSA is implemented by the Directorate of Statistical Analysis and Forecasting (DAPS), in conjunction with the Regional Directorate of Rural Development (DRDR) and its branch offices throughout

all 33 departments in Senegal. Time-series data and information on crop production and yields and climate are essential for the design and rating of any traditional crop insurance product or new area-yield or weather index product.

Main Recommendations

Agricultural Insurance Program

12. ***Agricultural insutance should rely on the existing programs aimed at modernizing the agricultural sector***. Agriculural insurance should complement other programs that aim to modernize the agricultural sector in Senegal: Promoting the disengagement of the public sector from productive and commercial activities, sustainable funding of demand-driven agricultural services, empowerment of producer organizations, and competitive funding of research activities.

13. ***The agricultural insurance program could be based on three pillars that clearly specify the commercial and social objectives of the program***. International experience shows that agricultural insurance should rely on the segmentation of the agricultural business activities and develop customized insurance solutions.

- ***Individual agricultural insurance for large commercial business***. Customized indemnity-based agricultural insurance products can be offered to large commercial agricultural firms (e.g. horticulture). This market is viable without public intervention.

- ***Weather-based crop insurance for semi-commercial farms***. Weather-based crop insurance may be viable for semi-commercial agricultural businesses involved in programs to enhance their production, such as the World Bank supported PSAOP. Weather-based crop insurance allows the farmers to complement their risk management toolkit. Public subsidies could be provided during the first years of operations as financial incentives to purchase agricultural insurance, but on a limited basis.

- ***Social safety net based on area-yield indices***. Market-based agricultural insurance is not an appropriate solution for the vast majority of subsistence farmers. These farmers face most urgent needs to improve their productivity, such as access to inputs (e.g. seeds, fertilizers). In the context of a social safety net program, the Government of Senegal may want to develop a program to protect subsistence farmers against catastrophic crop yield losses. Area-yield indices could be used as the basis for a payout scheme. This social program could be financed by the Government and managed by the CNAAS. This program could, in the medium term, replace the *Fonds de Calamités.*

14. ***Agricultural insurance should rely on the existing distribution channels***. The delivery costs of agricultural insurance can be prohibitive. The CNAAS should deliver and service its agricultural insurance products through exisiting delivery channels, such as the CNAAS, the CMS, micro-finance institutions, and producers' organizations.

15. ***The implementation of agricultural insurance should be gradual***. International experience shows that the development of agricultural insurance is a long-term endeavor, particularly in countries like Senegal, where the insurance culture is limited. Innovative

agricultural insurance products should first be piloted to ensure their efficiency and affordability, and then expanded.

Specialized Agricultural Insurance Company

16. ***The governance structure of the CNAAS should be clarified.*** The Government should consider and encourage the potential role that the private insurers could play in the provision of agricultural insurance, beyond their role as shareholders of the CNAAS. Private insurers could be involved in the distribution of agricultural insurance products, the design of innovative agricultural insurance products, etc. Index-based (area-yield and weather index based) crop insurance should be more attractive to private insurers than traditional agricultural insurance (as long as they are properly designed and priced) because they are less complex and less costly to administer.

17. ***The CNAAS should perform a formal crop risk assessment***. The CNAAS should perform a formal assessment of the catastrophe risk exposure of their potential insurance agricultural portfolio. They may want to use the specific crop risk assessment model (MARCS), which has been developed under this study. This would allow the company to set the insured yields, to price the Area-Yield Crop Insurance products, and to devise cost-effective reinsurance strategies.

18. ***The CNAAS should develop a sound risk financing and reinsurance strategy.*** The CNAAS should also model the exposures on its livestock portfolio, especially if All Risk Livestock Mortality insurance is provided in Year 1. These separate risk assessment exercises should be designed to establish the probable maximum losses expected on both programs and to structure the CNAAS's risk retention and reinsurance strategy as well as maximum protection requirements. In planning its reinsurance strategy, CNAAS should consider the role of both the commercial reinsurance market and possibly the Government as a reinsurer of last resort.

19. ***The CNAAS will require significant technical assistance in its first years of operations.*** The CNAAS will require major technical assistance in technical, financial, and operational areas: Information systems, product research and development, underwriting and loss adjustment techniques, catastrophe risk assessment and financing, etc. This type of expertise is currently limited in Senegal and may require international experts.

Role of the Government of Senegal in Promoting Agricultural Insurance

20. ***The objectives of the public intervention should be clarified.*** Should GoS want to increase the incomes of rural households or to create a social safety net program that assures some minimum level of income for farm households, agricultural insurance may not be a cost-effective instrument. Agricultural insurance can be an efficient risk financing tool, as part of an overall agricultural risk management strategy, but it is not cost-effective in transferring wealth to economically disadvantaged rural households.

21. ***The role of Government in supporting the development of agricultural insurance should be further clarified***. The proposed role of the Government, as stated in the provisional business plan developed by the *Direction des Assurances*, is twofold: As a minority shareholder of the specialized agricultural insurance company CNAAS and as a provider of direct insurance premium subsidies, currently advised as 50 percent subsidies on both crop and livestock insurance premiums. Alternatively, the GoS could perform a very important financial role in supporting agricultural risk market infrastructure: (i) Enhancing data and information; (ii) product research and development; (iii) farmer education and sensitization; (iv) training of insurance

companies; and (v) specific areas such as strengthening the crop-cutting yield surveys for selected crops in departments selected for the Area-Yield Index Insurance Program.

22. ***A Technical Support Unit for agricultural insurance should be established***. The GoS should consider the creation of a Technical Support Unit (TSU), which would be responsible for the key functions of data and information acquisition and analysis; product design and rating; training and education on behalf of CNAAS and the participating private commercial insurers; implementation of the national crop and livestock programs; and design of field inspection and loss assessment systems and procedures. The TSU would also be a key institution in the pilot testing of the proposed departmental Area-Yield Index Insurance Program and the weather index based crop insurance program.

23. ***Should the Government of Senegal want to provide premium subsidies, this program should be targeted to small and marginal farmers.*** Government-sponsored premium subsidies should be carefully considered, as premium subsidies have proved to be inefficient for farmers to encourage them to engage in viable agricultural activities and were increasingly expensive for the Government. Should GoS still envisage providing premium subsidies, they should be targeted to small and marginal crop and livestock producers as a social safety net program. Strategies could be developed to differentiate subsidy targets, and eventually to phase down subsidies over time. They should also be designed to limit the distortion of market-based insurance premiums.

24. ***The Government could act as a reinsurer of last resort***. Catastrophe reinsurance can be very expensive or even unavailable for the very infrequent (catastrophe) risk layers. The GoS could complement private reinsurance capacity by covering these top risk layers.

25. ***An appropriate sovereign risk financing strategy should be devised to limit the fiscal exposure resulting from the public financial support to agricultural insurance***. An appropriate risk financing strategy, including, for example, a contingent line of credit and other risk transfer options like weather derivatives, should be designed to limit the fiscal exposure of the Government to excessive losses. As other regional initiatives on agricultural insurance develop in Western Africa, a regional approach for the financing of catastrophic losses (e.g. drought-related ones) could be promoted, such as the creation of a regional agricultural insurance pool, similarly to the recently established Caribbean Catastrophe Risk Insurance Facility.

26. ***The GoS should ensure that market-based agricultural insurance and post-disaster assistance programs are complementary.*** In many countries disaster assistance has proved to be a disincentive for farmers to purchase crop insurance: Farmers tend to wait for a disaster to happen, and then rely on government assistance. The role of the *Fonds de Calamités* should be redefined to complement agricultural insurance promoted by CNAAS. For example, this fund should only cover risks that cannot be insured through the CNAAS or other insurance companies.

27. ***The insurance code CIMA should be amended to further support agricultural insurance.*** The insurance code CIMA, which regulates Western African countries, should be applicable to agricultural insurance, but should allow for different provisions for agricultural insurance, where appropriate, through regulations. The insurance code CIMA should also allow index-based products, such as Area-Yield Crop Insurance and weather index based crop insurance products, to be classified as insurance products where there is a reasonable correlation between the index and the insured's agricultural loss, and when the principle of insurable interest is met.

Suitable Crop Insurance Product Development for Senegal

28. ***Agricultural insurance is effective only if some preconditions are met***. Any crop insurance program for Senegalese farmers will only be effective if it is accompanied by timely access to improved seeds, fertilizers, and credit, and if output markets and sales prices are attractive to growers to make an investment in new technology. It would be inefficient to offer crop insurance in *départements* where farming is subsistence-oriented and where input supply and output marketing services are poorly developed, and credit availability is limited.

29. ***Traditional Multi-Peril Crop Insurance (MPCI) is unlikely to be viable for small farmers in Senegal***. International experience has highlighted several drawbacks with individual grower MPCI, including the absence of farmer-level yield data, which generates adverse selection and often prohibitively high costs of administering and adjusting losses at the individual farmer level. It is therefore recommended that individual grower MPCI should not be considered in the start-up of the new CNAAS crop insurance program for Senegal. It is understood that this view is shared by the CNAAS and that in 2009 the company does not intend to launch individual grower MPCI insurance.

30. ***Index-based crop insurance products should be devised for small farmers***. No single product solution will meet Senegal's needs, due to the wide range of climatic and farming conditions. As a result, a mix of index-based crop insurance products, such as Area-Yield Crop Insurance and weather index based crop insurance, is recommended to allow for the expansion of crop insurance in Senegal. Area-Yield Crop Insurance may be better suited for major food crops grown by small and marginal farmers (if basic preconditions are met), and potentially linked to credit, while weather-based crop insurance may better suit the needs of commercial farmers.

31. ***Area-Yield Crop Insurance is technically feasible in Senegal under certain conditions***. Area-yield crop insurance coverage should only be offered for the main crops, accompanied by strengthened farm and yield crop-cutting surveys. It is likely under an Area-Yield Insurance Program that the insurer will require the introduction of a system of independent auditing of the yield crop-cutting surveys to ensure these continue to be implemented on an objective and impartial basis. Minor crops, where yield measurement is based on visual estimation techniques, cannot be considered under an Area-Yield Index Program in Senegal. Initially, area-yield insurance should be considered only in those *départements* where average yields of the same crop are relatively homogeneous throughout the department.

32. ***Area-Yield Crop Insurance should be piloted for groundnut and millet in Nioro, Kolda, and Sedhiou***. Area-Yield Crop Insurance products could be implemented on a pilot basis to cover groundnuts and millet in the middle-size *départements* of Nioro, Kolda, and Sedhiou. Other *départements*, and particularly large *départements* like Kaffrine, need further investigation, as basis risk may be a major issue. These pilots would be aimed at testing the operational and technical procedures of the Area-Yield Insurance Program and improving farmers' education on area-yield insurance. They would also provide useful lessons for the design and implementation of the CNAAS Area-Yield Insurance Program, which is planned on a much larger scale for all major crops and departments throughout Senegal. Thus, although the three *départements* provisionally identified under this study for pilot testing of an Area-Yield Index represent the most stable rainfall and production regimes in Senegal and tend to have better rural infrastructure and more commercial farmers, it is intended to scale-up the programs as part of the program developed by the CNAAS.

33. ***Area-yield coverage levels should be set individually for each crop and each département***. The spatial differences in yield variation by crop type and department indicate that

the insured yield coverage level of an Area-Yield Crop Insurance Program should be set individually for each crop and each department, at affordable premium levels. This report provides a systematic methodology for adjusting yields for central tendency and for calculating appropriate insured yield coverage levels and corresponding technical pure loss cost rates.

34. ***Weather index based crop insurance is technically feasible in Senegal under certain conditions.*** A procedure has been specifically developed for the design and rating of standardized deficit-rainfall insurance products for smallholder groundnut farmers. This procedure, based on the international experience (such as models developed for Malawi and India) and the local characteristics, relies on the decomposition of the crop-growing period into three physiological growth phases. Payout structures are designed for each of the three phases.

35. ***Weather index based crop insurance should be piloted for groundnuts in specific locations of Nioro and Kaffrine départements.*** Weather index based crop insurance products could be pilot-implemented, in partnership with local farmer organizations in the Pascioto district of Nioro and the Kahi district of Kaffrine. The purpose of these Pilots would be to test the operational and technical procedures of the weather index based crop insurance program and educating farmers. Prototype products designed to protect improved groundnut-seed producers against rainfall deficit have been developed and rated for two weather stations located in Kaffrine and Nioro Departments. These products have a pure premium rate of less than 10 percent and a frequency of payout of 1-in-6 years. The sum insured is based on the costs of production.

36. ***The weather index based crop insurance Pilot could build on the existing agricultural modernization projects***. The Pilot could build on the existing PSAOP structure in the pilot locations. ASPRODEB, in association with the local Centrales d'Achat, could provide extension and promotion, and could supervise the enrollment of farmers for insurance. Farmer organizations could coordinate their farmer members in relation to the insurance program.

Abbreviations

AAL	Average Annual Loss
ANCAR	Agence Nationale de Conseil Agricole et Rural
ARC	Agriculture Reinsurance Consultants, Ltd
ARM	All Risks Mortality
ASPOP	Agricultural Services and Producer Organizations Project
AYCI	Area-Yield Crop Insurance
CA	Centrale d'Achat
CCE	Crop Cutting Experiment
CCPA	Cadre de Concertation des Producteurs d'Arachide
CERAAS	Centre d'Etude Régional pour l'Amélioration et l'Adaptation à la Sécheresse
CIMA	*Conference Interafricaine des Marches d'Assurance*
CIRAD	Centre de coopérétaion Internationale en Recherche Agronomique pour le Développement
CLCOP	Cadre Locale de Concertation des Organisations de Producteurs
CMS	Crédit Mutuel Sénégal
CNAAS	National Agricultural Insurance Company of Sénégal *(Compagnie Nationale d'Assurance Agricole du Sénégal)*
CNAAS	Caisse Nationale du Crédit Agricole du Sénégal
CNCR	Cadre National de Concertation et de Cooperation des Ruraux
COV	Coefficient of Variation
CPS	Centre de Prestation de Services
CRCA	Regional Insurance Control Commission (*Commission Regional de Controle des Assurances*)
CRMG	Commodity Risk Management Group, World Bank
DA	Insurance Department (*Direction des Assurances*)
DAPS	Statistics Department of the Ministry of Agriculture
DR	Census Bureau (*District de Recensement)*
DRDA	Regional Directorate for Agriculture and Rural Development
DRDR	Regional Department of Rural Development *(Direction Régionale du Développement Rural)*
EASRD	East Asia Sustainable Rural Development
FB	*Fonds de Bonification*
FC	*Fonds de Calamité*
FG	*Fonds de Garantie*
FPDSN	Finance and Private Sector Development, Financial Markets for Social Safety Net

FSSA	Senegalese Federation of Private Insurance Companies (*Fédération Sénégalaise des Sociétés d'Assurances*)
GIE	Groupement d'Intérêt Economique
GIPA	Groupement Intervillageois des Producteurs d'Arachide
GoS	Government of Senegal
GPF	Groupement de Promotion Féminine
MARCS	Portfolio Crop Risk Assessment Model for Senegal (*Modèle d'Analyse des Risques de Cultures du Senegal)*
MFR	Maison Familiale Rurale
MoF	Ministry of Finance
MPCI	Multiple Peril Crop Insurance
NOVASEN	Nouvelle Variéte d'Arachide du Sénégal
OP	Organisation de Producteurs
PML	Probable Maximum Loss
PRPA	Programme de Relance de la Production Agricole
PSAOP	Projet de Services Agricoles et Organisations des Producteurs
SDDR	Service Départemental du Développement Rural
SONACOS	Société Nationale des Oléagineux du Sénégal
SPSA	Permanent System for Agricultural Statistics (Système Permanent de Statistiques Agricoles)
TFESSD	Trust Fund for Environmentally and Socially Sustainable Development
TSI	Total Sum Insured
TSU	Technical Support Unit
UNCAS	Union Nationale des Coopératives Agricoles du Sénégal
URCA	Union Régionale des Coopératives Agricoles

CURRENCY EQUIVALENT
(Exchange rate effective May 31, 2008)

FCFA 450 = US$1

Chapter 1. Introduction

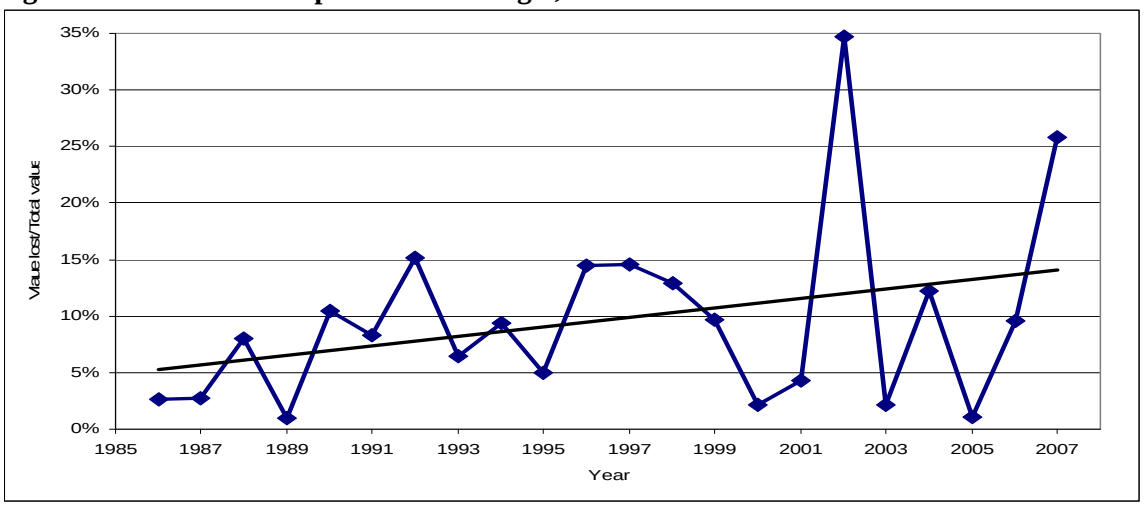
1.1 Senegal's recent relatively robust economic growth has only marginally benefited rural areas, where 58 percent of the population lives. The share of the primary sector in GDP fell from 25 percent in the early 1960s to less than 20 percent in the 2000s, with agriculture dropping from 16 percent to less than 10 percent of GDP in the same period. Nevertheless, 70 percent of the rural population derives its livelihood from agriculture, which remains largely dominated by smallholder producers cultivating rainfed crops and practicing extensive animal husbandry. Food security and rural revenues rely mainly on millet and groundnut. Groundnut growing occupies 700,000 households, for whom this crop is the main source of income and a substantial contribution to food security.

1.2 Stagnation of agricultural productivity is one of the major constraints to agricultural growth and one of the leading causes of the growing impoverishment of farmers. The main causes include limited access to input and working capital; soil fertility degradation; decreasing quality of seed (when available); and limited diversification and intensification.

1.3 In Senegal 3.8 million hectares of land are suitable for arable cropping, of which less than 2.0 million hectares are cultivated. Currently less than 5 percent of cropped area or 105,000 hectares benefits from irrigation, and the remaining 95 percent of cropping is rain-fed and therefore is exposed to drought and/or floods. About 1.85 million hectares were cultivated in 2007/08, which represents a decline of 7 percent compared with the previous year. Millet and groundnut account for 37 and 33 percent of the total cultivated area, respectively. The millet production and peanut production reached 319,000 tons and 331,000 tons in 2007, respectively. The year 2007 showed a general decrease in agricultural production compared to the previous season, mainly due to drought. The cereal production decreased by 12 percent mainly because of the decline of millet production by 27 percent. Likewise, the decline in peanut production is estimated at 7 percent.

1.4 When estimating the value lost per year relative to the total crop value, a distinct trend can be identified (Figure 1.1). The average loss value has increased from about 5 percent in 1986 to about 14 percent in 2008. This could be caused by a number of factors, including more marginal land that is also more vulnerable to natural disaster being brought into production over the last years and a potential increase in the frequency and/or severity of major natural disasters as a result of climate change. Figure 1.1 also shows the impact of major droughts in 2002 and 2007 on the total production losses.

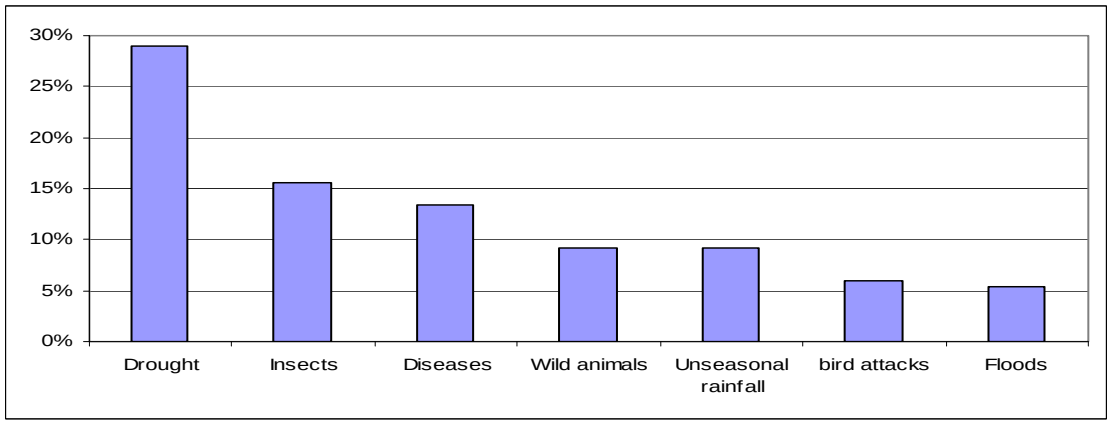
Figure 1.1: Trend in Crop Losses in Senegal, 1986 to 2007



Source: Authors, from DAPS (2008).

1.5 The causes of loss are not formally identified during the annual crop yield surveys conducted by the Statistics Department of the Ministry of Agriculture (DAPS). Nevertheless, a survey of 1500 households was conducted in 2004 by the consulting firm EMAP, at the request of the Direction des Assurances (DA). Figure 1.2 shows that, not surprisingly, drought is the primary cause of crop loss for almost 30 percent of rain-fed farmers, followed by locust infestation (16%).

Figure 1.2: Causes of Crop Losses for Rain-fed Agriculture



Source: EMAP (2004).

1.6 The weak performance of the Senegalese agricultural sector is caused by multiple factors, including rainfall deficit and variability; price instability of agricultural products, especially the price of groundnut; low productivity; decrease in soil fertility and deterioration of ecosystems; limited interest of the private sector to invest in the agricultural sector; and limited access to agricultural credit. All these factors have led to a reduction in cultivated areas and low yields and production.

1.7 Agriculture remains an important priority for the Senegalese government, as indicated in the mandate from the last Presidential elections and further emphasized by the recent food crisis. The Government is strongly committed to supporting rural development and the agricultural

sector. The Government of Senegal launched in 1997 an ambitious Program for the Modernization of Agriculture, *Programme de Relance de la Production Agricole* (PRPA), to help farmers purchase inputs (e.g. fertilizers, pesticides, improved seeds) through better access to credit. In 2004, the Agricultural Orientation Law (*Loi d'Orientation Agro-Sylvo-Pastorale*) was adopted, which outlines the vision of the Government for modernizing the agricultural sector over the next 20 years.

1.8 Since 2000 the agricultural sector has shown signs of recovery, notably in horticultural exports, cereals and poultry production, thanks in part to the Government's commitment to support the sector and implement reforms through the World Bank supported Agricultural Services and Producer Organizations Project (PSAOP). This Project promotes the disengagement of the public sector from productive and commercial activities, sustainable funding of demand-driven agricultural services, empowerment of producer organizations, and competitive funding of research activities. Nonetheless, numerous constraints continue to limit the country's potential for accelerated agricultural growth. The most serious include: Food safety and quality issues; access to investment and working capital; poorly functioning market infrastructures; inefficient distribution channels; and weak irrigation infrastructures that account for less than five percent of total arable land.

1.9 The Government of Senegal has adopted a post-disaster assistance approach to help farmers deal with the negative economic impacts of natural disasters. Under the PRPA, the Government of Senegal set up a *Fonds de Calamité* aimed at protecting farmers against natural disasters. In addition, the *Fonds de Garantie* provides partial credit guarantees for non-performing loans, which also covers farmers who cannot repay their loans due to major crop losses caused by natural disasters.

1.10 Access to formal risk financing instruments, such as insurance, can help Senegalese farmers transfer excessive losses to a third party (such as an insurance company), thus stabilizing household income, facilitating their access to credit, and ultimately enhancing their livelihoods. Thus, risk management is essentially the responsibility of individual farmers and their extended households. When disasters occur, the government often provides short-term immediate assistance through the *Fonds de Calamité* or *the Fonds de Garantie*, but systemic challenges remain.

1.11 GoS recognizes the importance of promoting agricultural insurance, and has undertaken a series of studies to examine the feasibility of agricultural insurance. The first report, published in 2004, developed a typology of insurable farms/crops and recommended a series of crop insurance products to be piloted. A second report, commissioned by the Insurance Supervisory Department (*Direction des Assurances*) in 2007, analyzed the viability of crop insurance and livestock insurance in Senegal. The report recommended the establishment of a specialized agriculture insurance company. It also suggested offering area-yield crop insurance, where the indemnity payments depend on a aggregate yield index of a given geographical area (e.g. *département*), and drought index insurance, where the insurance indemnity is based on a weather index like cumulative rainfall over a given period reported at a pre-defined weather station. While the report provided interesting thoughts and recommendations, it did not fully address the technical and operational challenges related to its implementation.

1.12 In this context, the Ministry of Finance (MoF) requested the World Bank to conduct a feasibility study of index-based crop insurance in Senegal and provide recommendations for its future development. This work aims to provide an overall framework for the development of sustainable market-based crop insurance in Senegal. It relies on the following components:

- *Review of the GoS proposal for agricultural insurance*. The provisional business plan of the proposed agricultural insurance company is reviewed in the light of international experience. The role of the government and the private insurance industry is discussed, with a particular focus on the financing of natural disasters in agriculture, and some guiding principles are drawn from the international experience.

- *Crop risk assessment*. A formal crop risk assessment is performed. The Portfolio Crop Risk Assessment Model for Senegal (Modèle d'Analyse des Risques de Cultures du Senegal, MARCS) has been specifically designed for Senegal. It is intended to assist policy makers and insurance practitioners in the planning, design, and rating of the index-based crop insurance. This assessment is instrumental in developing viable index-based insurance products.

- *Area-yield crop insurance product design and pricing*. Area-yield crop insurance has been proposed to be implemented in Senegal by the *Direction des Assurances*. The key design and rating issues and methodology for an area-yield crop insurance program are analyzed, based on the international experience. Outline proposals are presented for an area-yield crop insurance pilot for selected crops in selected districts.

- *Weather index based crop insurance pilots*. Prototype drought-based crop insurance products for groundnut producers are designed and rated for two specific pilots in the districts of Nioro Kaffrine. These products are based on sophisticated agro-meteorological models developed by local research institutions like CERAAS. The operational challenges related to the implementation of a pilot are discussed and the role of each stakeholder is identified.

1.13 The emergence of a sustainable crop insurance program relying on public-private partnership entails support from the Government in creating an economic and legal environment that attract private insurers in this new business and provides farmers with the incentives to engage in risk-financing strategies. It includes, among other, the development of a risk market infrastructure, such as efficient data collection and management systems, appropriate regulatory and legal frameworks, effective information and education programs, and the development of local technical expertise.

1.14 This report should be ideally complemented with a comprehensive demand assessment for agricultural insurance. While a basic demand assessment has been conducted in the two pilot areas selected for the weather-based crop insurance pilots, with very positive feedback from the farmers, there is a need for a more formal demand assessment for area-yield crop insurance.

1.15 The report consists of six chapters, starting with this introduction. Chapter 2 provides a review of agricultural insurance in Senegal, including the provisional business plan of the proposed agricultural insurance company, and discusses the role of the Government in the emergence of a viable crop insurance market. Chapter 3 presents a detailed risk assessment of the main crops in Senegal, based on a model specifically developed for Senegal, Portfolio Crop Risk Assessment Model for Senegal, MARCS. Chapter 4 discussed the technical and operational challenges in the design and implementation of an area-yield crop insurance program. Chapter 5 focuses on weather index based crop insurance pilots, with the design and rating of prototype drought insurance products for groundnut farmers, and present an action plan of its pilot implementation. Chapter 6 presents conclusions and recommendations. The report is completed by ten technical notes, available upon request.

Chapter 2. Agricultural Insurance in Senegal

2.1 This chapter provides a review of the Government of Senegal, GoS, proposals for agricultural crop and livestock insurance in Senegal. It first presents an overview of GoS support to agriculture and intervention mechanisms against natural disasters. It then reviews GoS proposals for the introduction in 2008 of a public-private national agricultural insurance scheme. Finally, it provides a review of international experience with public-private partnerships in agricultural insurance and guiding principles which may assist GoS in finalizing the planning, design, and implementation of Senegal's crop and livestock insurance scheme.

Government Intervention against Natural Disasters

2.2 In 1997, the Government of Senegal launched an ambitious Program for the Modernization of Agriculture, *Programme de Relance de la Production Agricole* (PRPA), to help farmers purchase inputs (e.g. fertilizers, pesticides, improved seeds) through better access to credit. Under this program, three funds for the financing of agriculture were established: (i) *Fonds de Bonification* aimed at providing subsidized interest rates; (ii) *Fonds de Garantie* aimed at covering non-performing loans up to 75 percent; and (iii) *Fonds de Calamité* aimed at protecting farmers against natural disasters.

2.3 The *Fonds de Bonification* aims to improve access to credit through subsidized interest rates and to increase the productivity of the agricultural sector. This fund pays the difference between the commercial interest rates (e.g. 13 percent for the CNAAS) and the subsidized interest rates offered to the farmers (7.5 percent).

2.4 The *Fonds de Garantie* provides partial credit guarantees to the farmers and herders and thus increases their creditworthiness. Non-performing loans are covered up to 75 percent for crop loans and 50 percent for livestock loans. Up to now, only the CNAAS has had access to this fund.

2.5 The *Fonds de Calamité* provides post-disaster financial assistance to farmers hit by adverse events (drought, pest infestation, etc.). This Fund, directly managed by the Ministry of Finance, helps farmers to pay back their loans, thus restoring their creditworthiness, and/or to purchase inputs in the aftermath of a natural disaster.

2.6 About FCFA 44 billion (US$99 million) have been allocated to these three funds during 1998-2005, of which 45 percent was allocated to the Fonds de Garantie and 23 percent to the Fonds de Calamité, to help farmers mitigate their exposure to adverse natural events (see Table 2.1).

Table 2.1: Resources of the Public Funds for Agriculture

FCFA million	Fonds de Garantie	Fonds de Bonification	Fonds de Calamité	TOTAL
1998	400	300	300	1,000
1999	1,925	700	225	2,850
2000	2,100	700	300	3,100
2001	3,100	900	3,500	7,500
2002	3,000	-	-	3,000
2003	500	-	1,556	2,056
2004	5,100	900	4,174	10,174
2005	9,964	1,517	3,000	14,481
1998-2005	**26,089**	**5,017**	**13,055**	**44,161**

Source DCEF (2008).

2.7 Table 2.2 shows the budget allocations in 2004-05. The total expenditures increased by 40 percent between 2004 and 2005 and reached FCFA 14.3 billion (US$32 million) in 2005. 43 percent of the expenditures in 2004 and 2005 were related to credit support, either direct loan repayment programs or support to CNAAS.

Table 2.2: Expenditures of the Public Funds for Agriculture

	2004			2005		
	FCAF million	Source	Percent	FCAF million	Source	Percent
Locust	4,200	FC	41%			
Excess rainfall	1,100	FG	11%			
Banana producers	530	FC	5%			
Agricultural loan repayment	3,444	FC/FG	34%	548	FG	4%
CNAAS	900	FB	9%	5,517	FG/FB/FC	39%
Agricultural input subsidies				1,600	FG	11%
Cassava program				243	FG	2%
Agricultural price subsidies				1,000	FG	7%
Cash flow support				5,000	FG	35%
Agricultural Intensification and Modernization Project				374	FG/FB/FC	3%
TOTAL	**10,174**		**100%**	**14,282**		**100%**

Source: DCEF (2008).
Note: FC: Fonds de Calamité; FB: Fonds de Bonification; FG: Fonds de Garantie.

2.8 The Funds offer the GoS post-disaster financial tools to help the agricultural sector to deal with adverse natural events. However, the efficiency of these Funds has been questioned, mainly due to the lack of transparency and discipline in the allocation of the resources.

2.9 Commercial agricultural insurance could complement these Funds and contribute to stabilizing the productivity of the agricultural sector. It could contribute to shifting from post-disaster risk financing to ex ante risk financing.

Government of Senegal Proposals for Agricultural Insurance

Senegalese Insurance Market

2.10 In Senegal the insurance industry is governed by the regional Code d'Assurances (insurance law) established by the *Conference Interafricaine des Marches d'Assurance*, CIMA, on 15 February 1995. CIMA works closely with the insurance regulatory authorities in each signatory country in Francophone Africa to promote the development of the insurance industry and to supervise and regulate the activities of the insurance companies in each market. As part of its legal authority, CIMA is responsible for approving the introduction of any new insurance product or policy. In this context any new agricultural crop or livestock insurance policy which may be introduced into Senegal will first need to be authorized by CIMA, including traditional indemnity-based products and new index-based crop insurance products (Area-Yield Index or Weather Index).

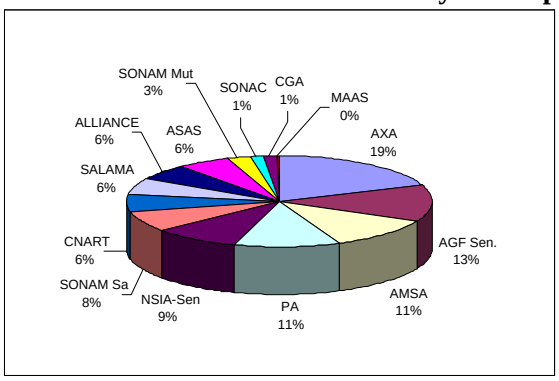
2.11 There are two insurance supervisory authorities in Senegal: (a) The Regional Insurance Control Commission (CRCA; *Commission Regional de Controle des Assurances*), based in Libreville, Gabon, and (b) the Senegalese Insurance Supervisory Department, *Direction des Assurances*, of the Ministry of Finance. Since 2007 the DA has been involved in developing a business plan for the introduction of a national agricultural crop and livestock insurance program for Senegal. Under this exercise the DA is actively collaborating with the Senegalese Federation of Private Insurance Companies (*Federation Senegalese des Sociétés d'Assurances*, FSSA).

2.12 In 2007 there were 14 registered non-life insurance companies in Senegal with total market premiums of FCFA 58.1 billion (US$ 129 million), which represents a 10.4 percent increase on the 2006 non-life market premium[1]. The French Insurer Axa Senegal is the largest non-life company with a 19 percent market share in 2007, followed by AGF Senegal, which is part of the Allianz Group, with 13 percent market share (see Figure 2.1.). Nearly all insurers are private commercial companies.

2.13 The most common form of insurance is motor vehicle accounting for 38 percent of total premiums in 2007, followed by health insurance with 17 percent of total premiums, property fire 13 percent, and transport 13 percent (Figure 2.2.).

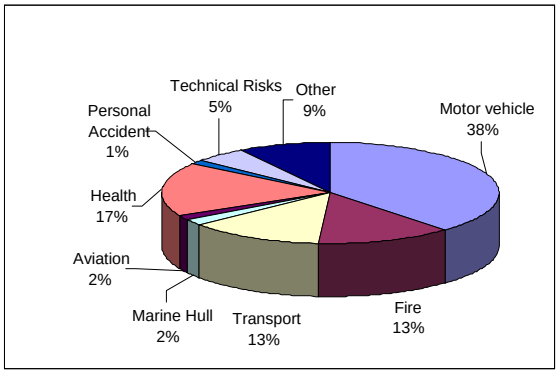
[1] Source: Federation Sénégalaise des Sociétés d'Assurances (FSSA), 2008.

Figure 2.1: Share of 2007 Non-Life Insurance Premiums by a Company



Source: FSSA (2008).

Figure 2.2: Distribution of 2007 Non-Life Insurance by Class



Source: FSSA (2008).

2.14 There is no tradition of agricultural crop or livestock insurance in Senegal, and the private commercial insurers do not have direct experience with the planning and design, underwriting, and claims adjusting for this class of business, or a rural branch-office network with which to administer insurance for small-scale farmers.

2.15 There is a national reinsurer (SEN-Re) formed in 1998 with 50/50 public and private insurer capital, with the objective of increasing premium retention levels of the Senegalese insurance industry. Insurance companies are required by law to make compulsory cessions to SEN-Re of 6.5 percent of their insurance premiums and 15 percent of their treaties. Local companies also have to cede a further 15 percent to the regional reinsurer (CICA-Re) and 5 percent to AfricaRe. Local companies can legally cede up to 75 percent of their business to other international reinsurers.

Proposals for Agricultural Insurance

2.16 The first steps to develop an agricultural insurance system date back to 1995 when the Government of Senegal commissioned the DA and the Departments of Statistics and Agriculture to form a working group to study the problem and to recommend potential solutions. Since 2003, the Government has sponsored three major initiatives to introduce agricultural insurance for Senegal's crop and livestock producers, including:

- EMAP Agricultural Risk Study in 2004;
- Agricultural Insurance Feasibility Study commissioned by the DA and implemented by a Swiss-based consultancy firm, Agricultural Reinsurance Consultants (ARC) in 2005; and
- Approval by Government in 2007, of the creation of a national agricultural crop and livestock insurance company, *Compagnie Nationale d'Assurance Agricole du Senegal* (CNAAS). The DA had been charged with the formation and incorporation of the CNAAS and the preparation of a detailed business plan for the new company.

EMAP Study 2004

2.17 The EMAP 2004 study involved a detailed farm-level production and risk management survey which was implemented with a sample of 1,500 rural households in the main production zones of Senegal[2]. The study provided a useful classification of Senegalese farming systems and the constraints to agricultural crop and livestock production. The study also produced a qualitative assessment of the natural, climatic and biological risk exposures faced by rain-fed and irrigated crop producers and also identified a series of management-related factors (soil degradation and declining fertility) and market-related issues (input supply constraints, lack of access to credit, output marketing, and price related risk). Drought and/or untimely and variable rainfall were identified as the major sources of crop production losses, followed by flood and insect pests (locusts) and bird attacks (especially in millet and sorghum). The EMAP study did not, however, provide a quantitative assessment of crop or livestock production losses at local, regional, and national levels.

2.18 EMAP recommended the establishment of a specialist mono-line agricultural insurance company to be financed by the state, private insurers, and producer organizations. EMAP also suggested starting with a limited number of pilot crops (e.g., bananas, irrigated rice, and rain-fed groundnuts) in a limited number of pilot areas (e.g. Goulombou area of Tambacounda and the North Delta). The study did not, however, include recommendations on the type of crop and livestock insurance products (policies) which would be most appropriate for Senegalese small-scale predominantly rain-fed farmers and cattle herders and did not extend to a technical rating analysis.

ARC Feasibility Study 2006

2.19 In 2006, the DA contracted the international consulting firm Agriculture Reinsurance Consultants Ltd (ARC), to conduct a technical and actuarial feasibility study for the introduction of crop and livestock insurance in Senegal[3]. The consultant noted that, currently, and for the foreseeable future, the private Senegalese insurance sector would only be able to provide very limited support for agricultural insurance. ARC therefore recommended the formation, in the start-up phase, of a specialized public-sector agricultural insurance company as a public-private partnership with close involvement of all stakeholders, and in a second phase, the formation of branch offices throughout the country.

2.20 **Crop Insurance Products**. ARC noted that in the start-up phase of the new Agricultural Insurance Company, the lack of rural insurance infrastructure would prohibit the development of

[2] Etude et Management du Projets, EMAP, 2004, Etude sur les Risques Agricoles. Cabinet EMAP, Décembre 2004.

[3] ARC 2006, "Agriculture Insurance Project for Sénégal", commissioned by Ministère de l'Economie et des Finances, Direction des Assurances, ARC – Agriculture Reinsurance Consultants Ltd, Switzerland.

individual farmer, Named-peril and Multiple-peril, traditional indemnity-based crop insurance products. The consultant therefore recommended in Phase 1, the development of Area-Yield Multiple-Peril Crop Insurance where the indemnity payments would be based on a yield index developed for a defined geographical area (in this case the Department). The consultant's report contained an outline wording for the area-yield policy and calculated technical rates and recommended commercial premium rates for up to 6 crops (groundnuts, cotton, maize, sorghum, millet, and rice)[4]. ARC also recommended a separate rainfall deficit crop weather index policy based on an aggregate seasonal rainfall deficit model and prepared indicative rates for this product.

2.21 **Livestock Insurance Proposals**. The ARC Report presented proposals for two main types of Individual Animal Livestock Insurance for horses, cattle, sheep, and goats: (i) Basic Accident & Mortality cover against the named perils of fire, drowning, road accidents and poisoning; and (ii) Comprehensive "All Risks" Mortality cover including accident and illness and disease which cause the death of the animal, but excluding epidemic diseases and intentional (or compulsory) slaughter. A third type of livestock insurance of Epidemic Diseases was identified, but the consultant specifically recommended that in Phase 1, epidemic disease cover should not be provided in Senegal, because of the lack of insurance infrastructure with which to administer such a cover. In the absence of detailed mortality statistics, the ARC report used transferred international experience to present indicative rates for individual animal insurance ranging from 2.5 percent to 3 percent for basic accident and mortality cover rising to between 6.0 percent (goats) and 9 percent (horses) for All Risks Mortality cover. ARC stressed that its livestock premium rates were illustrative and required confirmation.

2.22 The ARC feasibility study provides useful conceptual and technical proposals for the introduction of crop and livestock insurance in Senegal. The scope of the report did not, however, extend to an analysis of the organizational, operational and financial requirements and implications for the proposed specialist agricultural insurer of designing, rating and implementing the recommended crop and livestock insurance products.

Proposals for a National Agricultural Insurance Company

2.23 In 2007, the Government of Senegal (GoS), and the Ministry of Finance (MoF) appointed the DA to prepare a business plan for the formation of a new public and privately-owned agricultural insurance company, the CNAAS. In 2007, the DA prepared a short Technical Study[5] outlining their preliminary proposals for the new insurance program. Salient features of the DA's 2007 (Draft) Technical Study are reviewed in this section and further details are presented in Technical Note 1. It is, however, important to note that the DA prepared a revised business plan for the formation of the CNAAS in fall of 2008. So some of the proposals and figures contained in the 2007 (Draft) Technical Study were superseded and updated. However, the revised business plan was not available when this World Bank report was prepared.

[4] Technical and Commercial Premium Rates are presented in the ARC Report for Groundnuts in each Department and for Insured Yield coverage levels of 50%, 60% and 70%. These Departmental rates were calculated on the basis of an analysis of yields from 1990 to 2004. It is understood that rates for the other 5 main field crops were also calculated by ARC. ARC reported that "premium costs vary widely - between 1.5% and 15% - depending on risks, crops, cover level and locations (Departments) for the suggested catastrophe crop yield and rain shortfall insurance products (cover level 50% of long-term Departmental average yield or rainfall)".

[5] DA 2007, Etude Technique et Financière pour la Mise en Place d'une Société d'Assurance Agricole au Sénégal.

2.24 The CNAAS is planned as a public-private entity and Government intends to offer up to 50 percent of the shareholding to the private commercial insurance companies and to producer organizations and any other interested party. The company's capital is currently advised as FCFA 1,500 million (US$ 3.3 million). The private commercial insurers will be invited to participate in this new venture as shareholders and with representation on the Board. They will not, however, function as co-insurers of the new public-private company, and the CNAAS will exclusively underwrite the crop and livestock programs.

2.25 Government financial support for the new agricultural insurance initiative is planned to include:

- FCFA 495 Million (US$ 1.1 million) or a 33 percent share of the total share capital of the CNAAS of CFCA 1,500 Million (US$ 3.3 Million), and
- 50 percent premium subsidies, currently budgeted at:

    - Year 1: FCFA 1,211 million (US$ 2.7 million)
    - Year 2: FCFA 2,423 million (US$ 5.4 million)
    - Year 3: FCFA 3,295 million (US$ 7.3 million)

2.26 **Crop and Livestock Insurance Products**. The DA's 2007 (Draft) Technical Study identifies 2 priority products which will be developed over the next 3 years:

- Area-Yield Crop Insurance with the Department forming the Insurer Unit. Cover will be priced for 50 percent, 60 percent and 70 percent coverage levels; and
- Individual Animal All Risk Livestock Insurance Policy.

2.27 **Potential 3-Year Crop Insurance Portfolio**. The 2007 (Draft) Technical Study identifies a total of nine crops which will be insured under the District-level, Area-Yield crop insurance program including groundnuts, cotton, millet, sorghum, maize, rice, hungry rice[6], cowpea, and cassava. The plan assumes that over a three-year period approximately 20 percent of the national cropped area will be insured, rising from 118,500 ha in Year 1 (approximately 6 percent of national cropped area) to 395,000 ha by Year 3 (20 percent of national area)[7].

2.28 The report does not mention which departments will be selected for the Area-Yield Index program over the next 3 years. Some departments are extremely large (e.g. Tambacounda and Kaffrine) and the potential for major internal yield variation within such departments may invalidate the area-yield approach. This issue termed "basis risk" can only be addressed by studying the degree of variation in the DRDR's crop-cutting results for each crop taken in different locations and villages within each department.

2.29 The Area-Yield Index policy is not well suited to the insurance of predominantly subsistence crops such as cowpea (which, in any case, is usually sown as an intercrop in millet and used mainly for animal fodder), hungry rice, and cassava which is a perennial root crop with a staggered harvest and which does not lend itself to crop-cutting as a means of establishing an accurate estimate of actual average yields at a departmental level.

[6] Hungry Rice (*Digitaria exilis* and *Digitaria iburus*) and in Senegal known as "Fonio", is a subsistence cereal crop which is grown in arid parts of West Africa.
[7] Estimates based on 2005/06 national crop area of 1,974,148 Ha.

2.30 If this crop insurance program is marketed to Senegalese farmers on a purely voluntary basis, the projected uptake of 20 percent of cropped area by end of year 3 may be overly ambitious.

2.31 **Potential Livestock Insurance Portfolio**. In the case of livestock it is proposed in Year 1 to implement individual animal All Risk Mortality cover for approximately 0.53 million head of cattle, sheep and goats, rising in year 3 to nearly 1.8 million head of livestock, equivalent to 15 percent of the national herd. These projections are extremely ambitious for a new livestock program.

2.32 **Financial and Reinsurance**. The CNAAS year 1 provisional estimates of premiums and sums insured for crops and livestock are shown in Table 2.3. For crops insured under the Area-Yield Index program with a 50 percent coverage level, the total insured area is 109,009 ha with total sums insured, TSI, of FCFA 6.9 billion (US$ 15.4 million) and with estimated premiums of FCFA 0.48 million (US$ 1.1 million) and an average commercial premium rate of 7.0 percent. The year 1 livestock portfolio is considerably larger with TSI of FCFA 30.1 billion (US$ 66.8 million) with corresponding premiums of FCFA 1.9 billion (US$ 4.3 million).

Table 2.3: Estimated Year 1 Premiums and Sums Insured (FCFA 000)

Item	Insured Area (Ha)/ Number Insured Animals	Sum Insured (FCFA (000)	Premium (FCFA 000)	Average Premium Rate percent
Crops	109,009	6,925,671	484,429	7.0%
Livestock	489,757	30,077,908	1,938,093	6.4%
Total	n.a.	37,003,579	2,422,522	6.5%

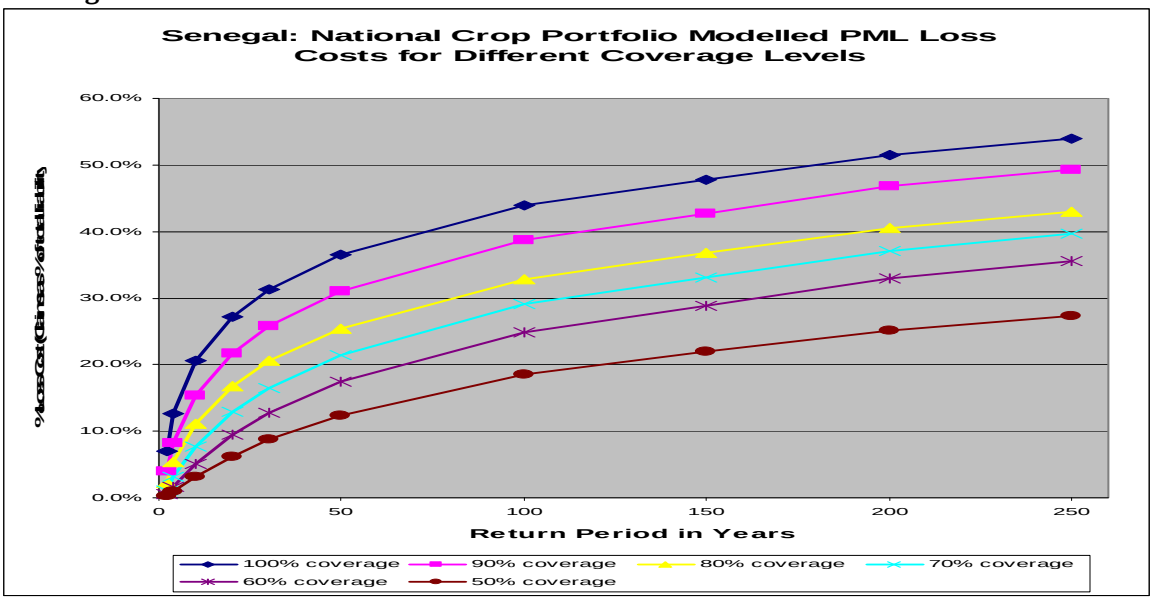
* Source: DA (Draft) Technical Study, 2007.

2.33 In Year 1, it is proposed that CNAAS will retain 60 percent of its agricultural insurance portfolio and purchase a 40 percent quota share reinsurance treaty from African and international reinsurers. Options for purchasing non-proportional stop loss reinsurance on CNAAS's retention should also be investigated.

2.34 **Probable Maximum Loss**. In assessing how much risk it can prudently retain for the crop and livestock insurance programs and how much reinsurance protection is required, CNAAS will need to analyze its Probable Maximum Loss (PML). Agricultural insurers conventionally calculate the 1 in a 100 year expected PML. Under this World Bank study, a detailed analysis of the PML exposure has been conducted for crops insured under the area-yield program. This analysis does not, however, extend to livestock. For the 6 insured crops, the calculated 1 in a 100 year PML for 50 percent coverage is a 18.5 percent loss cost, which, if applied to CNAAS's year 1 TSI, produces a maximum probable loss of FCFA 1,281 million (US$ 2.85 million), which is equivalent to a 264 percent loss ratio at the advised average premium rate of 7.0 percent (see Table 2.4. and Figure 2.3.). If CNAAS retains 60 percent of the crop portfolio and does not purchase any stop loss reinsurance on their retention, the 1 in 100 year PML liability of their 60 percent share would be equivalent to a claim of FCFA 769 million (US$ 1.71 million). This loss would be equivalent to 52 percent of CNAAS's capital of FCFA 1,500 million.

2.35 Figure 2.3. shows that, if the Area-Yield coverage level were to be increased to 60 percent, the corresponding 1 in a 100 year PML loss cost would rise to 25 percent of TSI, at a 70 percent coverage the PML loss would amont to 29 percent, and at an 80 percent coverage level the PML loss would be 33 percent.

Figure 2.3: Estimated Probable Maximum Loss for Crop Area-Yield Index Insurance with Coverage Levels 50 Percent to 100 Percent of Yield



Source: World Bank 2008.

2.36 It is recommended in the detailed planning stages for CNAAS, that the management conduct a similar PML study for the livestock portfolio.

2.37 **Timetable for Implementation.** It was originally planned to have the CNAAS fully capitalized and incorporated by March 2008 and for the company to then commence underwriting crops and livestock in the 2008/09 season. In May 2008 the DA advised that the formation of the CNAAS was re-scheduled for the summer 2008 and that the insurer was expected to commence operations in the 2009/10 cropping season.

Public-Private Agriculture Insurance: International Experience and Guiding Principles

2.38 In 2007, the Government of Senegal has embarked on a policy of public intervention in the provision of agricultural crop and livestock insurance through: (a) The formation of a new public-private owned specialist agricultural insurance company, CNAAS, and (b) the provision of a fixed-level 50 percent premium subsidy on both crop and livestock insurance. This section is devoted to a review of the rationale for government intervention, which follows a series of programs from developed and developing countries where government have taken an active role in supporting agricultural insurance, and the experience and lessons from them. Further information is presented in Technical Note 2. A series of guiding principles for public support to agricultural insurance is presented at the end of this section.

Rationale and Types of Government Intervention in Agricultural Insurance

2.39 Governments are interested in promoting agricultural insurance for a number of social and economic reasons which may include one or more of the following objectives:

- To manage natural or climatic catastrophes through an ex-ante formal crop or livestock insurance mechanism;

- To reduce (or ideally to replace) ad hoc free post-disaster payments by formal and technically rated insurance programs and to reduce the pressure which disaster payments place on public-sector budgets;
- To stabilize farm incomes and to maintain rural populations; and
- To use agricultural insurance as an instrument for agricultural development, for example through linking crop insurance to input credit for improved technology yield enhancing packages (hybrid seeds, fertilizers, etc).

2.40 Governments have been increasingly intervening in agricultural insurance both in developed markets in Europe (e.g. France, Poland, and Romania) and in developing countries (e.g. new subsidized programs in China, Brazil, Chile, and Turkey). Reasons given as to why governments should intervene in agricultural insurance typically include:

- Poorly developed insurance markets and non-availability of private-sector agricultural crop and livestock insurance;
- Financial capacity constraints of private commercial insurers, particularly for systemic risk (drought, flood, epidemic diseases, etc);
- High costs of insurance administration; and
- Inability of farmers to afford agricultural crop and livestock insurance premiums.

2.41 In 2008, agricultural crop and/or livestock insurance is available in about 60 countries. Agricultural insurance is most developed in high income countries in North America, Europe, and Australasia. The programs in the USA and Canada carry very high levels of government financial intervention in the form of premium subsidies and subsidies on the operating and administration costs and reinsurance programs. In Europe 15 of the 27 countries with agricultural insurance have public-private supported programs, of which the largest program is the Spanish national agricultural insurance scheme. In the remaining 12 European countries the programs are implemented exclusively by private commercial insurers with no form of government subsidy.

2.42 In Asian developing countries, public sector agricultural insurance has a lengthy tradition in India and the Philippines, and public-private subsidized agricultural insurance is now being heavily promoted in China and South Korea. In Latin America many countries introduced public sector agricultural insurance programs in the 1970's and 1980's, most of which have now been terminated and/or privatized. Today agricultural insurance is found in about 15 Latin American countries: The largest programs are located in Mexico, where the commercial insurers receive a high level of support from government, and in Argentina, which has a private crop-hail insurance market and until recently had received no government subsidies. In Africa there is very little agricultural insurance, the main exceptions being Mauritius, Sudan and Morocco where the programs operate with government support, and South Africa which has a well developed private and mutual company crop hail and MPCI insurance market with no government intervention.

2.43 Table 2.4. provides a summary of government support in a sample of the major national agricultural (mainly crop) insurance programs from developed and developing countries.

Table 2.4: Government Support to Agricultural Insurance in 2008 – Major Territories

		Forms of Government Financial Support					
Country	Year of Inception	Agricultural Insurance POOL (coinsurers)	Public-sector MPCI Insurer	Premium Subsidies	Subsidies on Administrative Costs of Crop Insurance	Financial Support to R & D and Training	Public-Sector Crop Reinsurance
Developed:							
USA	1930's	No	No	Yes	Yes	Yes	Yes
Canada	1970's	No	Yes	Yes	Yes	Yes	Yes
Spain	1980	Yes	No	Yes	No	No	Yes
Portugal	1979	No	No	Yes	No	No	Yes
Italy	1970's	No	No	Yes	No	No	No
France	2005	No	No	Yes	No	No	No
Developing:							
India	1985	No	Yes	Yes	Yes	No	Yes
Philippines	1980	No	Yes	Yes	Yes	No	No
China	1950's	Yes	No	Yes	Yes	No	Yes
Brazil	1950's	No	Yes	Yes	Yes	No	Yes
Mexico	1990	No	No	Yes	No	Yes	Yes
Chile	2000	Yes(No)	No	Yes	No	Yes	No
Colombia	2000	No	No	Yes	No	No	No
S. Korea	2001	Yes	No	Yes	Yes	No	Yes
Turkey	2005	Yes	No	Yes	No	No	Yes

Source Stutley (2007).

2.44 **Public vs. Private Sector Agricultural Insurers.** In the 1970s and 1980s many governments in developing countries created public sector agricultural insurers to underwrite highly subsidized multiple peril crop insurance for small-scale farmers. These public-sector programs tended to act as a major disincentive for the entry of private commercial insurers into agricultural insurance. The majority of the public sector agricultural programs performed very poorly, prompting governments to: (a) terminate the programs; or (b) take measures to strengthen and reform the public sector programs; or (c) transfer responsibility for implementation to the private insurance sector. It is noticeable that most of the new crop and livestock insurance programs which have been introduced in the past 10 years have been implemented by private commercial insurers with or without support from government, including Chile, Brazil, Colombia, Honduras, Sudan, South Africa, and Turkey.

2.45 Table 2.4. shows that, in 2008, Canada was the only major developed nation in this list of countries where crop insurance continued to be provided through the provincial government public crop insurers. Conversely, a higher number of developing countries currently have public insurance companies including India, Philippines, and Brazil.

2.46 **Coinsurance Pools in Agricultural Insurance**. In several countries governments have promoted the formation of agricultural coinsurance pools, of which the largest is the Agroseguro pool program in Spain formed more than 25 years ago. Since 2000 coinsurance pools have also

been formed in Chile[8], South Korea, Turkey and China (Table 2.1.). A pool is a legally binding risk sharing agreement entered into by a number of independent insurance companies for the purposes of collectively underwriting an agreed class (es) of insurance. Each insurer participates in the premiums, claims, profits, and losses according to his proportionate interest (percentage share of 100 percent) in the pool. The potential benefits of an Insurance Pool include: (a) The ability to underwrite a much broader and larger book of business and the potential to achieve a much better geographical spread of risk, than if the each company were operating independently; (b) economies of scale in the costs of developing new products and programs; and (c) underwriting risks and adjusting claims where a single lead coinsurer is appointed (or a separate Technical Support Unit is created) to administer the business on behalf of the pool members. There are also major potential cost savings in the purchasing of reinsurance protection for a pooled coinsurance program.

2.47 In developing countries, where insurance markets are often poorly developed and there is no tradition of crop or livestock insurance or rural insurance infrastructure, a pool coinsurance program may be a much more attractive proposition to commercial insurance companies than if they were to try to operate independently. Indeed, a pool approach may be the only economically viable solution by which barriers to entry by individual companies can be overcome, including:

- Where the company has a low capital and reserves base the ability to participate in and to share in the results of the business by taking up a small share in the pool. For example, in Spain, there are about 35 participating coinsurers, some with shares of less than 1 percent, and in Turkey the 16 participating commercial insurers each have an equal 6.5 percent share in Tarsim, the Managing Company they created to underwrite crop and livestock business in 2006;
- Sharing in the costs of the centrally-based technical and underwriting staff and claims adjusters as opposed to having to recruit these staff into their own company;
- Sharing in the costs of staff training and in products design and development, and in creation of marketing and loss adjustment infrastructure, and systems and procedures; and
- Shared costs of the pool reinsurance program.

2.48 It is not known whether the Senegalese Government and private commercial insurers considered the option of forming a Coinsurance Pool before electing to form a new public-private crop insurance company, the CNAAS.

2.49 **Type of Government Intervention**. Currently the most common form of government support to agricultural insurance is through direct insurance premium subsidies, applicable to all the countries listed in Table 2.4.[9]. Governments justify premium subsidies as a means of making crop insurance affordable to all farmers and especially small farmers. The costs, however, of government premium subsidies are extremely high in most countries. In 2005, MPCI premium subsidies in the USA amounted to US$ 2.34 billion (59 percent of MPCI premium), in Canada US$ 350 million (50 percent of MPCI premium), and in Europe US$ 600 million (32 percent of

[8] The Chilean Crop Insurance Pool has now been disbanded and the 2 main insurers operate independently.
[9] Legislation passed by the World Trade Organization over the past twenty years has been directed at phasing out all direct price support subsidies on agricultural commodities. Conversely, agricultural insurance premium subsidies are exempted (permitted) under Green Box legislation, and many governments, especially in Europe, have used this loophole to increase their support to agricultural insurance premium subsidies.

total premiums)[10]. Similarly, in Asia high levels of premium subsidies apply to almost all the major programs including India, Philippines, China, and South Korea. In China, 2005 total agricultural insurance premiums were about US$ 80 million, ranking it as about the 10th largest agricultural insurer in the world. Under the 11th 5-year Plan China is investing heavily in agriculture and promoting crop insurance through a series of very ambitious national and regional projects for key food crops and livestock, backed by premium subsidies. If 2007 targets are achieved of premiums of US$ 770 million (premium subsidy element several hundreds of millions), this will propel China into the top 4 countries in terms of premium volume. In Latin America, Chile introduced premium subsides in 2001, and in Brazil, the federal government ratified the reintroduction of premium subsidies in 2005 and is projecting to increase its financial support for premium subsidies from US$ 1.0 million in 2005 to US$ 50 million in 2007 and US$ 100 million in 2009. Finally, in Europe, Turkey and France have introduced premium subsidies since 2005. There are, however, very few developing countries in Africa, including Senegal, which could afford to finance such high costs of premium subsidies.

2.50 **Reinsurance Support**. The next most common form of government support is to the reinsurance of agriculture. In India government access to loss reinsurance protection is free of any charge, while in Canada, USA and South Korea this is provided at favorable (subsidized) terms[11]. In Spain, Mexico, and Brazil agricultural reinsurance protection is provided at commercial market rates by the national reinsurers, Consorcio de Compensacion de Seguros (Spain), Agroseguro (Mexico), and Brazilian Reinsurance Institute, IRB, (Brazil), and this also applies to Portugal where the government offers a voluntary crop stop loss reinsurance program.

2.51 **Subsidies on Administration and Operating Expenses**. In several countries government also offers premium subsidies on the insurance company's administration and operating expenses. The USA government effectively subsidizes 100 percent of insurer's acquisition costs, administration costs and the costs of adjusting crop losses. These subsidies are paid directly to the insurance company and the farmer only bears his share of the pure risk premium. Finally, in some countries, governments provide financial subsidies for product research and development and for training and education programs.

Guiding Principles for Public Intervention in Agricultural insurance

2.52 International experience tends to suggests that implementation of agricultural insurance is most efficient and effectively managed by the private commercial crop insurance sector. However, where insurance markets and infrastructure are poorly developed, government may have important roles to play in promoting agricultural insurance, particularly in the start-up phases of new private commercial agricultural insurance programs. This section reviews some of the roles for government under such private-public partnerships.

2.53 **Legal and Regulatory Framework**. One of the most important functions for government in facilitating agricultural insurance markets is the establishment of an appropriate legal and regulatory framework and where necessary specific agricultural insurance legislation.

[10] In Europe 15 (55%) of the 27 countries reviewed have government financial support to premium subsidies. Source: European Commission 2006. "Agricultural Insurance Schemes – Administrative Arrangement No Agri 2005-0321. Final Report". December 2006.

[11] In China, ChinaRe, the national reinsurer, participates in agricultural reinsurance on a strictly commercial basis. There are, however, several provincial pilot programs in 2008 where the local government is involved in providing free stop loss co-reinsurance.

In the context of Senegal, this report has noted that specific approval will need to be granted through CIMA for the new crop Area-Yield Index and Weather Index insurance products.

2.54 **Enhancing Data and Information Systems**. Time-series data and information on crop production and yields and climate are essential for the design and rating of any traditional crop insurance product or new weather index product. Governments can provide an invaluable service by creating national data bases and to then make these available to all interested private commercial insurers either free of cost, or at concessionary rates.

2.55 In Senegal there is an efficient crop production collection and reporting system through the DRDR and DAPS. This system could be usefully enhanced by increased government investment in crop-cutting resources at the Departmental level, by constructing a national data base of individual crop-cutting results and by increased monitoring and recording of crop-damaged area by cause of loss. Climatic weather data is also available through the Senegalese Meteorological Department, but at considerable cost, and Government may wish to consider subsidizing the cost of weather data access.

2.56 **Product Research and Development**. Among the major start-up costs for any new crop or livestock insurance program is the design (including the design of loss assessment procedures) and rating of new products, and then in the pilot testing of the new products and programs. Such costs may be prohibitive for individual private commercial insurers, especially in developing countries. In such situations there is justification for government to provide financial support to product design and rating, especially where the products and rates are then made available to all interested insurers. Such a need applies specifically to Senegal where there is no previous experience in the design and rating of crop and livestock insurance programs. As noted above, the Government of Senegal has in the past invested in product research and development through the EMAP and ARC studies. Further support will inevitably be required to launch the new crop and livestock insurance programs envisaged under the CNAAS scheme.

2.57 **Education, Training and Capacity Building**. Governments can play an important role in the introduction of new agricultural insurance programs by supporting: (a) Farmer education programs, and (b) capacity building and workshops and education programs for key agricultural insurance staff. The field studies conducted as part of the preparation of this report have identified a major need in Senegal for farmer awareness and general education about the role of crop (and livestock) insurance. Specific education will then be required for any new crop Area-Yield Index and or crop weather index products and livestock products which are planned for 2009. Capacity building and specialist education will also be required at the insurance company level, for the new staff that will be recruited by the CNASS. Currently in Senegal there is no agricultural insurance expertise in the private commercial companies from which the NCAAS staff will presumably be selected. Specific training for senior crop and livestock insurance managers and professionals will need to include product design, actuarial and rating, underwriting and claims administration, and loss assessment systems and procedures. The company field staff will also need to receive suitable training in operating systems and procedures.

2.58 **Catastrophe Risk Financing**. Multiple-peril crop insurance in semi-arid climates is very exposed to catastrophe drought losses, and the same applies to “all risk” livestock insurance programs which provide coverage against epidemic diseases. Most insurance companies do not have adequate capital to retain their catastrophe risk exposures, and they typically purchase some form of contingency financing and or reinsurance protection. For new companies which do not have large amounts of capital and have not yet built up claims reserves, the ability to retain risk is usually low, and they typically need to purchase quota share treaty reinsurance and to then seek

non-proportional reinsurance protection on their retention. In start-up situations, where the company does not have an established track record and loss history, the costs of reinsurance protection may be very high. In such situations, government support to the reinsurance program may be highly cost-effective. Indeed, the review of international experience shows that many governments both in developed and developing countries provide subsidized reinsurance to the crop and livestock insurers.

2.59 Crop production in Senegal is highly variable. The risk analysis conduced in this study (see Chapter 3) shows that, for an Area-Yield Index Program which insures the 6 main crops at a national level, the one in a hundred year expected loss costs are in the order of 19 percent for 50 percent coverage, 25 percent for 60 percent coverage, 29 percent for 70 percent coverage, and 33 percent for maximum 80 percent coverage. The corresponding loss ratios are therefore between 550 and 360 percent. In the detailed planning of the CNAAS program it will be important to ensure that the company's capital is adequately protected by reinsurance, and there may be an important role for considering a layered reinsurance program which is partly financed by international commercial reinsurers and by Government assuming a catastrophe risk layer.

2.60 **Public Sector Premium Subsidies**. Governments justify the provision of agricultural insurance premium subsidies on the grounds that they make insurance more affordable for farmers, particularly small and marginal ones, thereby increasing the rate of adoption and uptake of agricultural insurance. This argument may apply to individual grower Multiple Peril Crop Insurance (MPCI), where average premium rates commonly vary between 7.5 percent and 10 percent for coverage levels of 65 percent to 75 percent of normal average yield. However, this argument does not apply to private crop-hail insurance, which has been widely marketed in Europe, USA, Australasia, and Argentina for nearly a century with average rates of 2.5 percent to 5.0 percent and with no premium subsidy support from governments.

2.61 Premium subsidies are the most widely practiced form of government support to agricultural insurance, and as more farmers purchase crop and livestock insurance either on a voluntary or compulsory basis (for example, compulsory crop-credit insurance programs), the annual budget for premium subsidies is increasing dramatically in many developed and developing countries.

2.62 There are, however, a series of major drawbacks of direct insurance premium subsidies. Many countries provide single flat rate premium subsidies, typically 50 percent of the full commercial price of insurance for all farmers, all crop types, and all risk regions[12]. These undifferentiated premium subsidies disproportionately benefit the larger farmers to the detriment of small and marginal farmers, and they actively promote farmers in the highest risk-rated regions to grow high risk crops which are not best suited to that region, knowing that they are protected by their highly subsidized crop policy, and this in turn can result in severe moral hazard. Premium subsidies once introduced are very difficult to reduce or to withdraw[13], and in the major developed and developing economies reviewed above, the costs of premium subsides to the

[12] Technical Note 2 presents a review of the different types of premium subsidy regimes in different countries. Not all countries have flat rate premium subsidies. Spain and Portugal have highly developed premium subsidy scales which differentiate between crop types and risk regions and type of farmer purchasing cover, etc.

[13] It is interesting to note that of the 15 countries in Table 2.4. with premium subsidy support, Colombia is the only country which originally, in the mid-1990's, introduced crop insurance premium subsidies which were explicitly provided to individual farmers for a period of only 3 years and with a declining subsidy level over this period. In all other countries, governments do not have any explicit mechanisms for reducing and phasing out premium subsidies over time.

taxpayer are now extremely high and could not be afforded by the smaller developing countries such as Senegal.

Conclusions

2.63 The Government of Senegal should consider the potential role that the private commercial insurance sector could play in the provision of agricultural crop and livestock insurance under their proposals for the CNAAS. At present it is understood that the insurers' only role will be to subscribe to the shareholding of the CNAAS.

2.64 Furthermore, the Government of Senegal may want to review the role of premium subsidies in light of the other important roles that Government can perform in creating agricultural insurance market infrastructure through investment in: (a) Establishing an appropriate legal and regulatory framework, (b) enhancing data and information, (c) product research and development and testing, (d) providing farmer education and capacity building and specialist training at the insurance company level, and (e) participation in a structured risk financing/ reinsurance program for the CNAAS program. If Government were to provide this alternative range of institutional, capacity building, and financial and reinsurance support, it is possible that the private commercial insurance sector would be willing to consider becoming more active risk takers and possibly in underwriting the crop and livestock programs, possibly under a coinsurance pool arrangement.

2.65 It is also suggested that Government consider the formation of a Technical Support Unit, TSI, which would be responsible for the key functions of: (a) Data and information acquisition and analysis, (b) product design and rating, and (c) training and education on behalf of CNAAS and the participating private commercial insurers. The TSU would also be a key institution in the pilot testing of the proposed departmental Area-Yield Index Program and the Crop Weather Index Program (see chapters 4 and 5).

Chapter 3. Crop Risk Assessment

3.1 To date, in Senegal, there has been little formal assessment of the key climatic, biological, and naturally occurring risk exposures and their impact on crop production and yields and farm incomes. This chapter presents details of a Portfolio Crop Risk Assessment Model for Senegal (Modèle d'Analyse des Risques de Cultures du Senegal, MARCS), which has been specifically designed for Senegal. It is intended to assist policy makers and insurance practitioners in the planning, design, and rating of the proposed Crop Area Multi-peril Yield Index Insurance Policy.

3.2 The chapter starts with an overview of the agro-climatic constraints to crop production in Senegal, the main crops and production and yields. This is followed by a review of the available data from previous studies on the scale of crop production and losses as well as main causes of loss. The main part of this section deals with the MARCS model, including a review of the time series departmental production and yield data which has been used to develop the model, the methods used to clean and trend the yield data, and to model yield loss. The section also presents the main insurance-related applications of the tool, including the calculation of values of risk, loss costs, and probable maximum losses, as well as indicative pure rates and premium rates. Full details of this risk assessment exercise and the MARCS model are given in Technical Notes 3 and 4.

Influence of Climate on Agricultural Crop Production in Senegal

Influence of Climate on Cropping Systems

3.3 Farming systems, crop production and yields are highly influenced by rainfall, which is very variable spatially, temporally, and between years. There is a marked spatial rainfall gradient from north to south. The most northerly part of the country experiences an arid climate. Average precipitation recorded at Dagana is less than 300 mm per annum, and commercial crop production is only sustainable under irrigation. Average rainfall increases steadily southwards. In the central groundnut basin between Diourbel and Kaffrine, annual rainfall is between 500 mm and 600 mm and rainfall increases to a maximum of between 1200 and 1300 mm at Sédhiou in the far South of the country (see Table 3.1.). Rain-fed cropping is concentrated in the central and southern regions of Senegal.

3.4 There is also a marked dry season, which runs from November through to April (7 months), which is typified by near zero precipitation throughout Senegal and a single rainy season from June to October (5 months) with peak rainfall in August. In Senegal there is very little irrigated agriculture, and thus most cropping is rain-fed with a single cropping season starting from June planting, and with the main harvest from September through November.

3.5 Rainfall is highly variable year-to-year, especially in the northern low rainfall departments such as Dagana and Louga, as shown by coefficients of variation (COVs) around mean annual precipitation which are as high as 40 percent to 45 percent in these northernmost departments; in the central zone the COV's are between 30 percent and 35 percent, and these reduce to about 25 percent in the higher rainfall South (see Table 3.1.).

3.6 Table 3.1 also shows that, in the period 1986 to 2003, average annual rainfall in many departments is considerably lower than the long term average (which for many departments dates back to the 1920's) with a range from -21 percent of average annual rainfall in Douga and Louga

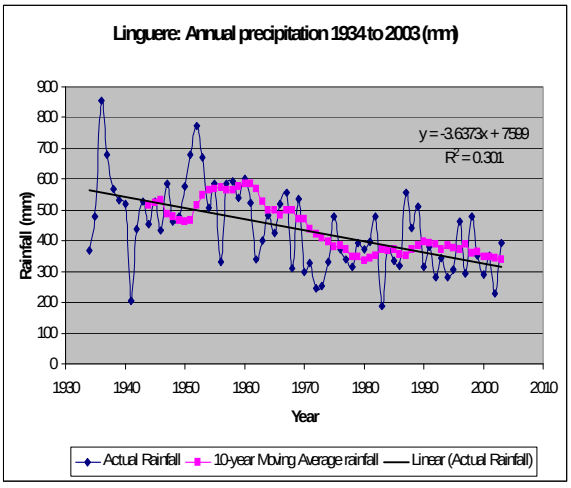
Departments to +5 percent in Bakel over these two reference period. Figure 3.1. shows, however, that the relationship in rainfall patterns over time is complicated. In Linguère Department, there appears to be a definite trend of declining precipitation since 1950 from about 600 mm per annum to only 400 mm in 2007. In the case of Foundiougne, annual rainfall decreased up to the mid-1980s; since then average annual rainfall has tended to increase again. These two trends in annual precipitation can be seen across most Departments of Senegal (Technical Note 4). As a final point it is noticeable that over the period 1986 to 2003, average annual rainfall has tended to be less variable (lower COVs) than over the long term.

Table 3.1: Senegal: Average Annual Rainfall for Selected Departments according to N-S Geographical Location

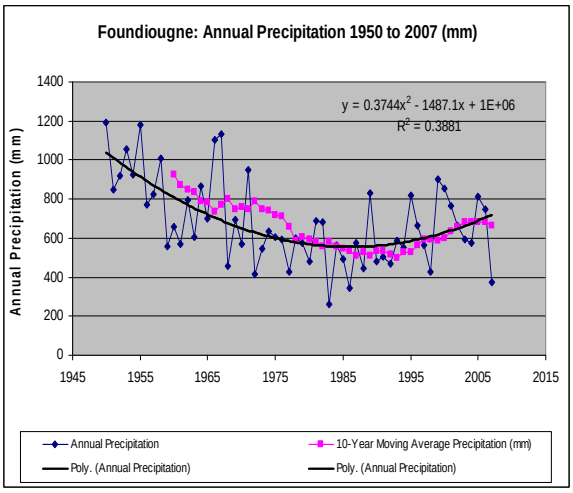
Department	Average Annual Rainfall All Years (data from 1920; mm)	COV All Years	1986-2007 Average Annual Rainfall (mm)	COV 86-2007	Percent Difference
Dagana	270	42%	213	31%	-21%
Louga	365	44%	287	32%	-21%
Linguère	435	31%	367	23%	-16%
Diourbel	580	33%	483	26%	-17%
Bambey	580	32%	479	30%	-17%
Bakel	503	25%	530	27%	5%
Thiès	527	39%	427	24%	-19%
Mbour	580	42%	476	26%	-18%
Kaffrine	664	26%	586	27%	-12%
Foundiougne	681	32%	617	27%	-9%
Nioro	805	24%	762	22%	-5%
Tamba	818	25%	704	26%	-14%
Kolda	1,124	23%	1,021	19%	-9%
Sédhiou	1,195	24%	1,062	16%	-11%

Source: Direction de la Météorologie Nationale.

Figure 3.1: Annual Rainfall at Stations Located in Linguère and Foundiougne



Source: Direction de la Météorologie Nationale.



Source: Direction de la Météorologie Nationale.

Crop Production and Yields

3.7 In Senegal there are 3.8 million hectares of land which are suitable for arable cropping, of which about 2.0 million hectares (53 percent of potential area) are cultivated. Currently less than

5 percent of cropped area, or 105,000 hectares, benefits from irrigation, and the remaining 95 percent of cropping is rain-fed and therefore exposed to drought and or floods.

3.8 Table 3.2. presents the sown area for the 8 main crops grown in Senegal for the past three years 2005/06 to 2007/08. The main rain-fed crop is millet, which is the preferred subsistence food crop grown by farmers, accounting for 36 percent of total average cultivated area, followed by groundnut (32 percent of total average area), which is grown both as a food crop and a cash crop. Sorghum and Maize account for 8 percent and 7 percent, respectively, of cultivated area. Cowpea is predominantly a forage crop, which is usually inter-cropped with millet, and once the millet is harvested, the cowpeas can then be cut and/or grazed in field by livestock. The main irrigated crop is rice (4 percent of total planted area); some maize is also grown under irrigation in St Louis and Matam Regions. Cotton is the principal cash crop, but it is grown in less than 2 percent of total area.

3.9 There has been a decline in total cultivated area over the past 3 years from 2.25 million ha in 1995/96 to 1.95 million ha in 2007/08. Crops which have experienced the largest reduction in cultivated area between 2005/06 and 2007/08 include cowpeas, millet and groundnuts. Conversely, the area of cassava has increased over this period, and the cultivated areas of cotton, sorghum, rice, and maize have remained stable.

Table 3.2: Cultivated Area Main Crops, 2005/06 to 2007/08 (hectares)

Crop*	2005/06	2006/07	2007/08	Average	Average % of Area	2007/08 as % average
Groundnuts	772,305	594,264	607,007	657,859	32%	92%
Cotton	38,220	43,769	43,157	41,715	2%	103%
Millet	800,759	748,311	686,892	745,321	36%	92%
Sorghum	149,173	159,063	155,300	154,512	8%	101%
Maize	142,844	130,461	145,891	139,732	7%	104%
Rice	97,425	85,037	86,629	89,697	4%	97%
Cowpea	221,907	193,462	167,825	194,398	9%	86%
Cassava	26,040	19,464	59,623	35,042	2%	170%
Total	2,248,673	1,973,831	1,952,323	2,058,276	100%	95%

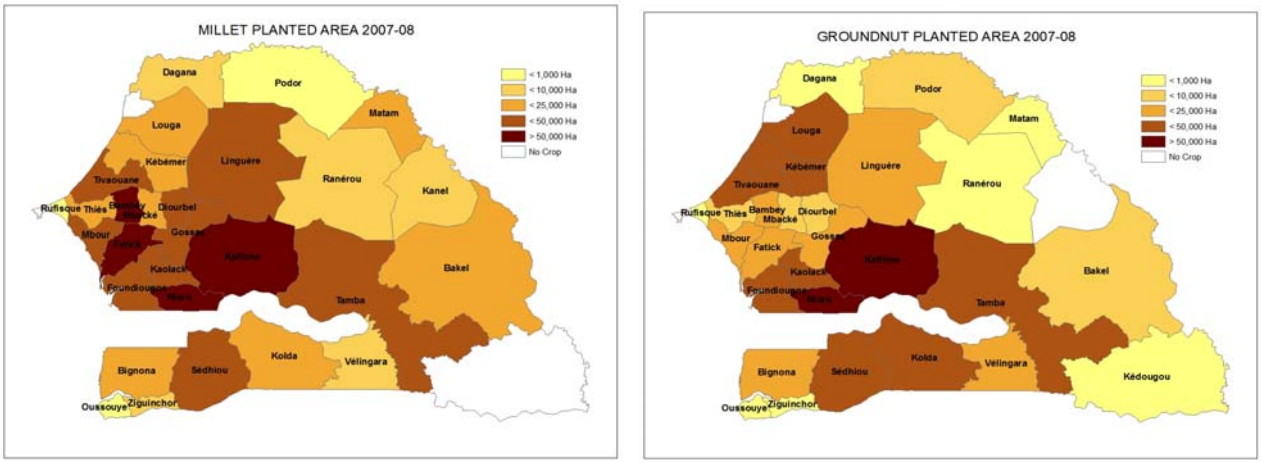
Source: DAPS, Senegal.

* Excludes minor crops including Hungry rice (Fonio), sesame, and horticultural crops

3.10 Senegal is divided into 11 administrative regions, which are then further divided into 3 departments per region, giving a total of 33 departments. Figure 3.2. shows the distribution of 2007/08 cultivated (sown) area in hectares for the 2 major crops millet and groundnuts by department. The distribution of these 2 crops is related to rainfall levels: Millet requires a minimum of 450 mm to 500 mm of seasonal rainfall, and groundnuts require a minimum of 500 mm to 600 mm of rainfall, to be economically viable (i.e. to be profitable). Therefore, in the northern departments, where average rainfall is less than 300 mm rainfall per annum, very little millet or groundnuts are grown. The main concentrations of millet and groundnuts are in the "Groundnut Basin" of central Senegal in the Departments of Kaffrine, Koalack, and Nioro (Koalack Region): These 3 departments accounted for 25 percent of all millet and 34 percent of all groundnut cultivated area in Senegal in 2007/08 and receive annual rainfall of between 550 mm in the north of Kaffrine to 800 mm in the south of Nioro Department. The second most important millet producing area is in the western region of Fatick (Departments of Fatick,

Mbacké and Diourbel) accounting for 14 percent of 2007/08 planted area, and for groundnuts, the second most important producing area is the Kolda Region (16 percent of 2007/08 groundnut area), comprising the southern departments of Kolda, Sédhiou and Vélingara (Kolda Region), which enjoy average rainfall in excess of 1,000 mm per annum.

Figure 3.2: Distribution of Millet & Groundnut Planted Area by Department, 2007/08 (ha)



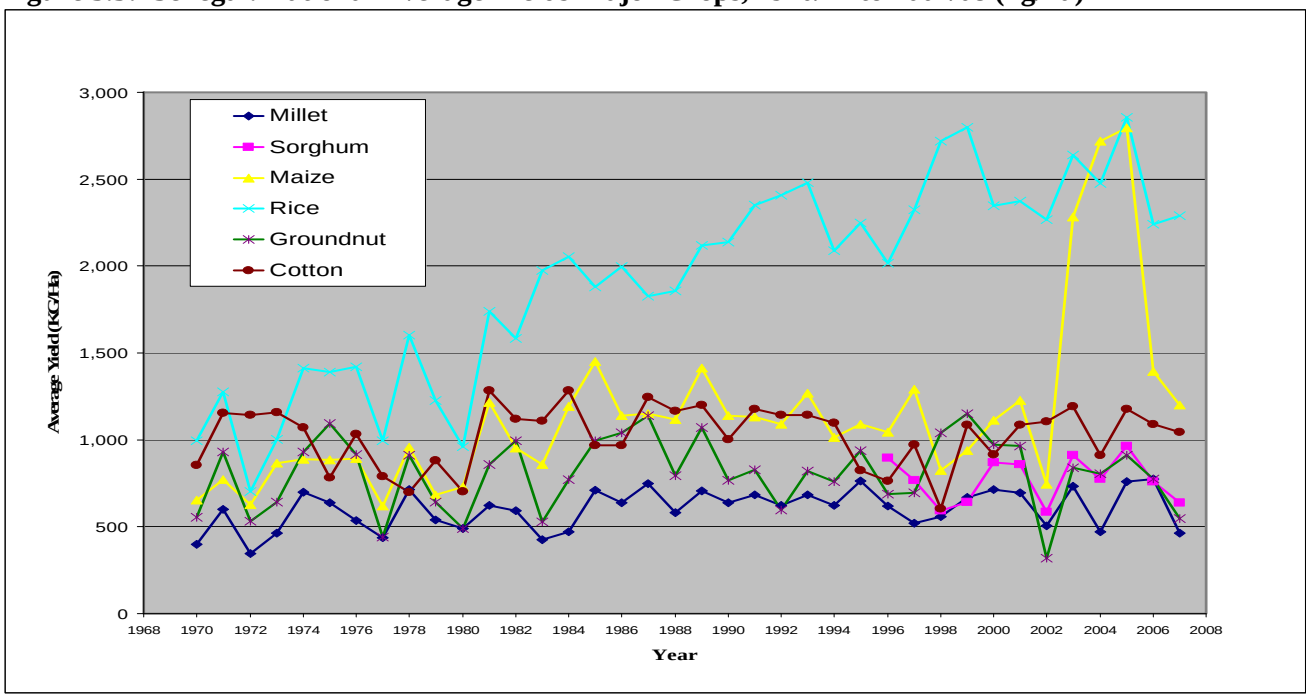
Source: Authors, using DAPS Sown Crop Area Data 2007/08.

3.11 In Senegal crop production and yields are reported by DAPS at 3 levels of aggregation: Departmental level, regional level, and national level. National average yields for main crops for the 47-year period 1960/61 to 2007/08 are presented in Figure 3.3. National average yields for all crops are low and extremely variable from year to year (as shown by the coefficients of variation, COV, in parenthesis), namely: Millet average yield of 579 kg/ha (19 percent COV); sorghum 771 kg/ha (17 percent); maize 1,066 kg/ha (43 percent); rice 1,788 kg/ha (32 percent); groundnuts 822 kg/ha (23 percent); and finally cotton 934 kg/ha (35 percent COV).

3.12 No consistent yield increase trends can be identified for any crop over the past 47 years, with the exception of rice, where average yields have increased from about 1,250 kg/ha prior to 1980 to about 2,500 kg/ha over the past 10 years. According to DAPS, the main reason for the increase in rice yields has been the increase in the percentage of the crop grown under irrigation, accompanied by the adoption of improved technology.

3.13 The reported maize figures show an average yield over 47 years of slightly over 1,000 kg/ha. Between 2003/04 and 2005/06, however, the national average maize yields increased by nearly 250 percent to an average of greater than 2,500 kg/ha. It is understood that part of the increase in national average yields is due to special projects in Saint-Louis Region, where maize is being grown under irrigation using improved hybrid seeds. However, this does not explain the major yield increases in non-irrigated areas, and it is believed that this may be due to over-reporting of maize production and yields during this 3-year period. It is noticeable that national average yields in maize have declined over the past 2 years to their former levels and this may be related to a combination of non-availability of hybrid seeds, inadequate fertilizer supplies, and adverse climatic conditions.

Figure 3.3: Senegal: National Average Yields Major Crops, 1970/71 to 2007/08 (kg/ha)



Source: DAPS.

3.14 In the case of groundnuts, average yields in many of the more northern departments have declined over the past 10 to 15 years. Various reasons for the declining yields are given by local groundnut experts, including decrease in average rainfall over the past 25 years and increased variability in seasonal rainfall, reduced output prices and accompanied reductions in the use of purchased inputs (improved seeds, fertilizers and plant protection chemicals), and seed and fertilizer input supply problems.

3.15 **Drought impact on Production and Yields**. Figure 3.3. shows that national average yields for nearly all rain-fed crops were severely reduced in the 2002-03 cropping season and again in the 2007/08 season. The 2002/03 major yield losses were due mainly to early season drought (unseasonable rainfall). This applied especially to groundnuts (actual average yield 320 kg/ha, i.e. only 38 percent of the past 10-year average), and maize (average yield 743 kg/ha, i.e. only 49 percent of the 10-year average). In 2002/03, average yields in more drought resistant cereals such as millet and sorghum were not as severely depressed (average millet yield 506 kg/ha, i.e. 80 percent of average; sorghum average yield 585 kg/ha, i.e. 77 percent of average). The 62 percent reduction in national average groundnut yields, the 51 percent reduction in national maize yields, along with yield reduction of 20 percent in millet and 23 percent sorghum in 2002/03, amount to a national catastrophe. The economic losses of the 2002-03 droughts at 2007 crop output prices are estimated at about CFCA 69 billion (US$ 150 million) for the 6 main crops grown in Senegal[14] (see next sections for full details).

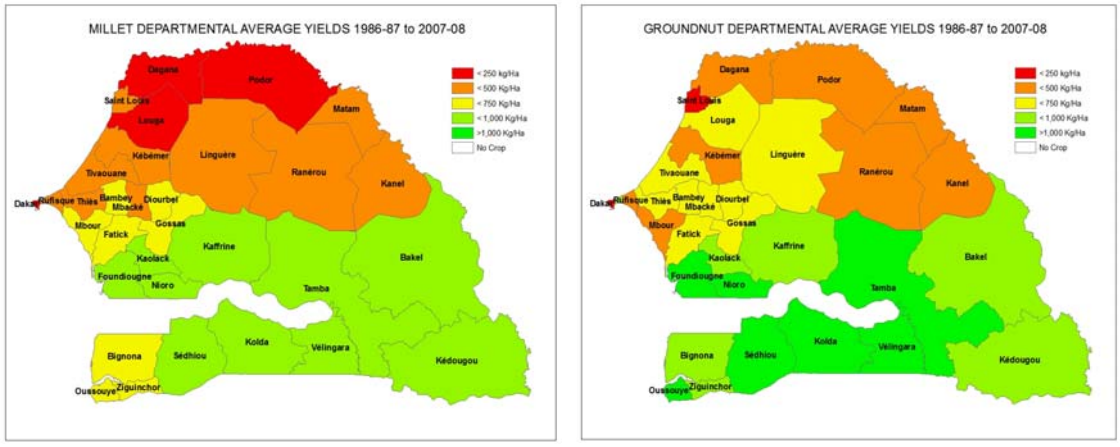
[14] This estimate is based on an analysis of variation in mean yields for the 6 main crops, valued at 2007 crop prices provided by DAPS and applied to the average cropped area from 2005/06 to 2007/08. This estimate compares with World Bank 2006, p. 15, which states "the economic losses caused by unseasonable rainfall in 2002 are estimated globally at CFCA 31 billion (about US$ 62 million)".

3.16 In 2007/08, severe production and yield losses were also experienced in groundnuts (actual average yield of only 545 kg/ha, or the second lowest national average yield in the past 20 years), in millet (average yield 464 kg/ha, or 73 percent of past 10-year average), and in sorghum (average yield 637 kg/ha, 84 percent of average). It is understood that the reduction in crop production and average yields in Senegal was due to a combination of early season drought, the non-availability of improved seeds, especially for groundnuts, and very short supplies of imported fertilizers.

Spatial Variation in Departmental Average Yields

3.17 The analysis of departmental yields shows that these are highly related to average rainfall patterns in Senegal (see Technical Note 4). Figure 3.4., which maps 22-year actual average yields (1986/87 to 2007/08) by department for the 2 main crops of millet and groundnuts, shows how the average yields for millet increase from an average of 250 kg/ha in the most northerly regions (departments) to an average of between 750 and 1000 kg/ha in the southern regions of Senegal. A similar pattern is evident for groundnuts where average yields in the arid North are between 250 kg/ha and 500 kg/ha and increase to between 750 kg/ha and 1,000 kg/ha in the groundnut basin (centered on Kaffrine and Nioro) and more than 1,000 kg/ha in the far South.

Figure 3.4: Increase in Millet and Groundnut Average Yields from North - South (kg/ha)



Source: Authors, using DAPS Departmental Average Crop Yields 1986/97 to 2007/08.

3.18 The spatial pattern of increasing yield from north to south is further analyzed in Table 3.3., where departmental average yields are correlated with the annual average rainfall for each department. The positive correlation from north to south between increase in yield with increase in average rainfall is strongest for groundnuts and millet with R-square values of 0.71 and 0.69, respectively. The correlation between departmental average yield and rainfall is not as strong for sorghum and maize, but still more than 50 percent of the variation in yield is explained by average annual rainfall.

Table 3.3: Relationship between Departmental Average Yields (1986-2007) and Average Rainfall (1986-2007) from North to South Senegal

Latitude N-S	Average Precipitation	Average Yields 1986/87 to 2006/07 (kg/ha)			
Department	1986-2007 (mm)	Groundnuts	Millet	Sorghum	Maize
Dagana	213	393	229	460	
Louga	287	504	184	257	600
Linguère	367	616	380	425	525
Diourbel	483	585	517	475	358
Bambey	479	564	522	571	454
Bakel	530	911	879	852	1,157
Thiès	427	532	459	497	561
Mbour	476	497	501	534	600
Kaffrine	586	945	771	879	1,220
Foundiougne	617	1,153	813	807	1,395
Nioro	762	1,039	912	1,034	1,501
Tamba	704	1,052	833	968	1,308
Kolda	1,021	1,219	898	885	1,430
Sédhiou	1,062	1,037	834	810	1,192
	Pearson correlation	0.8404	0.8295	0.7522	0.7283
	R Square coefficient	0.7062	0.6881	0.5658	0.5305

Source: Authors, from Meteorological Department Rainfall Data and DAPS Yield Data.

Relationship between Annual Rainfall and Annual Yields

3.19 Although there is a very strong correlation between departmental long-term average yields and long-term average rainfall, in most departments this relationship does not hold if one compares actual average annual yields with annual rainfall. Technical Note 4 contains an analysis of the relationship between 22 years (1986/87 to 2007/08) of annual yield and annual rainfall data for groundnuts in selected departments. On a season-to-season basis, total annual rainfall is not the only determinant of yield outcome in groundnuts in these departments. There are other important factors which influence yield outcomes and which may include: (i) The onset of the rainy season and distribution of rainfall during the growing season, (ii) timeliness of sowing, (iii) availability of and timeliness of supply of improved inputs (hybrid seeds and fertilizers), (iv) pest and disease incidence during the season, and (v) and temperatures and relative humidity.

3.20 The issue of rainfall timeliness and distribution during the cropping season is analyzed in detail under the Pilot Rainfall Deficit Crop Weather Index Program for Groundnuts (see Chapter 5).

Past Crop Risk Assessment Studies in Senegal

EMAP Study 2004

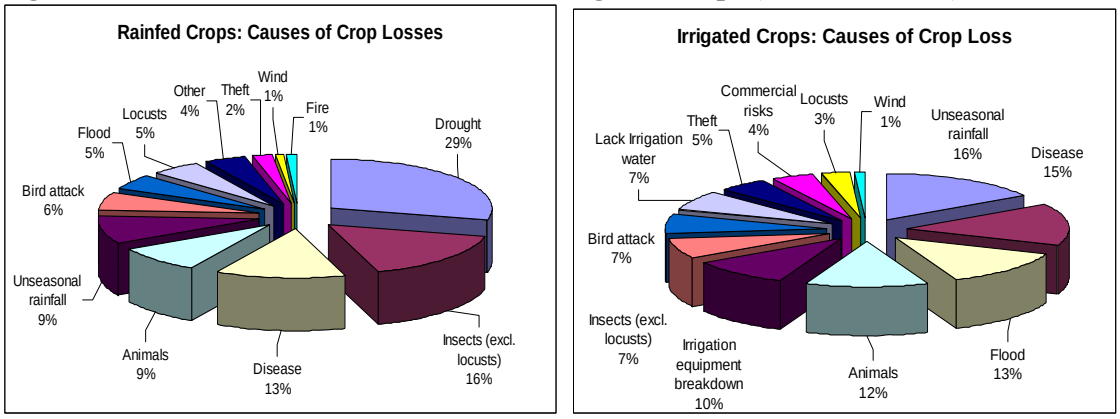
3.21 The EMAP study provided a qualitative assessment of the principal causes of crop production losses as reported by a sample of 1,500 irrigated and non-irrigated farms selected throughout Senegal (see Figure 3.5.).

3.22 For rain-fed crops, drought was identified by respondents as the most important cause of loss (29 percent of all causes of loss cited), followed by insects 21 percent (including grasshoppers, 16 percent, and locusts 5 percent), and diseases 13 percent. This was followed by damage caused by animals (livestock grazing the crops) and bird attacks. If one considers the total damage caused by all sources of pests (including insects, animals and birds) and diseases, this category sums to 49 percent of total, or by far the greatest cause of loss. Crop pests and diseases are management-related factors which, to a greater or lesser extent, can be prevented or controlled through an integrated pest management program, and for this reason many crop insurance programs specifically exclude pests and diseases which are deemed preventable or controllable. Normally, locust attacks would be covered, as this would be deemed uncontrollable by the individual farmer. Apart from drought the only other significant climatic risk was un-seasonal or untimely rainfall (9 percent of causes of loss).

3.23 In the case of irrigated crops, the main cause of climatic loss was un-seasonal rainfall (16 percent of total responses), followed by flooding (13 percent). Animal pests and crop diseases accounted for a further 18 percent of losses, and irrigation equipment and machinery breakdown and or lack of irrigation water were cited in a further 17 percent of cases.

3.24 The EMAP survey provided useful insights into farmers' identified causes of crop damage or loss, but the study did not extend to a quantitative assessment of the damaged area for the main irrigated and non-irrigated crops grown by each respondent.

Figure 3.5: Causes of Loss in Rain-fed and Irrigated Crops (EMAP 2004/05)



Source: EMAP (2004).

Production Loss and Damage Data

3.25 Senegal has a highly developed system of annual farm production and yield estimation surveys termed the "Permanent System for Agricultural Statistics" (SPSA), which is implemented by the Directorate of Statistical Analysis and Forecasting (DAPS), in conjunction with the Regional Directorate of Rural Development (DRDR), and its branch offices throughout all 33 departments in Senegal.

3.26 The SPSA farm survey system provides a very useful source of time-series crop production and crop-cut yield data which was used to design the MARCS risk assessment model for Senegal. The SPSA system does not, however, include any systematic survey of crop area or production loss or damage due to natural, or climatic, or biological perils. This is something which DSDA and DAPS could very usefully add to their surveys in future.

3.27 In the absence of systematically recorded time-series data on damaged area or production loss, some useful information on crop damage and production losses due to drought, flood, locusts, harmful insects, and parasites is contained in the World Bank's 2006 Risk Survey Report for Senegal[15]. In the case of drought, the report highlighted the average yield reductions for major crops in the severe drought years of 1979, 1980, 1983, 1990, 1992, and 2002, ranging from a low 24 percent yield reduction for groundnuts in 1980/81 to a maximum yield reduction of 72 percent in 2002/03, and for millet a minimum yield reduction of 8 percent in 1980 and maximum yield loss of 29 percent. Severe floods were experienced in Saint Louis and Matam in the Fleuve valley in 1994, 1999, and 2003, with unquantified damage to crops and irrigation infrastructure. In Tambacounda, floods in October 2003 caused damage in 2,200 ha of bananas grown by 3,200 farmers with losses valued at FCFA 3.6 billion (US$ 8 million, or an average of US$ 3,636 per hectare). Finally, severe locust invasions occurred in 1988 and 2004. In 2004, 6 of the northern and central regions of Senegal were affected with overall damage equivalent to 22 percent of crop production in these regions, and as high as 34 percent of production for millet and 30 percent for sorghum, with an overall production loss of about 45,000 tons.

Other Constraints to Crop Production

3.28 It is very important to recognize that farmers in Senegal face a number of constraints to crop production apart from climatic, natural, and biological perils. Table 3.4. reproduces the results for one study conducted in the Groundnut Basin as part of the Groundnut Seed Improvement and Multiplication Program where nearly three quarters of poor farmers and two-thirds of richer farmers gave "lack of seeds" as their main constraint to crop production and only 8.3 percent and 6.2 percent, respectively, cited climatic risk exposures as their main concern. If Table 3.3 is reworked with lack of seeds excluded, then climatic risk exposures were the main constraints faced by 29 percent and 20 percent of resource-poor and non-poor farmers, respectively.

3.29 Similar findings were also encountered during the World Bank's 2008 January field survey visits to groundnut producing areas in Nioro and Kaffrine and Gossas Departments. In Gossas and Kaffrine, the principal constraint to crop production in 2007/08 stated by farmers was lack of timely access to seeds and fertilizers. Conversely, the field visits to Nioro were conducted in areas which fall under the command area of the groundnut improved seed multiplication program, and in this case no farmer identified lack of seeds as a constraint. Climatic risks, particularly delayed rains at the start of the season, were also cited as a problem by farmers.

3.30 In conclusion, it should be stressed that any future crop insurance program for Senegalese farmers will only be effective if it is accompanied by timely access to improved seeds, fertilizers, and credit, and if output markets and sales prices are attractive to growers to make an investment in new and potentially riskier technology.

[15] Banque Mondiale 2006, Sénégal: Gestion de risques en milieu rural au Sénégal: Revue multisectorielle des initiatives en matière de réduction de la vulnérabilité, rapport No. 33435-SN, le 30 mars 2006.

Table 3.4: Main Reason Given by Farmers in Groundnut Basin for Reducing Their Cultivated Area

				(Excluding lack of seeds)	
Reason	Poor Farmers	Non-Poor Farmers		Poor Farmers	Non-Poor Farmers
Lack of seeds	71.7%	68.15%			
Lack of fertilizers	4.6%	9.45%		16.1%	29.7%
Lack of labor	3.1%	2.50%		10.8%	7.8%
Lack of equipment	2.6%	3.75%		9.0%	11.8%
Lack of animal traction	0.2%	0.40%		0.7%	1.3%
Difficulty of obtaining credit	3.1%	2.65%		10.8%	8.3%
Adverse climatic conditions	8.3%	6.20%		29.1%	19.5%
Poor seed quality	3.3%	2.20%		11.6%	6.9%
Price too low	0.0%	1.10%		0.0%	3.5%
Crop infestation (pests/diseases)	0.4%	0.20%		1.4%	0.6%
Illness of farm workers	0.6%	0.40%		2.1%	1.3%
Marketing difficulties	0.4%	1.00%		1.4%	3.1%
Other	2.0%	2.00%		6.9%	6.3%
Total	100.0%	100.0%		100.0%	100.0%

Source: World Bank 2006, citing the PSIA Groundnut Survey.

Crop Portfolio Risk Assessment Model - Design Features

3.31 This section presents the basic construction features of the Crop Risk Assessment Model for Senegal (MARCS), which is designed to assist decision makers at 2 levels: (a) Analysis of the risk of crop production and yield loss for the seven main crops at departmental, regional, and national levels in Senegal; and (b) design and rating of the proposed Area-Yield Index Insurance Product for Senegal. Full details of the MARCS Model are presented in Technical Note 4.

Yield Data Availability and Methods of Collection in Senegal

3.32 The MARCS model for Senegal is constructed on an "Analysis of Variation" in Departmental-level annual average yields for a 22-year time series 1986/87 up to and including the 2007/08 cropping campaign.

3.33 Senegal has a well established public sector system for measuring and recording crop production and yields, which has been used on an annual basis since 1980. DAPS and DRDA are responsible for conducting an agricultural farm production and yield survey every year under the Permanent System for Agricultural Statistics, SPSA. This comprehensive survey is carried out on a stratified random sample of households in all departments each year, and 5 types of crop production and yield questionnaires are implemented during the season including:

- Crop type and sown area questionnaire (Questionnaire 5)
- Crop machinery and equipment questionnaire (Questionnaire 3)
- Crop input questionnaire (types and quantities of seeds, fertilizers and plant protection products used for each cultivated crop; Questionnaire 4)
- Crop cutting yield survey questionnaire (Questionnaire 6)
- Crop stock inventory questionnaire (Questionnaire 13)

3.34 For the purposes of the farm surveys and crop-cutting surveys (termed CCEs in the remainder of this report), each Department is divided into 12 Census Districts (*District de Recensement*, DR), which comprise several Rural Communities and Villages. Prior to 2007, within each DR, a minimum of 3 households were pre-selected for the annual farm production surveys, and crop cuts were taken on their 3 main crops. This means that, on average, a total of 36 crop cuts were taken for each major crop in each Department, and the Departmental average yield was calculated as a simple average of the 36 crop cuts[16]. In the 2007/08 season, however, DAPS/DRDR have increased their CCE sample size to 5 households per DR, giving a higher average number of 60 crop cuts per crop per Department. Technical Note 3 contains a detailed review of the DAPS/DRDR crop-cutting procedures, which are used to establish the Departmental-level average-yields

3.35 Planted area statistics for each Department for the past 3 years 2005/06 to 2007/08 and the departmental average yields for all major field crops for the period 198/82 to 2006/07 have been provided by DAPS. This data has been used to construct the MARCS Model.

Design Features

3.36 The underlying crop production and yield data and crop valuation data which the MARCS model is built on, include:

- **Selected Crops:** The six principle crops grown in Senegal for which time series departmental yields area available including groundnuts, cotton, maize sorghum, rice, millet, and cowpeas. The insurance of cowpeas is not recommended, which is a highly speculative forage crop and for this reason, cowpeas are excluded from the MARCS portfolio analyses. The model is however, programmed to include cowpeas should the user wish to analyze this crop.

- **Cropped Area**: In order to remove seasonal variations from the cropped areas in each Department, the model takes the average of the past 3 years, 2005/06, 2006/07, and 2007/08 cultivated area for each crop. The model assumes that annual cropped area has remained constant at the 3-year average over the past 22-years. However, the user can also enter any crop area that they wish to model in their portfolio.

- **Crop Yields**: The earliest DAPS departmental yields date back to 1981/82. However, there are many gaps in the early years, and therefore the model uses the 22 years of yields from 1986/87 to 2007/08.

- **Valuation Prices:** Crops are valued at the 2007 average market price per kilogram advised by DAPS, and are shown in Technical Note 4. These crop prices are maintained at a constant 2007 value for all the past 22 years.

3.37 **Yield Data Cleaning and Trending to establish Central Tendency**. Standard statistical procedures have been used to adjust the Departmental annual yield data including: (i)

[16] Kaffrine Department is an exception in that it is very large, and for the purposes of the CCEs the department is divided into 2 sub-units and 30 CCEs are taken in each sub-unit. DAPS, however, only publish the single combined average yield for each crop in Kaffrine.

Data cleaning to eliminate outlier yields, (ii) adding yields for missing years, wherever possible[17], and (iii) yield trending to establish central tendency in the time-series yields. By trending the 1986/87 to 2007/08 crop yields for each crop in each department it is possible to extend the trend to calculate the "expected" Average Trend Yield for 2008/09. All Insured Yields are calculated in MARCS as a percentage of the 2008/09 expected yield. Full details of the data cleaning and yield trending procedure are given in Technical Note 4.

3.38 **Valuing the Crop Portfolio.** MARCS is programmed to allow users to define their own crop portfolio (for the purposes of risk analysis and/or for rating the Area-Yield Index) and for each crop in each Department to: (i) Specify the planted area in hectares (termed the Insured Area), (ii) select a percentage from 50 percent to 100 percent of the 2008/09 Expected Yield in kg/ha, which forms the Insured Yield coverage level, below which the policy will indemnify the yield shortfall, and (iii) to set a Price for each crop in CFCA/kg (termed the Unit Insured Value). The product of these 3 parameters sets the Value at Risk or Sum Insured.

3.39 **Modeling of Yield Losses and the Value of Losses.** Under a Departmental Area-Yield Index policy, an indemnity is due when the actual average departmental yield for a specified crop falls short of the Insured Yield Coverage Level as defined above. MARCS is programmed for each crop in each Department to calculate for each of the past 22 years the difference between the actual historical yield and the Insured Yield for that year, which is calculated as the trend yield times the percentage coverage level. In any year where the actual yield is below the Insured Yield, the amount of yield loss is calculated as a percentage of the Insured Yield to derive pure loss cost (claim/liability x 100 percent). The average pure loss cost is calculated as a simple average over the 22 years of yield data. MARCS therefore uses a historical database of up to 22 years of actual yield data for all major crops in all departments of Senegal to: (i) Model the expected value of losses under an Area-Yield Index Insurance Program as if this were operating in the forthcoming 2008/09 season, and (ii) to establish the technical rates for the Area-Yield Index Program.

Crop Portfolio Risk Assessment Model – Outputs and Applications

National Aggregate Crop Values

3.40 Table 3.5. and Figure 3.6. present the total national values for all 6 crops assuming a 100 percent coverage level of the 2008-09 expected trend yields for each crop in each Department where the cultivated area exceeds 1,000 Hectares and where there are more than 10 years of yield data. The total expected values amount to FCFA 199 billion or US$ 468 million. This value would equate to the Total Sum Insured under an Area-Yield Index Insurance Program which would insure 100 percent of the expected crop production and yields for the entire cultivated area for these 6 crops in Senegal

3.41 Groundnut is the most important crop with 100 percent values of FCFA 78.4 billion or 39 percent of the total value of the national crop portfolio, followed by millet accounting for a further FCFA 52.9 billion or 27 percent of total values. Both of these crops are grown in most of the departments in Senegal. This is followed by maize (13 percent of total values), rice (10 percent of total values), and finally sorghum and cotton which are relatively small crops in the overall portfolio.

[17] However, where the time series are very disjointed or there are less than 10 years actual reported yields for each crop, these data have not been included in the model as the time series is inadequate for the purposes of establishing Insured yields and crop rates for an Area-Yield Index policy.

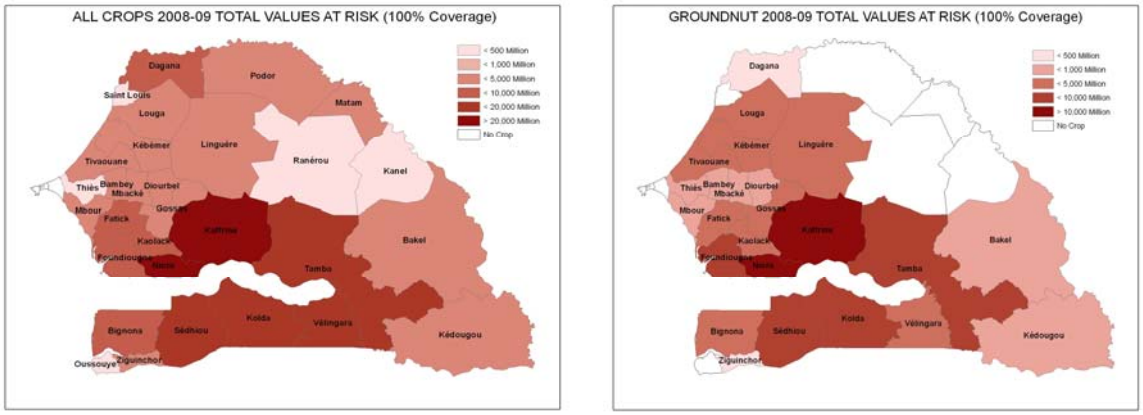
3.42 Two-thirds (67 percent) of the total national crop portfolio values are concentrated in the 3 central southern regions of Koalack, Kolda and Tambacounda, which are the most important groundnut, millet, maize, sorghum, and cotton producing regions. The planning and design of any future Area-Yield Crop Index Insurance program for Senegal will need to take into account the geographical concentration of risk and ways to achieve optimum risk spread.

Table 3.5: Senegal: Total Values at Risk for 100 percent Coverage Level (FCFA Million)

Crop	Groundnuts	Cotton	Maize	Sorghum	Rice	Millet	Total/ Department
TOTAL	78,398	7,940	25,581	14,237	19,930	52,891	198,976
Percent of total	39%	4%	13%	7%	10%	27%	100%

Source: MARCS model (2008).

Figure 3.6: Senegal: Distribution by Department of Estimated 2008/09 Crop Values for: (a) 6 Main Crops, and (b) Groundnuts (FCFA Million)



Source: Authors, from DAPS data.

Estimated Claims Costs for National Portfolio and 100 Percent Coverage Level

3.43 For any defined crop portfolio and sum insured and coverage level, MARCS is programmed to calculate the expected claims costs and associated pure loss costs[18] for insured yield coverage levels of 100 percent down to 50 percent (or lower) of the expected 2008-09 Departmental average yield for each of the 6 crops.

3.44 For the 100 percent coverage level national crop portfolio, Figure 3.7 shows the average expected claims costs in FCFA million which would have occurred in each crop over the past 22 years from 1986/87 to 2007/08. The corresponding loss costs (claims/liability) for 100 percent yield coverage area shown in Figure 3.8. Full details of this claims analysis are presented in Technical Note 4.

3.45 The main feature of the analysis is that crop production in Senegal is extremely risky as evidenced by the modeled 22-year average annual losses for 100 percent yield coverage for all

[18] The Loss Cost is an important insurance statistic, given by the value of claims divided by the value of liability (or total sum insured) and expressed as a percentage. The loss cost varies from 0% claims up to a maximum of 100% in the event of a total loss of the sum insured.

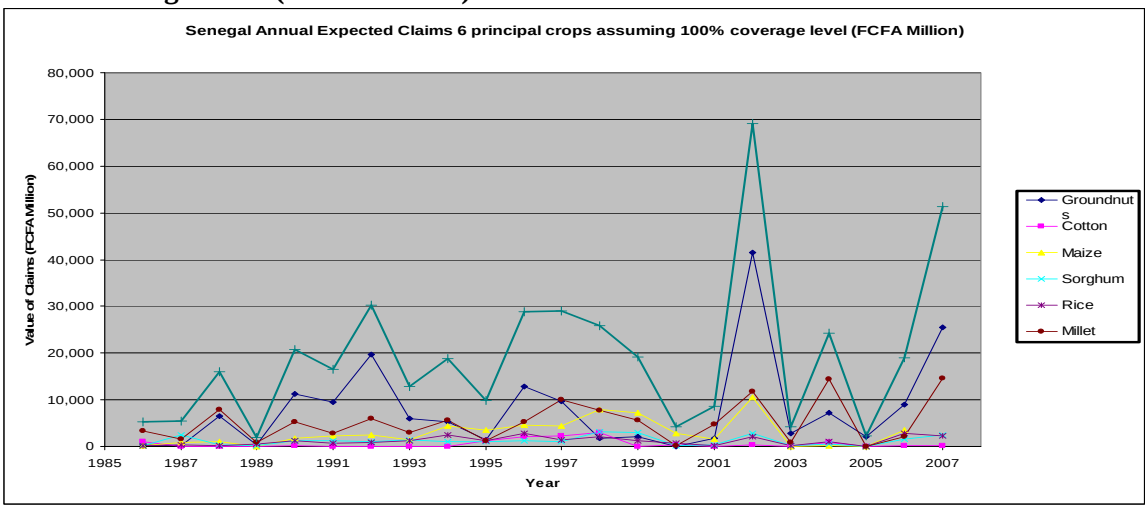
crop valued at FCFA 19.2 billion, or nearly US$ 43 million per year, which is equivalent to an average loss cost of 10 percent of the national average crop value each year.

3.46 The analysis also shows that 2002-03 was the worst drought year in this 22-year time series when the total value of crop production losses amounted to FCFA 69.1 billion (US$ 154 million) which is equivalent to an overall loss cost of 35 percent of the total value of national crop production. The next worst year was 2007 when total claims costs amounted to FCFA 51.3 billion (US$ 114 million) or an overall loss cost of 26 percent.

1.1. Groundnuts are the most risky crop grown in Senegal with an annual average loss cost of 13 percent valued at FCFA 8.0 billion per year and with a peak loss cost in 2002-03 of 53 percent of the total value of groundnut production valued at FCFA 41.1 billion (US$ 92 million). The next most risky crop is maize with an annual average loss cost of 11 percent over the past 22 years.

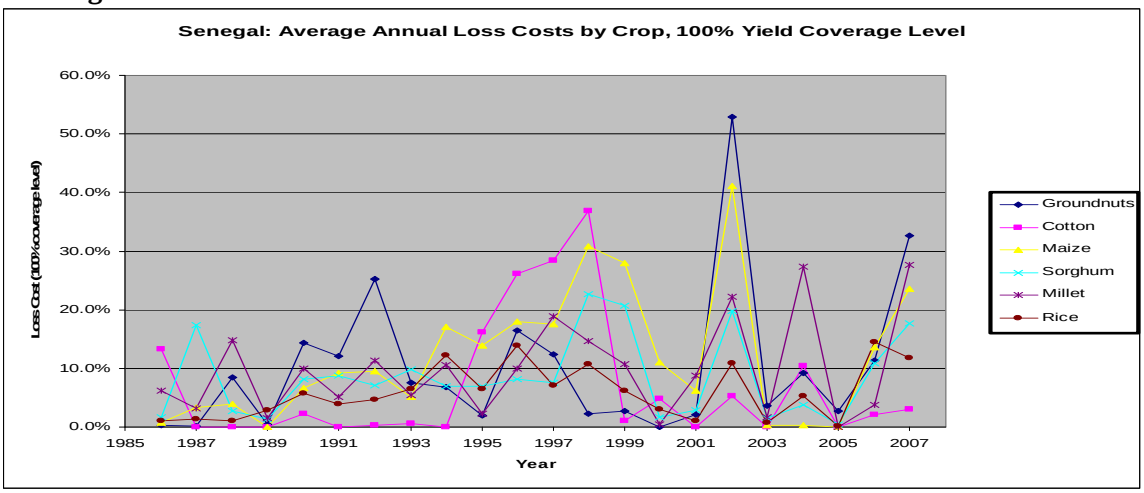
3.47 The 2002-03 losses clearly show the co-variance (correlation) in losses between crops at a national level in Senegal in a very severe drought year. This applies to both groundnuts and maize which incurred the highest losses out of all 22 years in 2002-03 and severe losses were also incurred in millet and sorghum. Conversely, cotton and rice do not appear to correlate with these crops in a severe drought year.

Figure 3.7: 22-Year Departmental Average Annual Claims Cost by Crop - 100 Percent Yield Coverage Level (FCFA Million)



Source: MARCS 2008.

Figure 3.8: 22-Year Departmental Annual Loss Costs by Crop - 100 Percent Yield Coverage Level



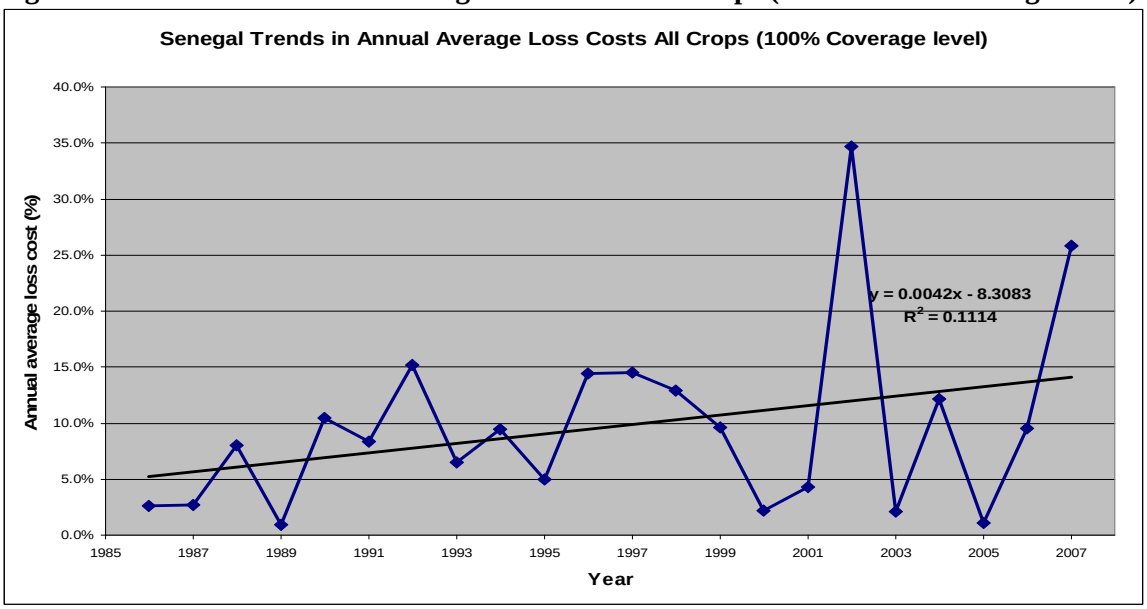
Source: MARCS 2008.

Trends in Crop Production Losses and Claims Costs

3.48 The analysis in Figure 3.9. shows that, over the past 22 years, there has been an increasing trend in losses from an average of about 7.5 percent (COV 53 percent) per annum prior to the turn of the century and with a peak of no more than about 15 percent, to an average of about 12.5 percent loss costs since 2000 (COV 108 percent). Crop production and yields have been much more variable, as measured by the variation in losses from a peak of 35 percent of total values in 2002/03 and 26 percent loss costs in 2007/08. The extent to which this trend is related to climatic change is yet to be verified in Senegal.

3.49 This implies that insurance planners should include adequate contingencies in their ratings to account for the changing and more variable pattern of crop losses since 2000.

Figure 3.9: Trends in Annual Average Loss Costs: All Crops (100 Percent Coverage Level)



Source: MARCS 2008.

Geographical Distribution of Crop Losses

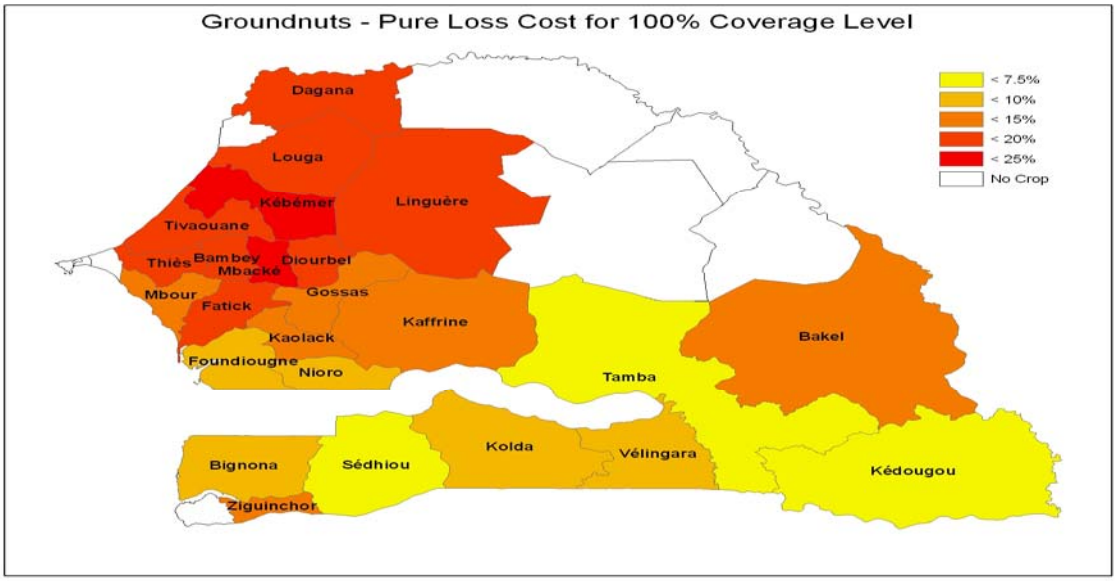
3.50 Technical Note 4 provides a detailed analysis of the distribution of crop losses by crop type and by department. The pattern of yield losses is closely related to rainfall distribution and crops grown in low rainfall, arid regions of the north exhibit much higher 22-year average annual loss costs than those grown in the centre of Senegal, and the lowest yield losses and thus loss costs are found in the most southern departments.

3.51 This loss pattern is illustrated in Figure 3.10. for groundnuts for the 100 percent insured yield coverage level[19]. The northern and northwestern departments highlighted in red exhibit annual average loss costs for groundnuts in excess of 15 percent, and in the case of Kébémer and Mbacké Departments, loss costs are greater than 20 percent. In the Groundnut Basin, average loss costs in Kaffrine, Gossas, and Koalack are between 10 percent and 15 percent at 100 percent coverage level; in the more southern departments of Nioro and Foundiougne, which enjoy average rainfall in excess 800 mm per annum, average loss costs are between 7.5 percent and 10 percent, and finally in the far South average loss costs in Sédhiou, Tamba and Kédougou are less than 7.5 percent for 100 percent coverage. Technical Note 4 shows a similar pattern of exposure to loss in other rain-fed crops.

3.52 The implications of this analysis for the proposed Area-Yield Index Insurance Program include: (i) The need to balance the portfolio by restricting the underwriting of groundnuts (and other crops) in the high loss northern departments and by underwriting proportionately more groundnuts (and other crops) in the lower risk central and southern departments, and (ii) that the Insured Yield Coverage levels for each crop in each Department must be related to the exposure to loss in that Department. These themes are discussed in more detail in subsequent sections.

[19] Departments in white "No Crop" are those where there is either less than 10 years yield data or where the 3-year average sown area is less than 1,000 Ha.

Figure 3.10: Groundnuts: Distribution of Expected Losses by Department for 100 Percent Coverage

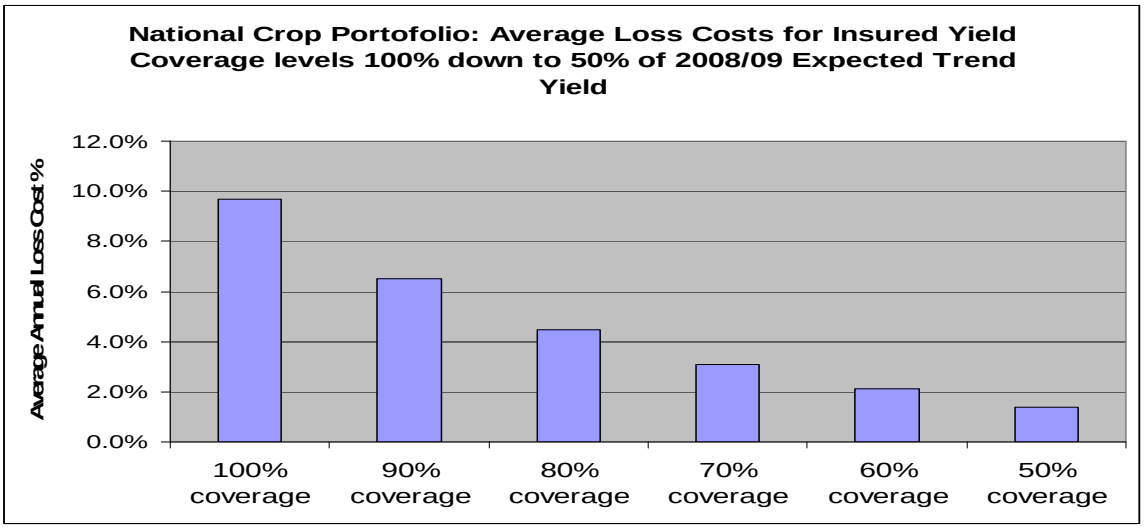


Source: MARCS model (2008).

Area-Yield Insurance and Impact of Different Coverage Levels on Claims Costs

3.53 The above analysis at 100 percent coverage level serves to illustrate the 22-year pattern of losses incurred in Senegal when crop production and yields fall below average (100 percent coverage level) across the 6 principal crops and 33 departments, and the catastrophe losses to both farmers and the national economy in severe drought years such as 2002-03 and 2007/08. No crop insurance program will, however, accept to insure 100 percent of the average yield. The MARCS model is programmed to adjust the insured yield coverage level from 100 percent down to 50 percent (or lower if required) of the 2008/09 expected trend yield for each crop and department, and to automatically recalculate the sum insured (liability), the annual claims cost for each of the 22 years, average loss costs, and finally the claims value corresponding to each coverage level. Figure 3.11 illustrates the reduction in overall claims costs for the national portfolio for reduced coverage levels from 100 percent coverage (average 9.7 percent loss cost) down to 50 percent coverage (average 1.4 percent loss cost). See Technical Note 4 for further details of effects of reduced coverage level on claims costs.

Figure 3.11: Annual Average Loss Costs for Coverage Levels 100 Percent down to 50 Percent



Source: MARCS model (2008).

Probable Maximum Loss

3.54 Table 3.6. shows the overall crop portfolio loss costs in 2002/03, the worst crop loss year actually experienced over the past 22 years in Senegal. The actual loss at 100 percent insured yield coverage level was nearly 35 percent of the total value of national crop production for the 6 main crops. Under an assumed Area-Yield Index Insurance Program with coverage level options from 90 percent down to 50 percent of expected trend yield, the worst losses in 2002/03 would have been reduced to an overall loss cost of between 30 percent (90 percent coverage) down to 12 percent (50 percent coverage).

Table 3.6: 1 in 22 "Worst" Year Loss Costs for Insured Yield Coverage Levels 50 Percent to 100 Percent

Year	100 percent coverage	90 percent coverage	80 percent coverage	70 percent coverage	60 percent coverage	50 percent coverage
Worst Year 2002/03	34.7%	30.2%	26.1%	21.8%	17.2%	12.3%
21-year Average	9.7%	6.6%	4.5%	3.1%	2.1%	1.3%

Source: MARCS model (2008).

3.55 Although 2002/03 was a very bad crop loss year in Senegal, it is apparent that under the laws of probability even worse losses could occur in the future. From an insurance viewpoint, underwriters need to know with a high degree of confidence the maximum losses that they might occur (termed the Probable Maximum Loss, PML[20]) either 1 in 100 years, or if it is necessary to be even more conservative, 1 in 250 years. This information is required to structure an insurance

[20] The Probable Maximum Loss is defined as "An estimate of the maximum loss that is likely to arise on the occurrence of a single event considered to be within the realms of probability, remote coincidences, and possible but unlikely catastrophes being ignored".

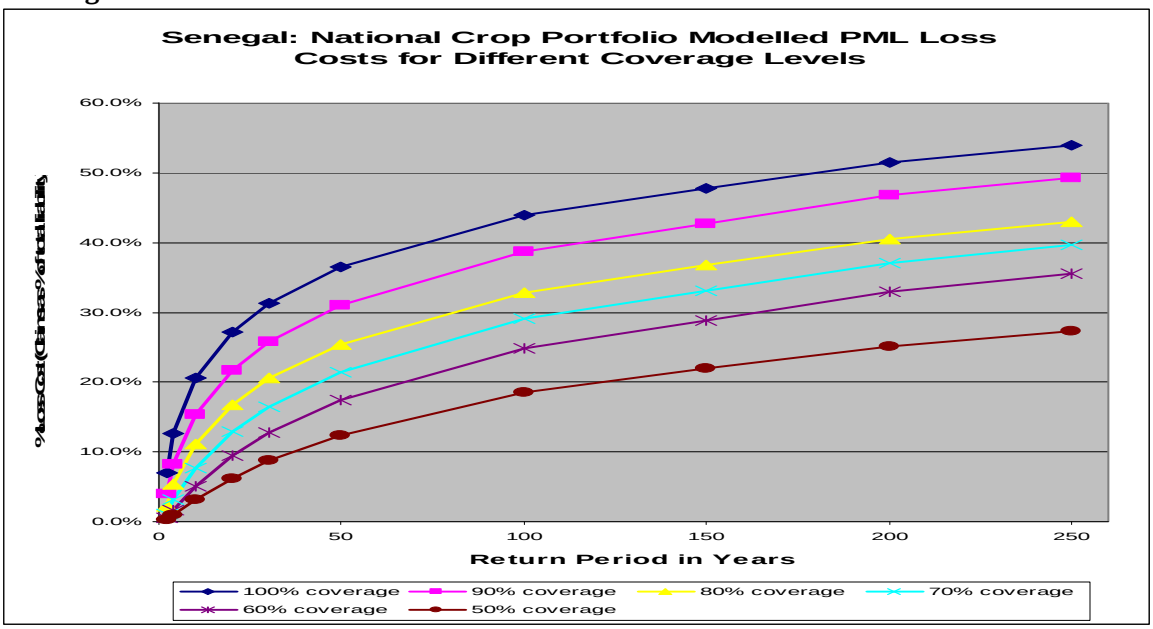
and reinsurance program and to determine how much capital must be reserved to cover the PML loss year.

3.56 Figure 3.12. shows the results of the World Bank's PML loss cost analysis for return periods of 1 in 2 years up to a maximum of 1 in 250 years for the 6-crop national portfolio and assumed coverage levels of 100 percent down to 50 percent of 2008/09 expected trend yield[21]. The analysis shows that:

- The losses in 2002/03 with loss costs of 35 percent (100 percent coverage level) equates very closely to a 1 in 50 year return period (50 year loss cost calculated at 36 percent);
- The 1 in 100 year loss cost is 44 percent at 100 percent coverage level, equivalent to a loss of FCFA 87.3 billion or US$ 194 million;
- For an Area-Yield Insurance Program which provides coverage levels of between 50 percent and a maximum of 80 percent of expected trend yield, the corresponding 1 in a 100 year PML costs are: 19 percent (at 50 percent coverage), 25 percent (at 60 percent coverage), 29 percent (at 70 percent coverage), and finally 33 percent (at 80 percent coverage). The corresponding losses associated with these 1 in 100 years PML's are shown in Technical Note 4 for the overall crop portfolio.

3.57 As noted in Section 2, under the proposed NCAAS, it will be very necessary to take into account these PML costs in the structuring of the company's retention and reinsurance purchasing requirements.

Figure 3.12: Estimated Probable Maximum Loss for Crop Area-Yield Index Insurance and Coverage Levels 50 Percent to 100 Percent of Yield



Source: MARCS model (2008).

[21] The PML Costs are calculated using appropriate statistical simulation techniques which are described in Technical Note 2.

Modeling Risk Exposures for Selected Crop Portfolios

3.58 MARCS is intended to model the sums insured calculated premiums and expected losses for an Area-Yield Crop Insurance Portfolio. Table 3.7. is a hypothetical crop insurance portfolio loosely modeled on the DA's 2007 Draft Technical Study Year-3 estimated crop insurance portfolio including the 6 main crops and cowpeas with insured area of about 390,000 hectares. In the absence of information on the selected departments and insured area in each department, the modeled figures assume that the area for each crop is proportional to the 3-year total average sown area in each Department. Three Insured Yield coverage levels are assumed, 50 percent, 60 percent, and 70 percent. All other parameters are automatically generated by MARCS.

3.59 Under these assumptions, TSI increases from FCFA 19.1 billion (US$ 42 million) for 50 percent coverage to FCFA 26.7 billion (US$ 59 million) and with corresponding Premiums of FCFA 684 million (US$ 1.5 million) and FCFA 1,812 million (US$ 4.0 million). Average expected claims vary from FCFA 265 million (US$ 0.6 million) for 50 percent coverage, rising to FCFA 815 million (US$ 1.8 million) for 70 percent coverage. The 1 in 100 year PMLs range from FCFA 3.5 billion (US$ 7.8 million) for 50 percent coverage to FCFA 7.8 billion (US$ 17.3 million) for 70 percent coverage.

Table 3.7: Example Area-Yield Crop Insurance Portfolio, 50 Percent to 70 Percent Coverage Levels

Coverage Level	Insured Area (Ha)	Total Sum Insured (FCFA)	Premium (FCFA)	Claims (FCFA)	Average Commercial Premium Rate percent	Loss Ratio percent	Loss Cost percent
50 percent	389,865	19,067,581,737	683,551,398	264,998,714	3.6 %	38.8%	1.4%
	PML (18.5%)	3,527,502,621					
60 percent	389,865	22,881,098,084	1,178,270,124	485,574,651	5.1%	41.2%	2.1%
	PML (24.8%)	5,674,512,325					
70 percent	389,865	26,694,614,432	1,811,917,922	814,968,482	6.8%	45.0%	3.1%
	PML (29.1%)	7,768,132,800					

Source: MARCS model (2008).

3.60 The average commercial premium rates generated by MARCS for the hypothetical portfolio and assumed target loss ratio of 55 percent are also shown in Table 3.7. The underlying pure loss cost rates calculated by MARCS represent technically calculated rates. The Commercial Premium Rates with 55 percent target loss ratio are illustrative and do not represent final recommended rates. The final Commercial Premium rates will need to be set by crop insurers and reinsurers in accordance with the acquisition and administrative costs of the program, and underwriter's required loadings for catastrophe reserves and profit margins. The analysis shows, however, that average commercial premium rates are highly influenced by the Insured Yield coverage level. Cowpeas are an extremely risky crop as evidenced by the very high average rates which would need to be charged of between 10.0 percent (for 50 percent coverage) and 15.3 percent (for 70 percent coverage), and it is recommended that this crop is not insured under the Area-Yield program (see Technical Notes 4 and 5 for full details of rates for each crop and coverage level).

Summary

3.61 The MARCS model represents a simple and flexible tool for conducting an analysis of variation in departmental-level time series average crop yields and which provides useful information on the relative levels of crop exposure by department, crop type, and insured yield coverage level. The model can be used for portfolio risk assessment and to establish a balanced crop insurance portfolio.

3.62 The main drawback of the model centers on the accuracy of some of the underlying departmental average yield data, and this applies specifically to the case of maize, where average yields in the past 6 years appear to be inconsistent.

3.63 The key finding of the risk analysis is that departmental-level average crop yields are extremely variable, both spatially between departments and temporally between years. The design and planning of an Area-Yield Index Program must take these two factors into account.

3.64 The analysis of variation in yields, year-on-year, has shown that in severe drought years such as 2002-03 and again in 2007-08, there is a high degree of correlation between yield reduction across the major field crops, and that catastrophe losses are incurred as demonstrated by the 35 percent losses in total crop values in 2002-03 and 25 percent losses in 2007-08. The analysis also shows that, for an Area-Yield Index Insurance Program providing on average a maximum insured yield coverage level of 70 percent, the 1-in-100 year PML is about 29 percent of total liability (or 19 percent loss cost for 50 percent coverage level) and this should taken into account in the structuring of the insurance and reinsurance program.

3.65 The spatial differences in yield variation by crop type and department indicate that, in the implementation planning for the Area-Yield Index Insurance Program, the insured yield coverage levels should be set individually for each crop and each department rather than a single blanket coverage level for all crops and departments. This is discussed further in Chapter 4.

Chapter 4. Area-Yield Index Crop Insurance for Senegal

4.1 As part of the Government of Senegal's initiative for public-private sector agricultural crop and livestock insurance in Senegal, it is proposed to introduce an Area-Yield Index Crop Insurance Program for main field crops using the departmental average yield as the basis of insurance and indemnity. Basic features of the proposed departmental Area-Yield Index Program were presented in Chapter 2.

4.2 This chapter provides an analysis of the key design and rating issues and methodology for an Area-Yield Index Program for Senegal and draws, where relevant, on international experience. Outline proposals are presented for a Pilot Area-Yield Index Program for selected crops in selected districts, but it is stressed that further design work will be required in any pilot implementation phase. The findings presented in this section are intended to assist the Government of Senegal and the private insurance companies in the design and implementation of the Area-Yield Crop Insurance Program. Full details of the Area-Yield Index crop insurance product design and pricing are given in Technical Note 5.

Features and International Experience

Features of Area-Yield Index Insurance

4.3 Traditional individual grower Multiple-Peril agricultural Crop Insurance, MPCI, is widely practiced throughout the world. The international experience with individual grower MPCI has, however, often been poor, with problems of low uptake, high anti-selection and moral hazard, high administrative costs and underwriting results which have generally been negative, and the programs have been very exposed to systemic losses in severe drought or flood years. As noted in Chapter 2, most MPCI is highly dependent on government premium subsidies and/or subsidies on claims payments. In developing countries, which are dominated by very small farm size, the costs associated with administering individual grower MPCI are often prohibitively high.

4.4 Area-Yield Index Insurance represents an alternative approach which aims to overcome many of the drawbacks of traditional MPCI. The key feature of this product is that it does not indemnify crop yield losses at the individual field or grower level. Rather, an Area-Yield Index product makes indemnity payments to growers according to yield loss or shortfall against an average area-yield (the index) in a defined geographical area (e.g. county or department). An Area-Yield Index policy establishes an Insured Yield which is expressed as a percentage (termed the "Coverage Level") of the historical average yield for each crop in the defined geographical region which forms the Insured Unit. Farmers whose fields are located within the Insured Unit, IU, may purchase optional coverage levels which typically vary between a minimum of 50 percent and a maximum of 90 percent of historical average yield. The actual average yield for the insured crop is established by sample field measurement (usually involving crop cutting) in the Insured Unit and an indemnity is paid by the amount that the actual average yield falls short of the Insured Yield Coverage level purchased by each grower.

4.5 The key advantages of the Area-Yield approach are that moral hazard and anti-selection are minimized. The costs of administering such a policy are much reduced, and this offers the potential to market this product at lower premium costs to growers. The main disadvantage of an Area-Yield Index Insurance policy is that an individual grower may incur severe losses due to localized perils, e.g. hail, or flooding by a nearby river, but because these localized losses do not impact on the county or departmental average yield, the grower does not receive an indemnity (see Box 4.1. for further details).

Box 4.1: Area-Yield Index Insurance: Advantages and Disadvantages

Advantages	Disadvantages
Adverse selection and moral hazard minimized The indemnity is based on average area-yields and not on individual farmer's yields. Individual farmers cannot therefore influence the yield outcome.	***Basis risk – payouts may not fully reflect individual grower's losses*** The occurrence of basis risk depends on the extent to which individual farmer's yield outcomes are positively correlated with the Area-Yield Index. An insured can experience a severe yield loss on his farm and not receive an indemnity if the area-yields are unaffected. The insured may also experience no yield loss and still receive an indemnity if the area-yields are affected.
Yield data availability for insurance Conventional individual grower MPCI is often constrained by a lack of reliable historical yield data at the individual farm level. Conversely, time-series country-level or departmental-level area-yield data are usually available in developing countries.	***Not suitable for localised perils*** Area-Yield Insurance will not work in areas with high losses due to localized perils, e.g. hail, or localized frost pockets.
Comprehensive Multi-Peril Insurance suited to the insurance of systemic risk The policy acts as an All Risk Yield shortfall guarantee policy and is best suited to situations where severe systemic risk (e.g. drought) impacts equally over the defined Area Insured Unit (e.g. Department).	***Requires homogeneous agroclimatic risk regions and cropping systems***. Area-yield insurance works best in a homogeneous climatic zone and where cropping systems for the insured crop are uniform (e.g. same varieties, planting dates, management practices). The policy is not suitable for inter-cropping and crops with staggered planting and harvest dates.
Lower underwriting and delivery costs There is no need to conduct pre-inspections on individual farms or to collect individual grower yield data.	***Accuracy of historical area-yield data*** Methods of yield measurement and reporting may have changed over time, raising questions over the accuracy of the historical area-yields.
Lower loss adjusting costs There is no requirement for individual grower in-field area loss assessment which is very time-consuming and costly. Area-yields are established by sample-yield measurement in the defined Area Insured Unit (e.g. Department).	***Problems of accurate measurement of area-yields*** Sampling error and enumerator bias can be a major problem in determination of average area-yields, particularly in large Area Units and where yields are very heterogeneous.
Affordability of product The combination of reduced exposure to yield loss of an Area-Yield Index policy and reduced administrative costs offers the potential for cheaper premiums than for individual grower MPCI.	***Time delays in settling claims*** Farmers often have to wait for at least 3 to 6 months post harvest for the official results of the area-yields to be published and for indemnities to be paid, if applicable.

Source: Authors.

International Experience with Area-Yield Index Insurance

4.6 The origins of Area-Yield Index Crop Insurance date back to 1952 in Sweden. India introduced Area-based crop insurance in the late 1970s, and the USA and Canada introduced Area-Yield Index Crop Insurance in the early 1990s. Other countries which have developed Area-based crop insurance in the past decade include Morocco, Sudan, and Brazil.

4.7 In India the Agricultural Insurance Company of India AICI, a public sector specialist crop insurer, is responsible for implementing area-based crop insurance under the National Agricultural Insurance Scheme NAIS. This Program has operated for over 20 years and key features include:

- The Program is targeted at small and marginal farmers (with less than 2 hectares), and who are highly dependent on access to seasonal crop credit. Crop Insurance is compulsory for borrowing farmers and voluntary for non-borrowing farmers;
- The Insured Unit is normally the block or panchayet which comprises a group of nearby villages and which may include up to 10,000 ha or more of a single crop and several thousands of small and marginal farmers. Farmers may select coverage levels of 60 percent, 80 percent, or maximum of 90 percent of the 5-year average area-yield;
- The Program is administered through the rural agricultural bank branch network in each state and department and block (group of villages). The AICI maintains a national headquarters staff and a small regional team in each state. It has not, however, attempted to establish branch offices, as there is no need to duplicate the rural bank branch network. The Insurers' administrative costs are kept to a minimum by linking insurance with rural finance.
- Actual area-yields are established through sample crop-cutting. This is a major and costly exercise and suffers from delays in processing the results. Indemnity payments are therefore often delayed for 6 months or more.
- By virtue of being a mainly compulsory program, the NAIS scheme is the world's largest crop insurance program, currently insuring about 20 million Indian farmers (representing an insurance uptake rate of about 18 percent of all farmers). The Program is, however, highly dependent of government subsidies and operates at a major financial loss.

4.8 In the USA, Area-Yield Index Insurance is marketed under the name Group Risk Plan. Further details of the experience with Area-based crop insurance are contained in Technical Note 5.

The Issue of Basis Risk

Choice of Insured Unit

4.9 Under an Area-Yield Index Crop Insurance Program, it is necessary to have an independent, accurate, and timely system of measuring actual yields on sample farms in order to establish a statistically acceptable[22] estimate of the actual average yield in the defined geographic area (Insured Unit) for the purposes of indemnifying yield losses. Furthermore, the yield recording system needs to have been in operation for a minimum of 10 years in order to provide

[22] As defined by an agreed confidence level of 90% or 95%.

historical area-yields which can be used to establish: (i) An average yield, (ii) an insured yield coverage level(s), and (iii) technical rates.

4.10 As noted previously there is a comprehensive system of crop yield measurement in Senegal, which has operated for more than 25 years, based on: (i) Sample crop-cutting surveys (CCEs) for the principle crops, and (ii) visual estimation techniques for the remaining crops, and which is conducted on representative farms in selected villages and rural communities in each Department throughout Senegal.

4.11 Currently, the Department is the lowest (smallest) administrative unit/geographic area for which crop-cutting results are publicly available both on a historical time series basis and during the current cropping season. It is for this reason that the DA has proposed to implement an Area-Yield Index Program with the Department forming the Insured Unit.

Issues of Basis Risk

4.12 An Area-Yield Index policy is only effective in areas where soils and climate are relatively homogeneous and where farmers' cropping practices and technology and husbandry levels are similar, so that the production and yields of the same crop are relatively homogeneous throughout the defined zone. If cropping conditions are not relatively homogeneous, the problem of basis risk may negate or undermine the effectiveness of the crop insurance program.

4.13 The 33 Departments of Senegal vary widely in size (area); the largest Departments including Bakel, Kédougou and Tambacounda (Tambacounda Region) have dimensions in excess of 100 km to 150 km from North to South with rainfall gradients from over 600 km in the North to over 1200 mm in the Aouth. Similarly, Kaffrine Department, which is the single most important crop-producing department in Senegal, is a very large department.

4.14 Under this study, basis risk (in terms of intra-departmental variation in soil type, rainfall, other climatic variables, crop technology, management and husbandry levels, and thus crop production and yields) was advised as being a major issue in the larger departments. In order to test this hypothesis, an analysis of DRDR original individual crop-cutting results was carried out for the major crops, in the Departments of Gossas, Kaffrine and Nioro. The results of this analysis are presented in Technical Note 3, and key findings are reviewed below.

4.15 Table 4.1. provides a summary of the 4-year (2004-05 to 2007-08) results of crop cutting for groundnuts in Gossas, Kaffrine, and Nioro Departments, and the individual crop-cut yields for groundnuts in 2005-06 are plotted in Figure 4.1.

4.16 In the Gossas Department, crop-cut yields are generally low and highly variable as demonstrated by the range in average yields from 263 kg/ha in 2007/08 to 680 kg/ha in 2005/06 and the COVs around mean yield as high as 77 percent. In 2004-05, the range in the 37 crop-cut yields was from 0 kg/ha to as high as 1,650 kg/ha with a mean yield of 653 Kg/ha, but on account of the very high variation in CCE yields, the 95 percent confidence limits for groundnut yields were between a minimum of 505 kg/ha and a maximum of 802 kg/ha. Under such circumstances, where the internal variation in crop yields between farmers within a single Department is very high, it is not only difficult to establish an accurate average yield for the operation of an Area-Yield Index Insurance Program, buts also the potential for basis risk is extremely high.

4.17 To put this into context, the 22-year average yield in Gossas is 626 Kg/ha and under an Area-Yield Insurance product with 70 percent coverage level, the policy would pay out if the

actual average yield in the current insurance period fell below 438 kg/ha. In 2004/05, the actual average yield as established by the 37 CCEs was 653 kg/ha or well above the 70 percent coverage level, leading to an indemnity: However, the yield in 13 CCEs or 35 percent of the total CCEs was below the trigger yield of 438 kg per hectare, and as these CCEs were systematically sampled from all 12 DRs in the department, the conclusion is: (a) That at least 35 percent of farmers incurred severe yield losses but would not have received an indemnity (i.e. basis risk is very high), and (b) that many of these farmers probably do not achieve an average yield of 653 Kg/ha even in a normal year because of differing technology and management standards. The very high variation in groundnut yields between farmers in Gossas means that this Department is not well suited to an Area-Yield Index policy.

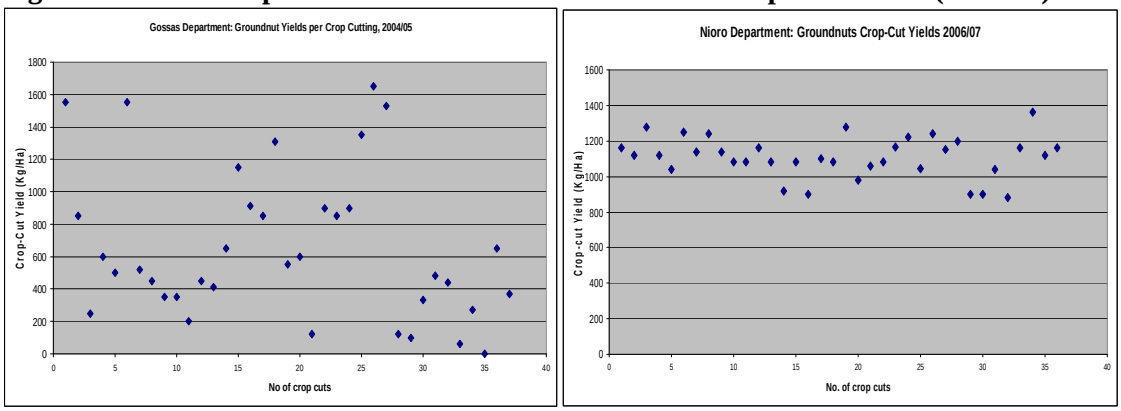
4.18 Conversely, in Nioro Department, CCE yields for groundnuts are much higher on average and are much more stable, as evidenced by average yields of about 1 metric ton per hectare or greater and COVs around mean yields of less than 20 percent in most years. In 2006-07, the average yield was 1,109 kg/ha with a minimum CCE yield of 880 kg/ha and maximum CCE yield of 1,360 kg/ha and 95 percent confidence limits of between 1,071 kg/ha and 1,144 kg/ha). In this Department, the 22-year average yield is 1,039 Kg/ha, and with a 70 percent coverage level, losses would be indemnified if actual departmental average yield falls below 727 kg/ha. Reference to Table 4.1 and Figure 4.1 shows that in 2006/07 the minimum CCE yield in Nioro Department was 880 Kg/ha, and in this case not one sampled grower would have incurred an insured loss and not received an indemnity under an Area-Yield approach, which implies that basis risk is not a big problem in this Department. In Nioro, the homogeneity in groundnut yields across the Department make it ideal for an Area-Yield Insurance Policy.

Table 4.1: Crop-Cutting Results: Groundnuts in Gossas, Kaffrine and Nioro Departments

Year	No crop cuts	average yield (Kg/Ha)	stdev yield (Kg/Ha)	cov %	min yield (Kg/Ha)	max yield (Kg/Ha)	95% confidence limits	lower limit (Kg/Ha)	upper limit (Kg/Ha)	Lower limit as % Average Yield
Gossas										
2004	37	653	461	71%	0	1,650	149	505	802	77%
2005	35	680	447	66%	50	1,930	148	532	828	78%
2006	38	592	182	31%	340	1,140	58	534	650	90%
2007	62	263	201	77%	0	1,650	50	213	313	81%
Kaffrine										
2004	66	915	334	37%	280	2,000	81	834	996	91%
2005	72	815	257	32%	220	1,480	59	756	875	93%
2006	68	752	238	32%	6	1,280	56	696	809	92%
2007	121	377	180	48%	0	760	32	345	409	91%
Nioro										
2004	40	1,323	525	40%	840	3,720	163	1,160	1,486	88%
2005	40	853	186	22%	500	1,520	58	795	910	93%
2006	36	1,109	116	10%	880	1,360	38	1,071	1,146	97%
2007	60	966	160	17%	720	1,440	40	926	1,006	96%

* Source. DAPS

Figure 4.1: Intra-Departmental Variation in Groundnut Crop-Cut Yields (2006-07)



Source: Authors, from DAPS.

4.19 Based on the study of CCE yields on crops grown in 3 departments, basis risk is likely to be a major problem for any Area-Yield Insurance Program in Gossas, and this problem also applies in Kaffrine. In Kaffrine, this problem might be overcome because the Department has been divided into two new administrative units (North and South), and DAP/DRDR collect CCE yield data from both North and South sub-divisions. In Nioro, CCE yields for the two principal crops, groundnuts and millet, are normally very uniform throughout the Department, and this Department is very suitable for a Pilot Area-Yield Index program.

4.20 It is not possible to comment on other departments because the CCE results have not been analyzed. It is, however, recommended that before any department is selected for a Pilot Area-Yield Insurance Program, a careful study should be made of the degree of homogeneity or internal yield variation between farmers as shown by the CCE results for each crop.

Area-Yield Index Design for Senegal

Yield Cleaning and Yield Trending to establish Expected Yields for Area-Yield Insurance

4.21 Technical Note 4 sets out the procedures which have been adopted for: (i) Cleaning the DAPS 22-year Departmental Average Yields for the 6 main crops, (ii) eliminating outliers (maximum and minimum yield years), and (iii) adding missing years. Departments, which have less than 10 years of continuous clean average crop yield data, have been eliminated from the MARCS model, as this is deemed the minimum number of years for the purposes of establishing average and insured yields and for rating purposes.

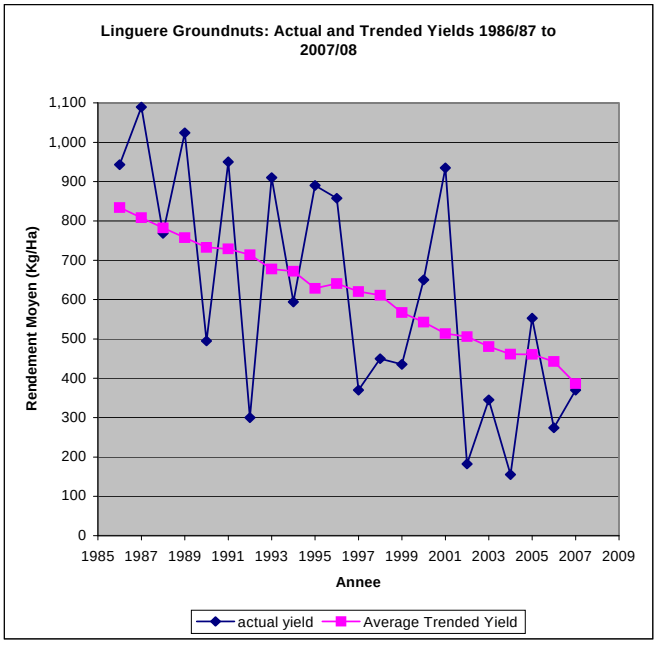
4.22 It is standard practice under an Area-Yield Index policy to adjust the time series annual yields for central tendency by fitting a trend line. Trending has the effect of smoothing the yields. In the USA, under the GRP program, Skees et al. (1996) recommended the use of "linear spline regression" to trend county average yield data. Conversely, in Romania, Varangis and Skees (2003) recommended the use of LOESS econometric procedures in SAS software to adjust Oblast area-yields for trends. Under the Excel-based MARCS model, this study has adopted a simplified procedure for forecasting the central tendency involving separate fitting of: (1) Linear trend, (ii) exponential trend, and finally (iii) 5-year moving average trends to the cleaned yield data, and then (iv) taking an average of the three trends. This procedure is intended to capture non-linear yield trends.

4.23 The trending methodology is also used to extend the time series yields beyond 2007/08 (last year for which departmental yield data available) and to establish the expected trend yields in the forthcoming 2008/09 season. The Insured Yield coverage levels are then expressed as a percentage of the 2008/09 expected trend yields.

4.24 The yield trending procedure is illustrated in Figure 4.2. for groundnuts grown in the Linguère Department. The 22-year average yield for groundnuts is 627 kg/ha. However, there is a consistent declining yield trend in this Department such that the actual average yield over the past 5 years is only 339 kg/ha. An Area-Yield Insurance Program which used the 22-year average yield of 627 Kg/ha to establish a 70 percent coverage level or 439 Kg/ha would in fact over-insure the current normal yield level of only 339 kg/ha and result in major indemnity payouts even where no yield loss has occurred. The trending process corrects these anomalies and results in an expected trended yield for 2008/09 of 375 kg/ha, which provides a very accurate estimate of current average yields for groundnuts in Linguère.

Figure 4.2: Example of Yield Trending, Groundnuts in Linguère Department

Linguere: Groundnuts average yields			
Year	actual yield	adjusted yields	Average Trended Yield
1986	943	943	834
1987	1,089	627	808
1988	768	768	783
1989	1,024	1,024	757
1990	495	495	733
1991	950	950	729
1992	300	300	714
1993	910	910	678
1994	594	594	672
1995	890	890	629
1996	858	858	641
1997	370	370	620
1998	450	450	611
1999	436	436	567
2000	650	650	543
2001	935	935	514
2002	182	182	506
2003	345	345	481
2004	155	627	461
2005	553	553	461
2006	274	274	443
2007	370	370	387
2008			**375**
Average 22 Yrs	627		
Average 5 Yrs	**339**		



Source: MARCS model (2008).

4.25 The proposed trending procedure is both consistent and simple to apply to the Senegalese Departmental yield data and should be adopted to avoid over-insurance of yields where declining yield trends apply.

Insured Yield Coverage Levels

4.26 Area-Yield Insurance policies usually offer coverage levels of between 90 percent maximum and 50 percent minimum of the area average yield, or in this case the "expected trended yield" in the forthcoming cropping season. For Senegal, the 2008/09 expected trend yields for all crops in all departments are given in Technical Note 5.

4.27 The feature of declining average yields of groundnuts (and this also applies to other crops) over time in many departments means that the 22-year actual average yield is very much

higher than the normal average yield over the past 5 years, and if the Insured Yield is established as a percentage of the 22-year average yield, this will result in severe over-insurance of current average yields in many departments. Yield trending overcomes this problem in most departments as shown by differences in the 2008/09 trend expected yield and most recent 5-year actual average yields. It is important that the Senegalese authorities deal with this issue in the design of their 2008/09 Departmental Area-Yield Index Insurance Program.

Area-Yield Index Rating Methodology for Senegal

Area-Yield Index Pure-Loss Cost Rating Methodology

4.28 The loss cost methodology is based on standard area-yield rating procedures. The loss cost formula is given by:

Loss cost = losses (claims /Liability (sum insured)

For the Area-Yield Index Program, the loss cost formula is given by:

Loss Cost$_{tdc}$ = Maximum (0, Average Trended Yield$_{tdc}$ x Coverage Level – Actual Yield$_{tdc}$) /Average Trended Yield$_{tdc}$ x Coverage Level.

where t = year, 1986/87-2007/08;
d = department 1 to 33;
c = crops 1-6;
Coverage Level is between a minimum of 50 percent and maximum of 90 percent of trended yield.

4.29 An example of the procedure for calculating the pure loss cost rates is given in Figure 4.3 for groundnuts in the Kaffrine Department for the maximum 90 percent insured yield coverage level. The analysis shows that at a coverage level of 90 percent, there would have been 8 years (36 percent of total years) in which the actual yield would have fallen below the corresponding 90 percent trend yield, resulting in an indemnity payout with an average pure loss cost rate of 8.2 percent and maximum of 54 percent loss cost in 2002/03. At this very high 90 percent coverage level the policy would pay out a claim every 2.75 years and the full commercial premium rate charged would be extremely high at about 15 percent. With a target payout frequency of 1 in 5 to 7 years, the 90 percent coverage level would be too high for Kaffrine groundnuts, and a lower coverage level should be selected.

4.30 In the Kaffrine Department the effect of reducing the coverage level to 70 percent for groundnuts is to reduce the frequency of payouts to 3 in 22 years (1 in 7 years indemnity payment) and the pure loss cost rate would be dramatically reduced to only 3.9 percent, offering the potential to provide insurance to farmers at commercial premium rates of about 7.0 percent. Finally, at the minimum recommended 50 percent coverage level there would have been 2 small indemnities, the first in 2002-03 and then again in 2007-08, with an average pure loss cost rate of 1.5 percent and commercial premium rate of less than 3.0 percent (see Technical Note 5 for further details).

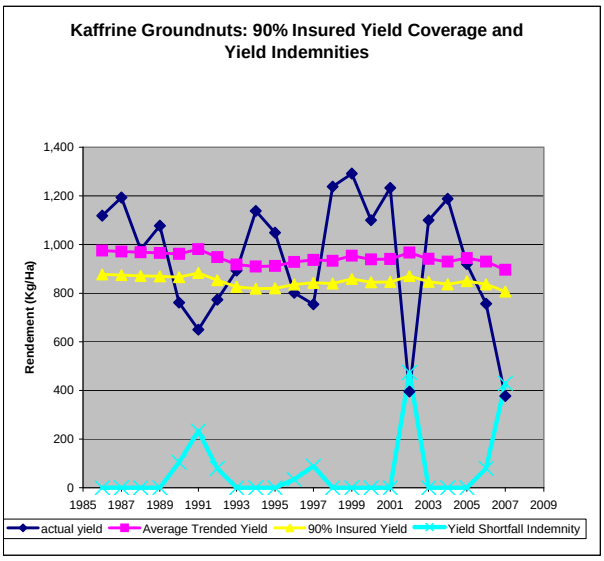
4.31 The above rating analysis for Kaffrine groundnuts clearly demonstrates the need to set the Insured Yield coverage level for each crop to the actual yield history in each department. For Kaffrine, groundnut yields are too variable to offer the maximum 90 percent coverage level, but at 70 percent coverage the grower is offered a reasonable level of yield protection for a

reasonable insurance premium. The question as to when catastrophe 50 percent Area-Yield coverage insurance is appropriate for small farmers in Senegal should be closely considered. Although there are advantages in the product being very cheap, the level of yield shortfall protection afforded to the grower is very low and catastrophe yield losses of greater than 50 percent of average yield at departmental level are required to trigger an indemnity.

Figure 4.3: Kaffrine Groundnuts Pure Loss Cost Rating Methodology for 90 Percent Coverage

Kaffrine Groundnuts			Insured Yield coverage 90%		
Year	actual yield	Average Trended Yield	90% Insured Yield	Yield Shortfall Indemnity	% loss cost
1986	1,119	975	877	-	0%
1987	1,193	972	874	-	0%
1988	980	968	871	-	0%
1989	1,077	965	869	-	0%
1990	761	962	866	105	12%
1991	650	981	883	233	26%
1992	773	948	853	80	9%
1993	893	917	826	-	0%
1994	1,138	910	819	-	0%
1995	1,049	911	820	-	0%
1996	801	929	836	35	4%
1997	754	936	843	89	11%
1998	1,238	933	840	-	0%
1999	1,292	954	859	-	0%
2000	1,100	939	845	-	0%
2001	1,233	940	846	-	0%
2002	396	967	870	474	54%
2003	1,100	941	847	-	0%
2004	1,188	930	837	-	0%
2005	920	944	849	-	0%
2006	757	930	837	80	10%
2007	377	896	806	429	53%
2008		**894**	**804**		
			Average loss cost		**8.2%**

Source: MARCS 2008

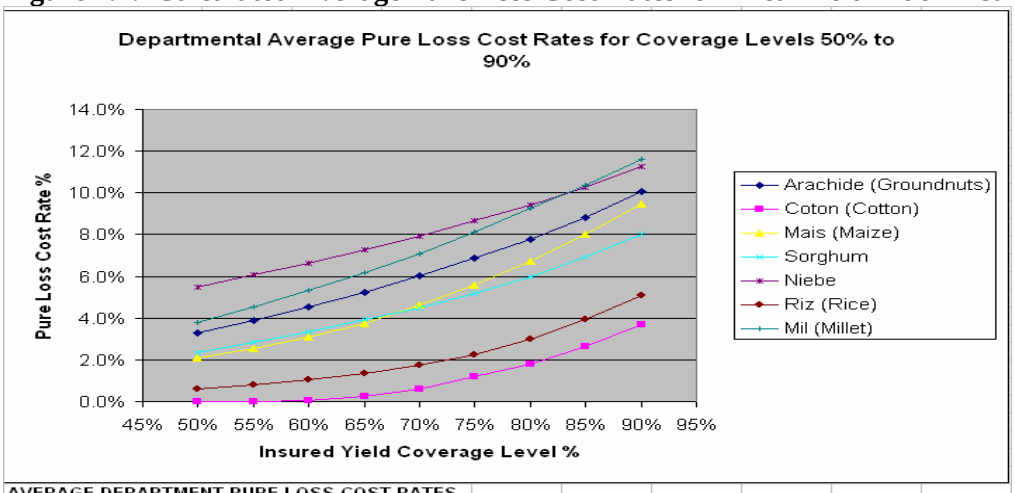


Average Pure Loss Cost Rates for Area-Yield Index Insurance

4.32 A summary of the average rates per crop is shown in Figure 4.4, and Technical Note 5 presents the pure loss cost rates for all crops in all departments at coverage levels of 50 percent up to 90 percent of trended yield. The highest average pure loss cost rates apply to cowpeas (niebe), and as previously recommended in this report it is not recommended to insure cowpeas under the Area-Yield Index Program. The next highest pure loss cost rates apply to millet and groundnuts with average loss costs of 11.6 percent and 10.1 percent, respectively, for 90 percent coverage, reducing to an average of 3.6 percent and 3.3 percent at 50 percent coverage. Average pure loss cost rates for maize and sorghum are somewhat lower.

4.33 The pure loss cost rates associated with cotton and rice are very low and less than 5.0 percent for 90 percent coverage levels, reducing to 0 percent loss cost at 60 percent coverage levels for cotton and less than 1 percent for rice. This is a reflection of the very stable yields in these 2 crops, and in the case of rice the fact that the crop is mainly irrigated. For rice and cotton it is possible to offer up to the maximum 90 percent insured yield coverage level in most departments at affordable premium rates. This analysis again shows the need to set insured yield coverage levels in relation to the exposure to yield loss for each crop in each Department.

Figure 4.4: Calculated Average Pure Loss Cost Rates for Area-Yield Index Insurance



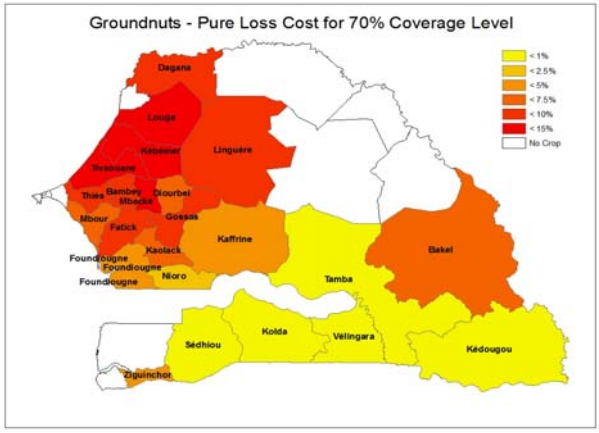
AVERAGE DEPARTMENT PURE LOSS COST RATES

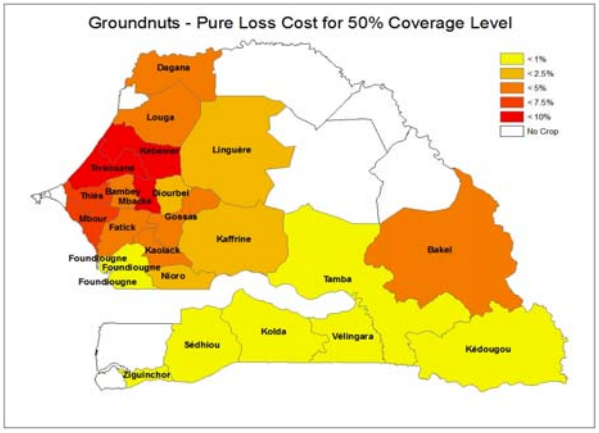
Coverage Level(%)	90%	85%	80%	75%	70%	65%	60%	55%	50%
Arachide (Groundnuts)	10.1%	8.8%	7.8%	6.9%	6.0%	5.3%	4.5%	3.9%	3.3%
Coton (Cotton)	3.7%	2.6%	1.8%	1.2%	0.6%	0.2%	0.0%	0.0%	0.0%
Mais (Maize)	9.5%	8.0%	6.7%	5.6%	4.6%	3.8%	3.1%	2.5%	2.1%
Sorghum	8.0%	6.9%	6.0%	5.2%	4.5%	3.9%	3.3%	2.8%	2.3%
Niebe	11.3%	10.3%	9.4%	8.6%	7.9%	7.3%	6.6%	6.1%	5.5%
Riz (Rice)	5.1%	3.9%	3.0%	2.2%	1.7%	1.3%	1.1%	0.8%	0.6%
Mil (Millet)	11.6%	10.4%	9.2%	8.1%	7.1%	6.2%	5.3%	4.5%	3.8%

Source: MARCS model (2008).

4.34 The distribution of calculated pure loss cost rates for groundnuts at 70 percent and 50 percent coverage levels are shown in Figure 4.5. These rates closely mirror the yield-rainfall pattern described in Chapter 3, with highest yield variability in the arid north, associated with high average pure loss cost rates greater than 10 percent at 70 percent coverage level, reducing to less than 5 percent average loss costs in the Groundnut Basin and less than 1 percent average loss costs in the most southern departments. A similar pattern applies to the pure loss cost rates for 50 percent coverage.

Figure 4.5: Groundnuts Pure Loss Cost Rates by Department (70 percent and 50 percent coverage)





Source: MARCS model (2008).

Minimum Pure Loss Cost Rates

4.35 Some crops in some departments exhibit extremely low variability in annual average yields over the past 22 years, and in these cases the calculated pure loss cost rates at coverage levels between 50 percent to 80 percent (and even 90 percent coverage) are often zero, or in other words there would never have been a claim on the Area-Yield policy. This applies especially to cotton and rice and also to groundnuts grown in the most southern departments. MARCS is therefore programmed to apply minimum pure loss cost rates for each crop and each coverage level varying from a minimum of 3.0 percent for 90 percent coverage down to 1.0 percent for 50 percent coverage (see Technical Note 5 for further details).

Loading Pure Premium Rates to Derive Commercial Premium Rates

4.36 The MARCS model calculates pure loss cost rates based on the 22-year average annual loss costs, which are subject to the minimum pure rates mentioned above.

4.37 The pure rates are then loaded to cover various cost components in order to derive final commercial premium rates which are paid by farmers (and possibly by the government through premium subsidies). The general formulae for developing the final premium rates include:

1) Pure loss cost rate + catastrophe load = Technical Rate (required to cover expected normal and catastrophe claims)

2) Commercial Premium Rate = Technical Rate + Profit Margin + Insurer's Administrative expenses + Acquisition Costs

4.38 Under the current study for the Area-Yield Index study, no formal technical analysis of the risk loading has been conducted. A loading should be added to the 22-year average pure loss cost rates to cover: (a) Catastrophe events; and (b) climatic change for each coverage level from 90 percent down to 50 percent of expected yield[23]. Furthermore, the detailed costing for the CNAAS's expected acquisition costs (brokerage or sales agents' fees) and administrative costs (underwriting costs and claims costs) and underwriters' and their reinsurers' profit margin expectations are not available.

4.39 For the above reasons, the current study assumes a target loss ratio of 55 percent for the Area-Yield Index Program and therefore the derivation of the illustrative commercial premium rates is given by:

Illustrative Commercial Premium Rate = Pure Loss Cost rate + 1 / (1-0.45), which is equivalent to a loading factor of 1.813 applied to the pure rates for each coverage level.

4.40 It should be noted that this is a conservative target loss ratio, and if cost savings can be achieved on acquisition and administration expenses, the gross-up factor/loading factor can correspondingly be reduced. The MARCS model allows the user to change the target loss ratio.

4.41 Table 4.2. provides one illustration of how the commercial premium rates might be built up, assuming the Area-Yield Index Program is reinsured under a proportional quota share treaty

[23] There are several possible approaches to calculating the catastrophe load which should be applied to the pure rate. Technical Note 5 contains a review of: (a) The World Bank 2006, India, Premium Ratemaking methodology for the NAIS Area-Yield IndexArea-Yield Index Program, and (b) World Bank Romania 2003.

arrangement. It is assumed that a load of about 35 percent is required to cover catastrophe losses and contingency reserves, giving a technical rate of 130 percent of the pure rate. A load of 12.5 percent has been applied to the technical rate to cover reinsurers' expenses and profit expectations, giving a net rate to reinsurers of 152 percent of pure premium. Finally, the net rate is grossed-up by 16.7 percent (equivalent to a load of 20 percent) for ceding commission to cover the CNAAS's acquisition and administrative expenses and which amount to a total cost load factor on pure premium of 30 percent[24]. The premium loadings will need to be refined during the detailed implementation planning phase for the proposed Pilot Area-Yield Index Insurance Program.

Table 4.2: Illustrative Build-up of Commercial Premium Rates with Gross-up 45 Percent (Load Factor 1.81) Applied to Pure Loss Cost Rates

Cost Item applied to pure rate	Type	Load Factor (Multiplication)	Gross-up*	Load applied to pure rate %
Final Commercial Premium Rate				**182%**
Ceding Commission	Gross-Up	0.20	16.7%	30%
Net Rate to Reinsurer				**152%**
Reinsurers Expenses + Profit	Load	0.125	11.2%	17%
Technical Rate				**135%**
plus Catastrophe Load	Load	0.35	25.9%	35%
Pure Loss Cost Rate				**100%**

* Note gross-up applied at each stage of premium build-up and does not add to 45%

Source: MARCS model (2008).

Indicative Commercial Premium Rates

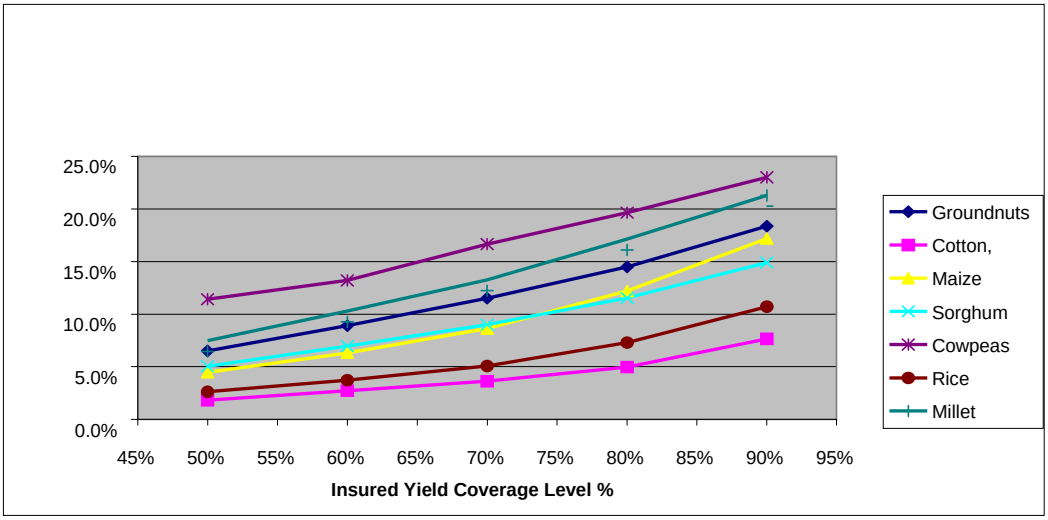
4.42 Technical Note 5 presents full details for all 6 crops of the departmental-level commercial premium rates with 45 percent gross-up (target loss ratio 55 percent) for each coverage level, and these rates are summarized for all crops in Figure 4.6.

4.43 The highest commercial premium rates are for cowpeas, with average departmental rates[25] for 90 percent coverage level which are greater than 20 percent and which only reduce to an average of about 12.5 percent for 50 percent yield coverage. This crop is not considered insurable under any pilot Area-Yield Insurance Program. The average commercial premium rates for millet are also very expensive at a 90 percent coverage level, and these reduce to about 7.5 percent average for 50 percent coverage. This is followed by groundnuts, sorghum, and maize with average departmental commercial premium rates of 15 percent at 90 percent coverage level, reducing to about 5 to 7.5 percent at 50 percent coverage level. Finally, commercial premium rates for cotton and rice are very much lower.

[24] The DA's 2007 Draft Technical and Financial Plan identifies possible acquisition costs of 10% of premium and administrative costs of 20%. If the program is marketed through producer associations or banks, it is assumed that cost savings can be made on acquisition costs.

[25] These rates are the simple average of the departmental rates for each crop at each coverage level.

Figure 4.6: Departmental Average Commercial Premium Rates for Target 55 Percent Loss Ratio



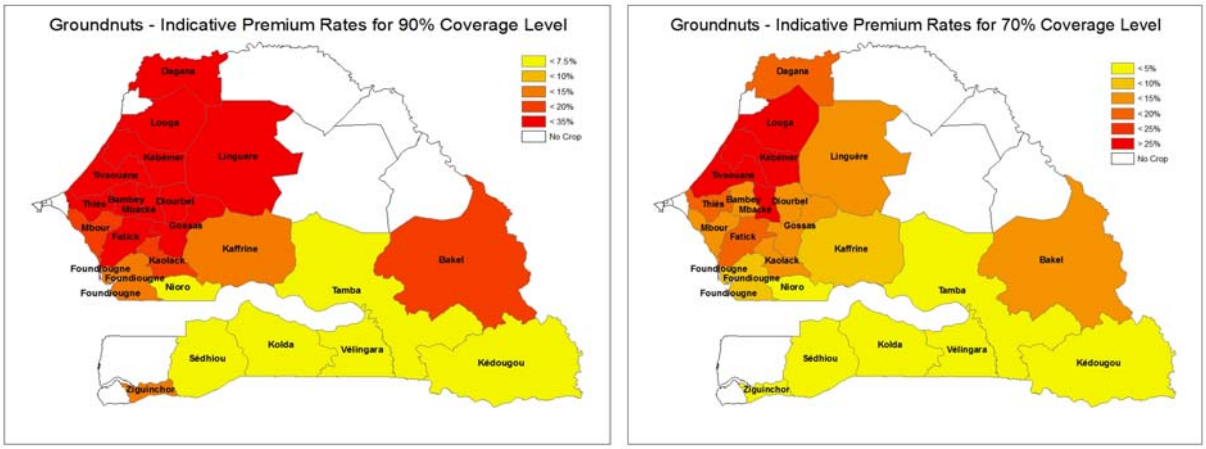
AVERAGE COMMERCIAL PREMIUM RATES WITH 45% GROSS-UP

Coverage Level (%)	90%	80%	70%	60%	50%
Groundnuts	18.4%	14.5%	11.5%	8.9%	6.5%
Cotton,	7.7%	5.0%	3.6%	2.7%	1.8%
Maize	17.2%	12.2%	8.6%	6.3%	4.5%
Sorghum	14.9%	11.6%	9.0%	7.0%	5.0%
Cowpeas	23.0%	19.6%	16.7%	13.2%	11.4%
Rice	10.7%	7.3%	5.1%	3.7%	2.6%
Millet	21.3%	17.1%	13.3%	10.3%	7.5%

Source: MARCS 2008

4.44 Under an Area-Yield Index Program the coverage level in each department should be set in accordance with: (a) Underlying risk exposure and frequency of payout which should not exceed 1 claim in every 5 to 7 years, and (b) the commercial premium rate which should not exceed 7.5 percent to 10 percent. Figure 4.7 shows the distribution of indicative commercial premium rates for groundnuts in all departments for different coverage levels of 90 percent and 70 percent. Very few departments can achieve a premium rate of less than 10 percent at 90 percent coverage level, and these are located exclusively in the South of the country. At a 70 percent coverage level the average rates in the Groundnut Basin are in the order of 3.5 percent to 7.5 percent, but most of the northwestern departments could only be insured at the 50 percent coverage level to achieve average rates of less than 10 percent; Indicative Commercial Premium Rates for all crops and coverage levels are given in Technical Note 5.

Figure 4.7: Groundnuts: Indicative Commercial Premium Rates by Department 90 Percent and 70 Percent Coverage Levels



Source: MARCS 2008.

Criteria for Selection of Crops and Departments

4.46 **Crop Selection**. It is recommended that the Pilot should be restricted to the two principle crops grown in Senegal, millet as a strategic food crop, and groundnuts as a food and cash crop, both of which are widely grown by farmers.

4.47 **Department Selection**. In order to ensure the success of a pilot program it is recommended that the selection of departments should focus on relatively stable, high yielding millet and groundnut departments in the Groundnut Basin and or South of the country rather than starting with the high risk, drought prone departments in the North of Senegal. The recommended selection criteria include:

- Stable rainfall regime to achieve normal average yields of about 800 kg/H for millet and 1,000 kg/ha for groundnuts;
- Relatively homogeneous agro-climatic regime and farming systems so that basis risk is minimized. Here the pilot project technical team should analyze past CCE yield data to verify whether basis risk is an issue or not;
- Relatively stable agricultural production and yields so that coverage levels of between 60 percent and 80 percent of insured yield can be offered to farmers at commercial premium rates of between 5 percent and 10 percent maximum;
- Farmer access to input supplies and financial services so that key constraints to crop production center on weather-related risks as opposed to lack of timely access to inputs and or other management-related problems; and
- Fully resourced local DRDR/DAPS branch offices whose staff is involved in the CCEs to ensure that actual yields are measured accurately and in a timely fashion in order to settle any insurance claims on time.

4.48 On the basis of this feasibility study, the Nioro Department meets all the above criteria, and it is recommended that this Department be selected for a Pilot Area-Yield Project for millet and groundnuts. Other possible departments for consideration may include Kolda and Sédhiou. Kaffrine and Tamba are considered too large for the effective operation of an Area-Yield Index

Program because of the issue of basis risk, unless it is possible to subdivide these departments into smaller geographic regions.

Illustrative Portfolio Estimates

4.49 To date no Area-Yield crop insurance demand studies have been conducted in the possible pilot project departments of Nioro, Kolda, and Sédhiou. At this stage therefore, any portfolio modeling is purely hypothetical and will require validation in the implementation planning phase. Using the MARCS model, several scenarios have been modeled, assuming 5 percent and 10 percent uptake of millet and groundnuts 3-year sown area in these 3 provinces and with an assumed coverage level of 70 percent of trend yield and maximum 80 percent of trend yield. The results are summarized in Table 4.3, and further details are presented in Technical Note 5. For an assumed uptake rate of 5 percent of groundnut and millet cultivated area in the 3 pilot departments and coverage level of 70 percent, insured area would amount to about 14,000 ha with TSI of FCFA 1.4 billion (US$ 3.0 million) and with Illustrative Commercial Premiums of FCFA 53.2 million (US$ 118,000). For the higher demand level of 10 percent of cultivated area and maximum 80 percent coverage level, TSI would increase to FCFA 3.1 billion (US$ 6.9 million) and estimated premiums to FCFA 161 million (US$ 360,000).

Table 4.3: Illustrative Pilot Portfolio Projections for Groundnuts and Millet

Area-Yield Pilot Portfolio Projections: 5 Percent Uptake Rate and 70 Percent Coverage Level

Department	Crop	Total Area (Ha)	Insured Area (Ha	Sum Insured (FCFA)	Premium (FCFA)	Claims (FCFA)	Average Premium Rate percent	Loss Ratio percent
Nioro	Groundnuts	76,549	3,827	436,700,682	19,377,987	10,657,893	4.4%	55.0%
	Millet	62,390	3,120	241,441,331	8,779,685	3,862,643	3.6%	44.0%
Kolda	Groundnuts	46,591	2,330	300,577,718	10,930,099	0	3.6%	0.0%
	Millet	18,136	907	61,821,103	2,248,040	375,004	3.6%	16.7%
Sédhiou	Groundnuts	45,349	2,267	224,624,367	8,168,159	2,242,540	3.6%	27.5%
	Millet	30,884	1,544	92,467,177	3,693,216	2,031,269	4.0%	55.0%
Total Portfolio		**279,900**	**13,995**	**1,357,632,378**	**53,197,185**	**19,169,349**	**3.9%**	**36.0%**

Area-yield Pilot Portfolio Projections: 10 percent uptake rate and 80 percent coverage level

Department	Crop	Total Area (ha)	Insured Area (ha)	Sum Insured (FCFA)	Premium (FCFA)	Claims (FCFA)	Average Premium Rate percent	Loss Ratio percent
Nioro	Groundnuts	76,549	7,655	998,172,988	53,814,811	29,598,146	5.4%	55.0%
	Millet	62,390	6,239	551,865,900	29,828,761	16,405,819	5.4%	55.0%
Kolda	Groundnuts	46,591	4,659	687,034,783	31,228,854	4,371,034	4.5%	14.0%
	Millet	18,136	1,814	141,305,379	6,422,972	1,590,489	4.5%	24.8%
Sédhiou	Groundnuts	45,349	4,535	513,427,124	23,337,597	10,101,125	4.5%	43.3%
	Millet	30,884	3,088	211,353,547	16,120,049	8,866,027	7.6%	55.0%
Total		**279,900**	**27,990**	**3,103,159,721**	**160,753,043**	**70,932,640**	**5.2%**	**44.1%**

Source: MARCS 2008.

Organization and Operation of Pilot Area-Yield Programs

4.50 The details of the proposed Area-Yield Index Pilot Project should be further developed by the key Senegalese stakeholders. The following options could be considered:

- The Pilot Project could be implemented by the CNAAS and or by private insurers;
- The Technical Assistance Unit which is recommended for the Weather Index Pilot Insurance Program (see Chapter 5) would also act as the center of technical expertise for the planning and implementation of the Pilot Area-Yield Index Program in Nioro, Kolda, and Sédhiou Departments;
- Farmers' organizations and agricultural credit banks with local rural branch networks would play an active role in marketing and promoting and administering the crop insurance program;
- The DRDR would play a very important role in monitoring implementation of the pilot Area-Yield Project and in conducting farm surveys and CCE yield measurements in the insurance period;
- International technical assistance would be required to assist the local insurance authorities to finalize the planning and design and rating of the Area-Yield Index product and then in assisting in the implementation of the pilot project; and
- An insurance and reinsurance program should be put in place to protect CNAAS or the implementing agency against major yield losses.

Conclusions

4.51 Area-Yield Index Insurance is technically feasible in Senegal. DAPS/DRDR have a statistically designed and comprehensive system of annual area-yield measurements through sample CCEs, which are conducted for the major crops in each department. Area-yield insurance coverage should only be offered for the main crops for which CCEs are conducted; minor crops where yield measurement is based on visual estimation techniques cannot be considered for the pilot program.

4.52 Crop and Department selection should first involve an analysis of past CCE results to verify whether intra-departmental average yields are so high that basis risk would pose a major problem to the successful implementation of the program. On the basis of the preliminary investigations conducted in this report, Nioro, Kolda, and Sédhiou appear to have stable yields for the main crops of groundnuts and millet; basis risk does not appear to be a problem, and these crops and departments are recommended for consideration under an Area-Yield Crop Insurance Pilot Project.

4.53 Planning for the Pilot Project should commence in 2008 in order to ensure that all technical, organizational, operational and financial components of the Project are completed and ready for the Pilot to be launched in the 2009/10 cropping season. The success of this Project will be highly dependent on the support of all public and private sector stakeholders.

4.54 The Program should be launched on a strictly pilot basis and expanded over time once experience has been gained, to cover new crops and new departments.

Chapter 5. Weather Index Based Crop Insurance for Senegal

5.1 This chapter briefly reviews the international experience on weather-based crop insurance and then investigates the feasibility of a pilot project to test weather index insurance in Senegal. It discusses the technical, operational, financial, and institutional challenges associated with the development and implementation of a pilot weather index based crop insurance program in Senegal.

International Experience with Weather Index Based Crop Insurance

5.2 Index insurance is a simplified form of insurance, where payments are made based on an index, rather than measurement of crop loss in the field. The index is selected to represent, as closely as possible, the crop yield loss likely to be experienced by the farmer.

5.3 The most common application of weather index insurance is against drought, where rainfall measurements are made at a reference weather station(s), during defined period(s), and insurance payouts are made based on a pre-established scale set out in the insurance policy. The sum insured is normally based on production costs.

5.4 The origins of weather index insurance come from the international weather derivative market, where major corporations hedge weather risks. The interest in index insurance applications for agriculture grew from a realization that traditional insurance programs (especially Multiple Peril Crop Insurance, MPCI) carried major challenges in developing countries, where agricultural sectors are semi-commercialized and farm size is small. Traditional individual farmer MPCI programs are only considered as feasible for large-scale farms, where high levels of technology are adopted.

5.5 There is major international interest in this product, but so far it has only moved from pilot scale to commercial implementation in India and Mexico. In Malawi, after intensive capacity building work it is expanding in scope and product type. Many other countries, such as Thailand; Indonesia; Guatemala; Nicaragua; Honduras; Tanzania; Kenya; Ethiopia; and Nepal are developing or testing this product in pilot programs for agriculture. There is a diversity of structures from micro (farmer level) to macro (regional and national level) indices. Index insurance at an aggregated level is used in Mexico, to insure state governments' emergency responses to assist farmers in drought years. Livestock mortality index insurance has been introduced in Mongolia. In developing countries, much of this development work has been initiated by the World Bank and, in Ethiopia, by the World Food Program in partnership with the private insurance and reinsurance industry.

5.6 The most relevant experience for Senegal comes from Malawi, where micro-level index insurance has been developed for groundnuts, maize, and tobacco. Technical Note 7 describes experiences from Malawi, as well as from India and Mexico.

5.7 Key findings from international experience with weather index insurance are shown in Box 5.1., and key advantages and constraints are shown in Box 5.2.

Box 5.1: Key International Experiences in Weather-Index Insurance

1. Types of hazards covered by index insurance: The most important hazard for which weather index insurance has been developed is for drought (rainfall deficit). Index insurance is particularly promising for slow-onset hazards (such as drought), as opposed to a sudden-event hazards (such as frost, or windstorm; see Technical Note 6).

2. Types of crops covered by index insurance: The most important crops for which index insurance has been developed are for annual rain-fed, field-scale crops (e.g. cereals, oilseeds, fiber crops). Nevertheless, index insurance is under development internationally for a wide range of annual and perennial crop types; see Technical Note 6.

3. Drought contract design in 3 plant growth phases: Standardization of product design has been achieved through experience. The timing of rainfall during a growth season is equally important as the total amount for the final yield outcome. Index contracts for drought divided into three phases (establishment/vegetative phase; flowering/reproductive phase; and grain filling/ripening phase) allow improved index correlation with yield, whilst still allowing a product which can be understood by the farmer. Further details are given in section 4, and for Senegal, are explained in a brochure in Technical Note 6.

4. Use of weather station measurements for weather index insurance: The simplest form of weather index insurance uses primary weather parameters (principally rainfall), measured at specific weather stations, to form the index.

5. Weather observing infrastructure and data: An adequate recording station network and historical data, in terms of length (typically 20 years minimum daily records), and quality (few missing data) are needed. Experience, even in LDCs, shows there are usually enough weather stations and data to begin piloting initiatives. However the ultimate reach of any index-based weather insurance program may be extended by addition of additional automated rainfall stations.

6. Scalability: Weather index insurance is not a universal product, and may be difficult to scale up rapidly. For drought insurance, product design and appropriate parameters need to be adapted to location and crop type. A high degree of input is required to design and adapt the product, but the advantage is that the operational distribution and management requirements of the product is very much reduced, compared to conventional MPCI insurance.

7. Linkage of index insurance to input supply and credit is effective: The experience of Malawi and other countries is that demand for weather-index insurance from farmers is high, where there is an integrated "package" approach to increasing farmer productivity, which addresses constraints such as access to quality seed, and credit, within the supply chain.

8. Stakeholder groups: Implementation of pilot programs requires that a high degree of attention is required to stakeholder participation, and leadership. Local ownership and capacity building are central to creating sustainable programs.

9. Farmer education and extension: Education efforts are critical for both stakeholders, and for farmers. A key is the design of simple contracts which are easy to communicate to customers.

10. Risk layering and reinsurance: The insurance sector is often receptive to the advantages of index insurance products, in enabling them to reach new markets through appropriate and transparent products, but remain concerned over the catastrophic nature of weather risk (and weather trends). Risk layering can structure financial protection through the reinsurance market and, if required, through government intervention for extreme events.

Source: Authors.

Box 5.2: Summary of Advantages and Challenges of Index Insurance

Advantages	Challenges
Less moral hazard The indemnity does not depend on the individual producer's realized yield. ***Less adverse selection*** The indemnity is based on widely available information, so there are few informational asymmetries to be exploited. ***Lower administrative costs*** Does not require underwriting and inspections of individual farms. ***Standardized and transparent structure*** Uniform structure of contracts. ***Availability and negotiability*** Standardized and transparent, could be traded in secondary markets. ***Reinsurance function*** Index insurance can be used to more easily transfer the risk of widespread correlated agricultural production losses. ***Versatility*** Can be easily bundled with other financial services, facilitating basis risk management.	***Basis risk (note 1)*** Without sufficient correlation between the index and actual losses, index insurance is not an effective risk management tool. This is mitigated by self-insurance of smaller basis risk by the farmer; supplemental products underwritten by private insurers; blending index insurance and rural finance; and offering coverage only for extreme events. ***Precise actuarial modeling*** Insurers must understand the statistical properties of the underlying index. ***Education*** Required by users to assess whether index insurance will provide effective risk management. ***Market size*** The market is still in its infancy in developing countries and has some start-up costs. ***Weather cycles*** Actuarial soundness of the premium could be undermined by weather cycles that change the probability of the insured events (i.e. El Niño events). ***Microclimates*** Make rainfall or Area-Yield Index based contracts difficult for more frequent and localized events. ***Forecasts*** Asymmetric information about the likelihood of an event in the near future will create the potential for intertemporal adverse selection.

Source: World Bank (2005)[26]

Note 1: Basis Risk: Since index-insurance indemnities are triggered by exogenous random variables, such as area-yields or weather events, an index-insurance policyholder can experience a yield or revenue loss and not receive an indemnity. The policyholder may also experience no yield or revenue loss and still receive an indemnity. The effectiveness of index insurance as a risk management tool depends on how positively correlated farm yield losses are with the underlying index.

[26] World Bank, *Managing Agricultural Production Risk: Innovations in Developing Countries*, 2005.

Pilot Projects

5.8 The feasibility of a Pilot Project to test weather-index insurance in Senegal has been investigated. The objectives of the Pilot Program, in preparation and implementation phases, are:

- To develop and test a weather index insurance product adapted to specific crop(s) in specific location(s);
- To design the organizational structure needed to underwrite and to deliver the product;
- To form a stakeholder group, composed principally of insurer, distribution, and technical support organizations;
- To set up extension services to farmers;
- To test the insurance scheme for up to 3 years;
- To evaluate and adjust the product, and organizational arrangements; and
- To set up a plan for national scaling up, if the outcomes of the pilot are positive.

5.9 Groundnut was proposed as the crop to be insured under the Pilot. Groundnut in Senegal is an important commercialized crop for domestic and export markets. Further, the crop was already part of a program supported by the World Bank, the Projet des Services Agricoles et Organisations des Producteurs (PSAOP), which aims to strengthen the sector by overcoming identified constraints faced by farmers in growing and marketing this crop, notably the availability of quality seeds, the availability of other inputs such as fertilizer, and the availability of credit. Agricultural insurance (including weather index insurance) can have a positive impact when linked to improvements in other components constraining production. It is unlikely to have benefits to farmers if offered as a "stand-alone" product. Hence, linkage to the PSAOP provides the best opportunity to deliver the benefits of market-based insurance to farmers. Farmers face significant constraints to groundnut production, such as quality seeds and timely fertilizer supply, and drought risk is only one of a series of challenges faced by farmers.

5.10 Following discussions with ASPRODEB, as project management unit for the PSAOP, Nioro and Gossas were identified as fitting the required criteria in respect of a South and North location, respectively. Options for a middle rainfall area were Kaolack or Kaffrine. It was determined that Kaffrine, specifically the CLCOP of Kahi, had better opportunities as the third pilot location. In particular, there were active farmers' organisations (OPs), more active groundnut production, and the CLCOP had participated with a quality groundnut production program in 2007.

5.11 A field mission was conducted in January 2008, during which it was determined that Gossas presented some difficulties for inclusion in the pilot. In particular there were significantly more constraints in input supply, credit was problematic, and the location of the proposed Centrale d'Achat at Ndiago was too far from the official weather station at Gossas. Later, it was found that design of an index product for Gossas was problematic on technical grounds (see Technical Notes 6 and 10). Finally, it was determined that the pilot locations should be restricted to two: The Pascotto district of Nioro, and the Kahi district of Kaffrine.

Weather Index Based Crop Insurance Product Design and Pricing

Index-Based Contracts for Farmers in Practice

5.12 Designing contracts that are simple to understand and that are based on parameters familiar to a farmer, such as cumulative rainfall, facilitates the farmer's decision making and the marketing process. In addition, contracts must also be standardized as much as possible from station to station so that the contracts can be easily replicated and retailed to farmers living in the different locations. A procedure for designing standardized deficit-rainfall insurance contracts for smallholder crop farmers, developed by the World Bank, has been adapted to the context of Senegal in collaboration with the CERAAS (see Technical Note 10). The simple contracts have the following features:

- A **dynamic start date** that mimics the decision a farmer would take as to when to sow his crop[27];
- **Three or more phases** depending on the length of the crop growing period, during which cumulative rainfall is measured, with a trigger and exit levels in each phase. The trigger level determines the level at which compensation would begin for the farmer, i.e. if the cumulative rainfall measured during the phase dropped below this trigger, the farmer would begin to receive a fixed payout per mm, for every mm that the cumulative rainfall recorded was below the trigger level. These trigger levels correspond to rainfall levels at which the crop would begin to feel water-deficit stress. The exit level determines the level at which the farmer would receive a maximum payout, i.e. if the cumulative rainfall measured during the phase dropped below this exit level, the farmer would receive the entire limit (sum insured) for that phase as it is assumed his crop would have failed or would have been permanently damaged. Hence, the cumulative rainfall totals per phase are the underlying indices for these contracts.
- **A payout rate per phase**, i.e. the payout rate per mm if the recorded cumulative rainfall in each phase falls in between the trigger and exit levels.

5.13 The three-phase weather insurance contract design was pioneered by the Indian insurance company ICICI Lombard and sold to farmers for the first time in 2004. The design proved to be popular with groundnut and castor farmers in Andhra Pradesh and farmers of other crops, as well as intermediaries who found the contracts easy to communicate and retail to farmer clients. Hence the design was chosen as the prototype groundnut structure for the first Malawi pilot in 2005 and subsequent African pilots. It is also being used in Central America. From a design point of view the contract structure has the advantage that its key features are easy to calibrate and relate to local agro-meteorological parameters and expertise without having to communicate technical details of crop models to farmer clients, as will be explained below. The contract design is appropriate for the non-humid tropics, where meteorological drought is a potential risk and for rain-fed field crops that are susceptible. As Senegal and groundnuts fall into this category, the three-phase contract structure was also chosen for the pilot locations in Nioro and Kaffrine.

[27] In order to the capture events on the ground as well as possible, an agricultural weather insurance contract should begin in the sowing window when the farmer sows his crop. As the key feature of such insurance contracts is that they are index-based, rather than being based on field inspections, an objective method must be defined to identify the timing of a farmer's sowing decision. In Senegal, assuming a farmer acts rationally, he will sow his crop once the rainy season begins and when there is enough moisture in the soil to plant his crop and secure good probability of seed germination. This decision can be related to an amount of rainfall received within a fixed period of time, a rainfall trigger, at a given location.

Setting Contract Parameter Values

5.14 Having chosen the overall contract structure, the remaining steps of the contract design process involve setting the key parameters of the contracts. These parameters must reflect the specific groundnut variety chosen for insurance, and the local meteorological and growing environment conditions of each location, so that the contracts perform an insurance function for the farmer and at a premium rate he can afford. This process of parameter setting must also be transparent so that it satisfies regulatory requirements and each choice can be justified, and so that the process can be communicated and transferred to local actors who will be running these programs in the future.

The Contract Parameters

5.15 For the three-phase contact design the following parameters have to be set for each crop and each location:

- **Sowing Window:** The time window within which a farmer should plant his crop.
- **Rainfall Sowing Trigger:** The farmer's decision to sow is defined by when X mm or more of cumulative rainfall is recorded within a dekad[28] at his reference weather station. The rainfall sowing trigger therefore is the first opportunity within the sowing window that this sowing definition is satisfied, i.e. the first dekad where rainfall recorded at the weather station is X mm or more.
- **Phase Lengths**: The growing cycle of the crop must be broken down into three phases ,which correspond to the three major phenological stages of the plant's growth that have distinct water stress response characteristics. In the case of groundnut these are: Phase 1 – Establishment, Phase 2 – Vegetative Growth & Flowering, and Phase 3 – Yield Formation & Ripening.
- **Phase Trigger Levels, $T_{1,2,3}$:** The levels of cumulative rainfall received per phase below which the insurance compensation begins for a farmer.
- **Phase Exits Levels:** The levels of cumulative rainfall received per phase, below which a maximum payout per phase is made to the farmer. The levels are set to represent a critical amounts of minimum rainfall that represent levels at which the crop is severely water stressed, which either leads to crop failure or a situation where it is no longer economically viable for a farmer to continue tending this crop due to the damage incurred.
- **Maximum Payouts per Phase, $M_{1, 2, 3}$:** The maximum payout, in CFA Francs, received per farmer per hectare insured, if the cumulative rainfall total received in a phase is less than or equal to the phase exit level set for that phase.
- **Maximum Payouts per Contract, M:** The total payout of the insurance contract is capped at a maximum payout level per hectare in CFA Francs. Usually, this level is equal to the maximum payout of Phase 3.
- **Ticks per Phase, $N_{1,2,3}$:** The fixed payout or "tick" per mm the farmer receives per hectare, for every mm that the cumulative rainfall per phase recorded drops below the trigger level for that phase, defined as follows:

[28] A 10-day period, see Technical Note 6 for definition.

Tick per Phase = Maximum Payout per Phase/(Trigger Level per Phase – Exit Level per Phase)

- **Rainfall Cap:** As the contract is designed to protect against water deficit – and as a crop can only use, and the soil only store so much water – the cumulative dekadal rainfall recorded during each of the dekads in the growing period must be capped at some level, before being used in the contract payout calculation (see below). This is so that excessive rainfall[29], that would not be used by the plant and would result in soil runoff, does not contribute or detract from the water-deficit compensation of the structure design, i.e.

Capped Dekadal Rainfall = min(Y, Dekadal Rainfall)

where Y mm is the excessive rainfall dekadal cap. The contract payout calculation is therefore explicitly defined as follows:

$$\text{Payout per hectare} = \max [M, \max (M_1, \max [0, T_1 - R_1] * N_1) + \max (M_2, \max [0, T_2 - R_2] * N_2) + \max (M_3, \max [0, T_3 - R_3] * N_3)]$$

where $R_{1,2,3}$ is the total cumulative capped dekadal rainfall received per phase, and each phase's start and end date is defined with respect to the sowing dekad[30], as defined by the rainfall sowing trigger in the specified sowing window. If the rainfall sowing criterion is not met, the contract automatically starts on the last dekad of the sowing window.

Fixed and Variable Parameters

5.16 In practice, the sowing window, rainfall sowing trigger, phase lengths, dekadal rainfall cap, and exit levels are set by local experts to reflect specifics of the crop in question, the local soil and climatological conditions, and the best practices and recommendations for growing that particular crop in a specific area (see Technical Note 6). The maximum payouts per phase are determined by the financial context within which the insurance contract is used by the farmer (see Technical Note 6), but are usually set to reflect the cumulative input and production costs incurred by the farmer per phase. Therefore, the only variable parameters than can be adjusted by the contract designer to arrive at a contract that offers the required protection at an affordable price are the trigger levels, as the tick values will be specified in terms of these levels, the exit levels, and maximum payouts.

5.17 The setting of the triggers must be guided by the following considerations. First, they must be set at levels where the crop actually feels water stress. As this is an insurance contract, the levels cannot be sets arbitrarily but must be related to an actual rainfall-related loss of the farmer. From a cost consideration perspective a weather insurance contract, however, is not designed to guarantee the maximum possible yield for the farmer; rather it is there to protect against severe events that can cause serious or total yield losses. In other words, there is some element of risk retention, or self-insurance, by the farmer for the small and frequent losses that result in a crop not reaching its full optimal yield potential, yet nevertheless producing satisfactory overall yields for the farmer's business to break-even or for him to be able to pay off his production loan. Therefore, although the initial triggers per phase in the design process may be related to rainfall levels where the crop is expected to feel water stress (see Technical Note 6),

[29] As a result of a localized storm.
[30] The sowing dekad is taken to be the first dekad of Phase 1.

often these levels have to be adjusted down to create a contract that is affordable to the client farmer.

5.18 To study the agro-meteorology of groundnut varieties in question and the impact of water stress on yields to set the trigger levels of the insurance contracts, the project used CERAAS/CIRAD's Sarrabil©Cirad water balance crop model, to index groundnut crop yield and therefore production to rainfall variability. A more detailed description of the model is given in Technical Note 10. The advantage of using a model such as the Sarrabil©Cirad is that as it can be set to use rainfall as the only variable input parameter. Therefore, by using historical rainfall data from a weather station, one can observe the impact due to rainfall deficit and deviation only on a crop's yield from year to year. In other words, the model does not capture other aspects that can impact yield levels, such as management practices, input supply, technological changes, and pest attacks. By considering the variations in the Sarrabil©Cirad model output from the long-term average, from the previous year or some other baseline, one can quantify the relative difference in yield from that baseline due to the impact of rainfall alone. It is this quality that we can exploit to inform the trigger setting of weather insurance contracts.

5.19 It is important to note that other production risks, in addition to deficit rainfall risk, are captured in the historical yield data, and because of this, using historical yield data can lead to misleading results when one is trying to quantify the risk and impact of only rainfall on a crop's performance. The yield data for groundnut in the Kaffrine and Nioro Departments has a relatively long history (1980-2007), and it captures the yields of several different varieties of groundnuts and different sets of farmers. It also covers large geographical areas represented by the districts, which may experience different weather patterns in a given season. Further, the inter-annual variability in the records represents the entire spectrum of risk to smallholder groundnut production over the past 27 years in the two areas. Therefore, although department-level yield data is one information source that is available to assist in contract design, it is not the best choice to optimize a contract using this information when a specific indicator, such as the Sarrabil©Cirad output – based on a model that has been verified for and used to model groundnut production in the Basin d'Arachide – is available for the two weather station locations for a longer period of time[31].

Adjusting the Trigger Levels

5.20 To adjust the trigger levels from the initial water stress level starting points, an optimization process is used. The phase-wise triggers of the prototype contract are adjusted up and down so that the contract performs as well as possible, given a target premium rate. The performance of the contract is judged by how well the historical payouts of each phase trigger level combination contribute to reducing a farmer's overall income loss exposure to deficit rainfall risk. The annual farmer's income per hectare is assumed to be equal to the yield predicted by the Sarrabil©Cirad model, multiplied by the expected sales price of the groundnut, less his estimated input and production costs (and financing costs if he has taken credit). A loss year is defined as a year when a farmer's income drops below average; years when his income is at or above average are not considered. Therefore, contract options are judged by how well payouts from them match loss years in terms of occurrence and magnitude. For a given premium rate, the best contract is deemed to be the one where payouts and loss years agree best, and therefore the worst case scenarios for the farmer are best managed by the mitigating insurance payouts.

[31] For 1950-2007 for Nioro and for 1960-2007 for Kaffrine.

5.21 This optimization process can be carried out by using a numerical optimization engine. It can also be done manually as often it is very clear which trigger level in which phase is contributing to the cost of the insurance but not performing well from a risk management point of view. Therefore, the designer will be able to see which trigger should be brought down and perhaps which other trigger levels could be moved up to ensure the premium price does not go above the target level, but the contract performs more efficiently in terms of capturing loss years through contract payouts and minimizing the farmer's overall exposure.

5.22 A product designer should also keep payout frequency as well as premium in mind when setting the triggers[32]. Although frequent payouts may be desired by farmer clients, they are more expensive to administer for the insurer. Once a prototype contract is chosen, it should also be compared against the historical department data to ensure the contract also performs well against that dataset. If the contract were to perform badly against events represented in the historical yield data set, stakeholders should be comfortable with the reasons for this lack of performance before accepting the contract.

The Prototype Contracts for Kaffrine and Nioro

5.23 Using the design process outlined above, and a target technical premium rate of 10 percent, the following contract parameters were chosen for the Kaffrine and Nioro prototype contracts for groundnut variety 73-33.

Table 5.1: Nioro Prototype Contract (per hectare)

Parameter	**Value**		
Sowing Window	Dekads 17-20[33] (inc)		
Rainfall Sowing Trigger (mm)	30		
Rainfall Cap (mm/dekad)	70		
	Phase 1	Phase 2	Phase 3
Phase Lengths (dekads)	3	4	3
Phase Trigger Level (mm)	55	155	40
Phase Exit Level (mm)	20	30	5
Phase Tick (FCFA/mm)	3671	1144	4571
Phase Maximum Payout (FCFA)	128,500	143,000	160,000
Contract Maximum Payout (FCFA)	160,000		
Indicative Technical Premium (FCFA)	15,800 (9.9%)		

Source: Authors.

[32] The use of triggers and exits that are specified to a high level of precision may incorrectly suggest that the data sources driving the analysis and the contract itself are more precise than they actually are. Therefore triggers and exists should be rounded to the nearest 5mm.

[33] Dekad 17: 11th-20th June; Dekad 18: 21st-30th June; Dekad 19: 1st-10th July; Dekad 20: 11th-20th July. Therefore the sowing window for Nioro for groundnut variety 73-33 is 11th June-20th July.

Table 5.2: Kaffrine Prototype Contract (per hectare)

Parameter	Value		
Sowing Window	Dekads 17-20[34] (inc)		
Rainfall Sowing Trigger (mm)	30		
Rainfall Cap (mm/dekad)	70		
	Phase 1	Phase 2	Phase 3
Phase Lengths (dekads)	3	4	3
Phase Trigger Level (mm)	50	150	40
Phase Exit Level (mm)	20	30	5
Phase Tick (FCFA/mm)	4283	1192	4571
Phase Maximum Payout (FCFA)	128,500	143,000	160,000
Contract Maximum Payout (FCFA)	160,000		
Indicative Technical Premium (FCFA)	15,800 (9.9 %)		

Source: Authors.

5.24 In tables 5.1 and 5.2., the "Indicative Technical Premium" does not include administrative costs of the insurance company. The following table shows how the contracts perform against a range of indicators of historical groundnut yield. The historical payouts are shown in Figure 5.1 and Figure 5.2 below for the two stations.

Table 5.3: Contract Performance

Performance Indicator	Nioro	Kaffrine
Correlation of Payouts to Sarrabil©Cirad Model	-66%*	-60%*
Correlation of Payouts to Department Yield	-71%*	-22%
Payout Frequency	16%	17%
Farmer's Worst Income Year without Contract (Net Income per Hectare that Year)	2002 (-11,875 FCFA)	1997 (-35,508 FCFA)
Contract Maximum Payout Year (Contract Payout)	2002 (126,412 FCFA)	1997 (107,081 FCFA)
Farmer's Exposure (Uninsured Scenario)[35]	-11,875 FCFA	-35,508 FCFA
Farmer's Exposure (Insured Scenario)[36]	4879 FCFA	-24,437 FCFA
percent False Negative Predicted by Contract[37]	0%	4%
percent Poor Years Missed by Contract (+)	0%	6%

Note: (*) values are statically significant at the 99 percent confidence level.
(+)Years where Sarrabil©Cirad model is below 90 percent of long-term average.

Sources: Authors.

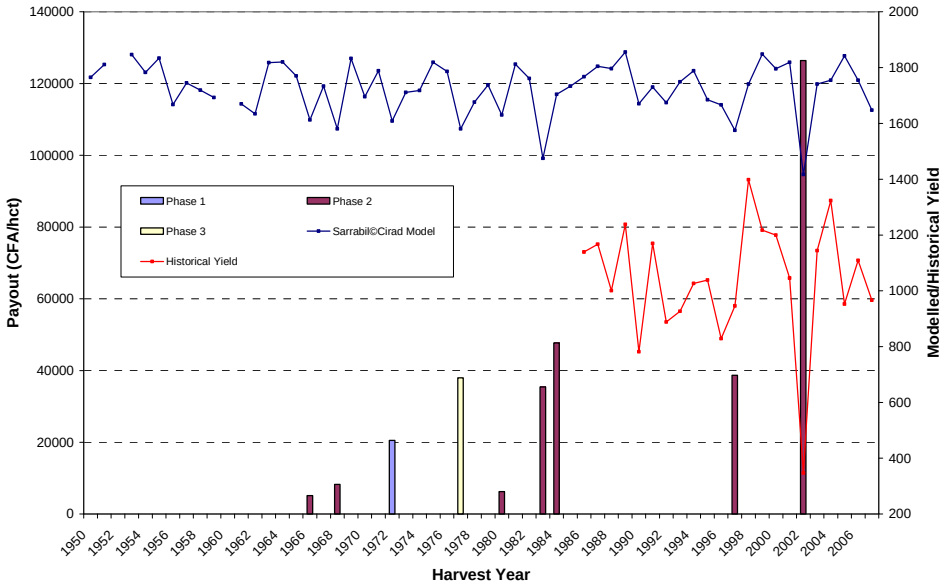
[34] Ibid.
[35] Worst income year experienced by farmers from 1960-2007 (Kaffrine) or 1950-2007 (Nioro), where income is defined each year as the yield predicted by the Sarrabil©Cirad model, multiplied by today's expected sales price of the groundnuts, less his input and production costs per hectare.
[36] Worst income year experienced by farmers from 1960-2007 (Kaffrine) or 1950-2007 (Nioro), assuming he had bought insurance every year, where income is defined as the yield predicted by the Sarrabil©Cirad model, multiplied by today's expected sales price of the groundnuts, less his input and production costs per hectare, less the annual premium cost.
[37] False negative indicates years in which a payout is predicted although the model estimates that a farmer's income does not drop below average.

5.25 Table 5.3 shows that the Nioro contract performs better than the Kaffrine contract against the range of indicators. Payouts from the contract exhibit a stronger correlation to the Sarrabil©Cirad model output and historical department-level yield data and trigger a payout in every one of the eight worst years, as predicted by the Sarrabil©Cirad model. The contract also performs very well in reducing the farmer's overall income exposure to drought risk. Had the farmer bought the insurance every year for 15,800 FCFA per hectare since 1950, his worst income year would have been 4,879 FCFA, compared to -11,875 FCFA without insurance. Therefore, although the farmer's average annual income is less when paying an annual premium cost, the catastrophic risk he runs is significantly reduced.

5.26 The payouts from the Kaffrine contract correlate well against the Sarrabil©Cirad model output, but not well against the historical department level yield data. This is discussed further in Technical Note 6, but this discrepancy is most likely to come from the fact that the Kaffrine department covers are large geographical area which can experience inhomogeneous weather patterns in any one season. Therefore, weather events at the Kaffrine weather station may not be representative of the wider Department as a whole. However, Kaffrine is also a drier weather station than Nioro with greater variability in rainfall, and this also reflects in the contract's performance against the Sarrabil©Cirad model. Although the contract correctly picks out 1997 as the worst year, it does not trigger a payout in 1991, the fourth worst year, and therefore the difference in a farmer's financial exposure with or without insurance is not as dramatic as in Nioro. In addition, although it is clear the year was below average, the Sarrabil©Cirad model does not indicate 2002 was a catastrophic drought year at the Kaffrine weather station, and therefore there is no insurance payout, although the department-level yields were the lowest ever. A further detailed discussion of the Kaffrine contract's performance in 1991 and 2002 is given in Technical Note 6.

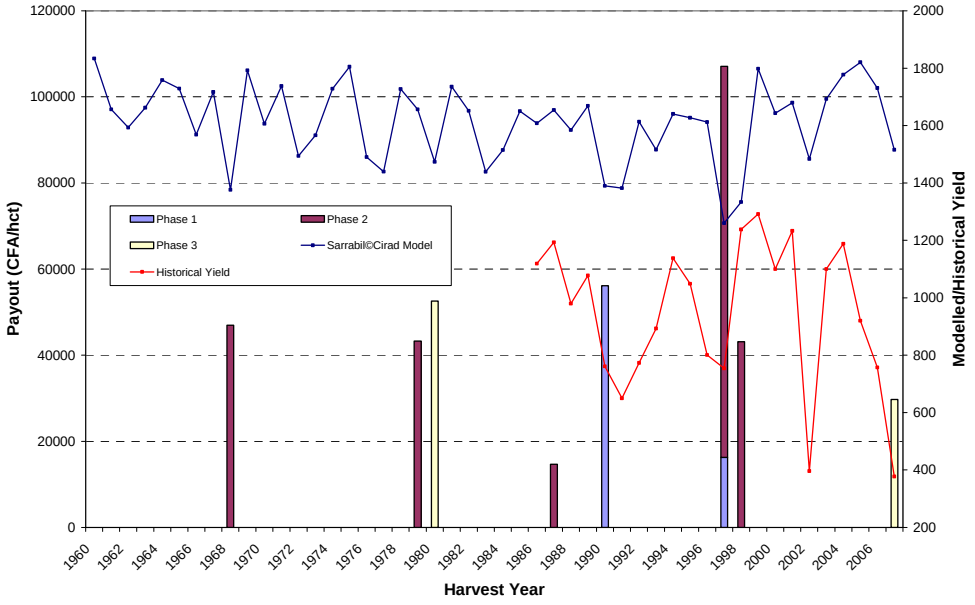
5.27 Nevertheless, the contract only misses 6 percent of poor years in Kaffrine and picks up four of the five worst years since 1960 as predicted by the Sarrabil©Cirad model, and therefore still reduces significant drought risk for farmers in the weather station area. The most recent payout would have been in 2007 in the amount of 29,714 FCFA per hectare due to an early cessation of rains in Phase 3. Further analysis is provided in Technical Note 6.

Figure 5.1: Historical Payouts of Prototype Contract in Nioro



Source: Authors.

Figure 5.2: Historical Payouts of Prototype Contract in Kaffrine



Source: Authors.

5.28 Before the contracts for both Nioro and Kaffrine can be finalized, they must be reviewed by the farmers who will ultimately purchase them. An important cross check is to gauge the contract against farmer recollections of difficult years, particularly if the farmers can recall when during the growing season the crop faced difficulties in a particular year. As with the historical yields, this information is likely to be noisy, and it can be difficult to discern the impact of specific events. However, it also provides important information that could distinguish a robustly performing contract from one that is inappropriately designed (Osgood 2007). Farmer interaction

also provides the opportunity to begin educating farmers on index-based products and both the benefits and limitations of the contracts. The rainfall data used to design the contracts must also be cross-checked and verified and the premium calculations finalized to include administrative and operational costs before the contract design process is complete.

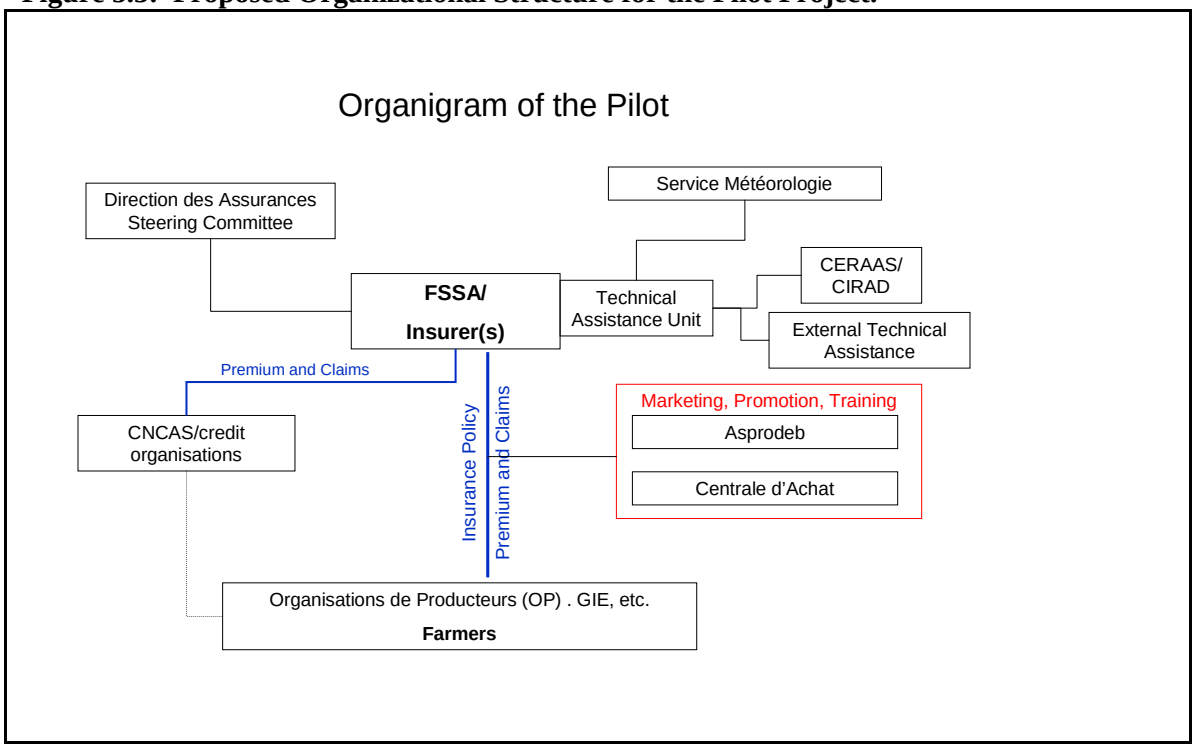
Organization of the Pilot

5.29 Insurance companies in Senegal do not have a network within the rural areas, and they do not have many farmers amongst their clients. It is therefore necessary to identify new distribution channels for weather index insurance. The role of all parties during the pilot has to be defined and responsibilities for the pilot implementation allocated.

5.30 Figure 5.3 shows the proposed organizational structure for the Pilot. The key stakeholders in the Pilot are as follows:

- **Insurance company or companies**: The task of the company is to issue the contract of insurance, to collect premiums, and to pay claims.
- **Technical Assistance Unit**: A technical assistance unit would act as the center of expertise for the planning and implementation of the pilot activities and the focal point for stakeholder coordination. It could be attached to the insurance company.
- **Distribution and marketing organizations**: The Project would build on the existing PSAOP structure in the pilot locations. ASPRODEB, in association with the local Centrale d'Achat (CA), was identified as the organization able to provide extension, promotion and to supervise the enrolment of farmers for insurance. Note that NGOs could also play a role in relation to distribution in regions where they are active.
- **Farmer Organizations (OP)** would coordinate their farmer members in relation to the insurance program, to assist in the information and education of farmers.
- **Agricultural Credit Organizations** (in particular the CNAAS) would play an important role. For those farmers who are clients of CNAAS and are purchasing insurance, the intention would be that the insurance premium forms a part of the loan package for the farmer.
- The **Direction des Assurance** would establish an overall supervisory committee, to oversee the conduct of the weather index pilot.
- The **Service Météorologie** would provide reporting to the Pilot Project Unit on an agreed frequency concerning rainfall recorded at official stations in the pilot areas. However, the weather index payouts would be based on measurements made at automatic rain stations in each pilot area. The stations of the Service Météorologie would act as backup stations in the event of failure of the automatic stations.

Figure 5.3: Proposed Organizational Structure for the Pilot Project.



OP: Organisation de Producteurs (Farmer Organisations);
CA: Centrale d'Achat (Rural Service Centre);
GIE : Groupement d'Intérêt Economique (Farmer economic groupings).

5.31 A detailed activities description for the Preparation and Implementation Phases are shown in Technical Note 6.

5.32 If stakeholders in Senegal, under the Direction des Assurances, determine that they wish to pursue pilot implementation for the season commencing in May 2009, then decisions are needed by November 2008. Key activities include:

- Formation of a steering committee and technical support unit
- Finalization of product parameters and pricing, policy wording, etc.
- Legal and regulatory approval by CIMA[38]
- Product sales and distribution arrangements
- Farmer education
- Implementation, including policy sales, and rainfall recording

Financial Implications

Setting the Insured Values

5.33 The value insured in crop insurance is typically the value of the inputs, and not the value of the expected production (revenue).

[38] A draft technical note to be submitted to CIMA is provided in Technical Note 9.

5.34 Maximum Sums Insured are proposed to amount to 160,000 FCFA per hectare, based on production costs up to point of harvest (see Technical Note 6). The Sum Insured would increase incrementally to this maximum over the three phases of the contract.

Setting the Premium Rates

5.35 In general the premium charge for a contract can be broken down as follows:

Premium = Expected Loss + Risk Margin + Administrative Costs

5.36 A detailed description of the methodology used in developing premiums is provided in Technical Note 6, section 6.2.

5.37 Indicative technical rates are in the region of 10 percent, applied to the Sum Insured (production costs of FCFA 160,000 per ha, as above, and not of revenue).

Table 5.4: Indicative Technical Premium Breakdown

Premium Components	Nioro	Kaffrine
Expected Loss	6801	8372
Maximum Histroical Payout	126,412	107,082
Period Considered	1960-2007[39]	1960-2007
Premium per Hectare	15,771	15,775
Rate on Line	9.9%	9.9%

Note: The Technical Premium does not include Administrative and Business Expenses referred to above. To arrive at the final premium, therefore, the technical premium must be grossed up by multiplying by the factor (1 + TE), where TE are the total administrative and business expenses reflecting the insurer's fixed costs, expressed as a percentage of the technical premium.

Sources: Authors.

Implementation Budget for the Pilot

Pilot Preparation

5.38 A technical assistance budget needs to consider particular components:

- Consultant costs (local and international, including contracts to specialist institutions);
- Training costs;
- Direct investment costs by stakeholders which are additional to staff time; e.g. software programming; weather stations;
- Project management unit (including full time staff, if any, allocated to the project).

[39] The data at Nioro begins in 1950. However, the rainfall data prior to 1960 was significantly higher than post 1960; therefore, the first ten years are not included in the premium analysis.

5.39 Some tasks for the preparation for pilot implementation have been completed. A specific budget will be required for final pilot preparation (see Technical Note 6).

Post-Pilot Expansion

5.40 A post-pilot expansion budget should be developed during the course of the Pilot. The Pilot would be operated over a three-year period, including some controlled expansion during the three years.

5.41 Ongoing services which are essential during the expansion phase include:

- Technical capacity building to enable the design of appropriate index parameters for different crops and regions of Senegal;
- Purchase of meteorological data; an arrangement will be required with the Service Météorologie to enable historical meteorological data to be accessed at affordable cost for all stations in Senegal; and
- Installation of new automatic weather stations. This issue needs to be addressed in the context of the need to upgrade weather infrastructure for many objectives, not least in relation to international research into climate change.

Hypothetical Portfolio Values for a Pilot

5.42 Initially, a target portfolio, intended for implementation during the 2007 season, was identified from known farmers who participate in the PSAOP program for groundnut improvement in the two pilot areas of Pascotto (Nioro) and Kahi (Kaffrine). This was a highly limited portfolio of potential farmers, but nevertheless a pre-identified client base, where farmers could be linked to the program providing input supplies, seeds, and technical support. Assumptions of 100 percent take-up, and 50 percent take-up, by these farmers, were then projected.

5.43 A second calculation was made, using an estimate that there are 2000 groundnut farmers located within a radius of approximately 20 km of the weather station in each pilot district, and that all decided to insure, and that 50 percent decided to insure (Table 5.5.) These assumptions are for indicative purposes and would need to be revised based on further market testing.

Table 5.5: Hypothetical Portfolio of Farmers Taking up Insurance in Each Pilot Area

Revised projection based on an assumption of farmers insuring in each district

Province		Nioro	Kaffrine	Total FFCA	Total US$
District		Pascotto	Kahi		
Number of farmers		2000	2000		
Average area of groundnut per farmer		3	3		
Total area per district		6,000	6,000		
Sum insured (FCFA/ha)		160,000	160,000		376
100 percent uptake					
Total insured values (FCFA)		960,000,000	960,000,000	1,920,000,000	4,517,647
Premium rate/ premium (FCFA)	7.50%	72,000,000	72,000,000	144,000,000	338,824
Premium rate/ premium (FCFA)	10%	96,000,000	96,000,000	192,000,000	451,765
50 percent uptake					
Total insured values (FCFA)		480,000,000	480,000,000	960,000,000	2,258,824
Premium rate/ premium (FCFA)	7.50%	36,000,000	36,000,000	72,000,000	169,412
Premium rate/ premium (FCFA)	10%	48,000,000	48,000,000	96,000,000	225,882

Note: A smaller average area is assumed per farmer compared to those participating in PSAOP

Source: Authors.

5.44 It should be noted that the figures in table 5.5 above are indicative of the "market potential" for this type of insurance, given the available client base, in the Groundnut Basin. A scaled-up program covering a wide area of the Groundnut Basin could become commercially interesting for insurers, recognizing the need for careful reinsurance planning to ensure that potential exposures are covered.

Insurance and Reinsurance

5.45 An advantage of piloting a new product at a small scale is that financial exposure to the insurer are relatively small. Management of catastrophe exposures through reinsurance purchase, as with catastrophe exposures in any other class of insurance business, is necessary. Again, as with other classes of business, there are advantages in establishing relationships with national and international reinsurers at an early stage, in anticipation of a possible expansion. There exists a reinsurance market interested in weather index programs of the type proposed for Senegal. Proportional reinsurance is often considered at an early stage of a new program, as insurer and reinsurer are involved in risk in a proportional manner, and this is often converted to a non-proportional program as exposures grow. Clearly, the retention capacity of national insurers involved with weather index insurance in Senegal will dictate the levels of reinsurance purchases necessary. In this respect, Senegal can benefit from experience of other countries.

Chapter 6. Conclusions and Recommendations

6.1 This chapter summarizes the key outcomes and conclusions of the technical and operational analysis of the proposed index-based crop insurance products (area-yield crop insurance and weather index based crop insurance). It provides recommendations based on international best practice that the Government of Senegal and insurance companies may want to consider for the development of agricultural insurance in Senegal in order to make it attractive to farmers and viable for insurance companies without relying on heavy government subsidies.

Conclusions

6.2 ***The Government of Senegal provides post-disaster assistance to the farmers hit by natural disasters***. The Government of Senegal (GoS) launched in 1997 an ambitious Program for the Modernization of Agriculture (*Programme de Relance de la Production Agricole*; PRPA), to help farmers purchase inputs (e.g. fertilizers, pesticides, improved seeds) through better access to credit. Under this Program, three funds for the financing of agriculture were established: (i) *Fonds de Bonification* aimed at providing subsidized interest rates; (ii) *Fonds de Garantie* aimed at covering non-performing loans up to 75%; and (iii) *Fonds de Calamité* aimed at protecting farmers against natural disasters. The Fonds de Calamité and, to a certain extent, the Fonds de Garantie, provide post-disaster assistance to the farmers affected by natural calamities. However, the lack of discipline and transparency in the allocation of these resources may have limited their efficiency.

6.3 ***There is no tradition of crop or livestock insurance in Senegal***. The private commercial insurers have neither direct experience with the planning, design, underwriting, and claims adjusting for this class of business, nor a rural branch office network with which to administer insurance for small-scale farmers.

6.4 ***The Government of Senegal supports the emergence of agricultural insurance.*** The Direction des Assurances has undertaken several studies on the feasibility of agricultural insurance in Senegal and is in the process of moving into implementation. One of the key outputs is the creation of a specialized agricultural insurance company, Compagnie Nationale d'Assurance Agricole du Sénégal (CNAAS), capitalized by the public sector, private insurance companies, and farmers' organizations.

6.5 ***The specialized agricultural insurance company CNAAS has been established in February 2009***. The business plan of the CNAAS suggests implementing an area-yield crop insurance product with the department forming the insurance unit, an individual animal all risk livestock insurance policy, and a weather-based crop insurance product.

6.6 ***The business plan needs some further operational, legal, technical, and financial refinements***. While the plan describes the main functions to be performed by the CNAAS, it does not mention which departments will be selected for the Area-Yield Index Insurance Program over the next three years. Some departments are very large (e.g. Kaffrine and Tambacounda), and the potential for major internal yield variation within such departments may invalidate the area-

yield approach. Likewise, some subsistence crops such as cowpeas or cassava may not be well suited for an area-yield approach. A detailed portfolio risk analysis should be carried out to assess the catastrophe risk exposure of the insurance portfolio of the CNAAS. This analysis could be the basis for the reinsurance strategy, including proportional reinsurance and non-proportional reinsurance. If the crop and livestock insurance programs are marketed to the farmers on a voluntary basis, the projected uptake of 20% of cropped area after three years may be too ambitious.

6.7 ***There is currently no legal and regulatory framework for agricultural index-based insurance***. The implementation of index-based insurance will require authorization from the regional insurance regulatory body CIMA.

6.8 ***Departmental crop yields are highly variable***. One of the key findings of the crop risk analysis is that department-level average crop yields are highly variable, both spatially between departments and temporally between years. An Area-Yield Crop Insurance Program providing a coverage level of 70 percent has a 1-in-100 year probable maximum loss of 29 percent of total liability.

6.9 ***A portfolio crop risk assessment model, MARCS, has been specifically developed for Senegal***. The *Modèle d'Analyse des Risques de Cultures du Sénégal* (MARCS) is a simple tool for conducting analyses of departmental crop exposure. It is intended to assist policy makers and insurance practitioners in the design and rating of the proposed Area-Yield Crop Insurance Program. In particular, it offers a detailed analysis of catastrophe risk exposure, which is central for the development of a financial viable crop insurance program.

Recommendations

Agricultural Product Development

6.10 ***Traditional multi-peril crop insurance is unlikely to be viable for small farmers in Senegal***. International experience has highlighted several drawbacks with individual MPCI, including the absence of farmer-level yield data, which generates adverse selection.

6.11 ***Index-based crop insurance products should be developed for small farmers***. No single product solution will meet Senegal's needs, due to the wide range of climatic and farming conditions. As a result, a mix of index-based crop insurance products, such as area-yield crop insurance and weather-based crop insurance, is recommended to allow for the expansion of crop insurance.

6.12 ***An Area-Yield Crop Insurance Program is technically feasible in Senegal under certain conditions***. Area-yield crop insurance coverage should only be offered for the main crops, accompanied by strengthened farm and crop-cutting surveys. Minor crops, where yield measurement is based on visual estimation techniques, cannot be designed as technically sound.

6.13 ***Area-yield crop insurance should be piloted for groundnuts and millet in Nioro, Kolda, and Sedhiou***. Area-yield crop insurance products could be implemented on a pilot basis to cover groundnuts and millet in the middle-sized Departments of Nioro, Kolda and Sedhiou. Other departments, and particularly large Departments like Kaffrine, need further investigation, as basis risk may be a major issue.

6.14 ***Area-yield coverage levels should be set individually for each crop and each department***. The spatial differences in yield variation by crop type and department indicate that, the insured yield coverage level of an Area-Yield Crop Insurance Program should be set individually for each crop and each department, at affordable premium levels.

6.15 ***Weather index based crop insurance should be piloted for groundnuts in selected areas***. A procedure has been specifically developed for the design and rating of standardized deficit-rainfall insurance products for smallholder groundnut farmers. This procedure, based on the international experience (such as models developed for Malawi and India) and the local characteristics, relies on the decomposition of the crop growing period into three phases. Payout structures are designed for each of the three phases. Prototype products have been designed and rated for two weather stations located in Kafrine and Nioro. These products have a pure premium rate of less than 10 percent and a frequency of payout of 1-in-6 years. The Sum Insured is based on the costs of production.

6.16 ***The weather index based crop insurance pilots could build on the existing agricultural modernization projects***. The Pilot could build on the existing PSAOP structure in the pilot locations. ASPRODEB, in association with the local Centrales d'Achat, could provide extension and promotion, and could supervise the enrollment of farmers for insurance. Farmer organizations could coordinate their farmer members in relation to the insurance program.

6.17 ***Agricultural insurance is effective only if some preconditions are met***. Any crop insurance programs for Senegalese farmers will only be effective if it is accompanied by timely access to improved seeds, fertilizers, and credit, and if output markets and sales prices are attractive to growers to make an investment in new technology.

Specialized Agricultural Insurance Company

6.18 ***The role of the private insurance industry should be clarified.*** The Government should consider the potential role that the private insurers could play in the provision of agricultural insurance. At present, it is understood that the private insurers' role would be to subscribe to the shareholding of the CNAAS. Private insurers could be involved in the distribution of agricultural insurance products, in the design of innovative agricultural insurance products, etc. Index-based (area-yield and weather index based) crop insurance should be more attractive to private insurers (as long as they are properly designed and priced) because they are less complex to administer than traditional agricultural insurance.

6.19 ***The CNAAS should perform a formal crop risk assessment***. Insurers and/or the specialized agricultural insurance company should perform a formal assessment of the catastrophe risk exposure of their potential insurance agricultural portfolio. A specific crop risk assessment model, MARCS, has been developed for Senegal. This would allow them to properly price the crop insurance products and to devise cost-effective reinsurance strategies.

6.20 ***The creation of the CNAAS will require significant technical assistance.*** The CNAAS will require major technical assistance in technical, financial and operational areas: Information systems, product research and development, underwriting and loss adjustment techniques, catastrophe risk assessment and financing, etc. This type of expertise is currently limited in Senegal and may require international experts.

Role of the Government

6.21 ***The objectives of the public intervention should be clarified.*** Should the Government want to increase the incomes of rural households or to create a safety net program that assures some minimum level of income for farm households, agricultural insurance may not be a cost-effective instrument. Agricultural insurance can be an efficient risk financing tool, as part of an overall agricultural risk management strategy, but it is not cost-effective in transferring wealth to economically disadvantaged rural households.

6.22 ***The financial role of Government should be further elaborated***. The proposed role of the Government, as stated in the provisional business plan developed by the Direction des Assurances, is twofold: Shareholder of the specialized agricultural insurance company CNAAS and provider of direct insurance premium subsidies (50 percent). The Government could also have an important role in supporting agricultural risk market infrastructure: (i) Enhancing data and information; (ii) product research and development; (iii) farmer education and sensitization; and (iv) training of insurance companies.

6.23 ***The GoS should ensure that market-based agricultural insurance and post-disaster assistance programs are complements.*** In many countries disaster assistance has proved to be a disincentive for farmers to purchase crop insurance: Farmers tend to wait for a disaster to happen and then rely on government assistance. The *Fonds de Calamités* should complement the market-based agricultural insurance. This fund should only cover risks that cannot be insured through the CNAAS or other insurance companies.

6.24 ***A Technical Support Unit for agricultural insurance should be established***. The Government may want to consider the formation of a Technical Support Unit (TSU), which would be responsible for the key functions of: (a) Data and information acquisition and analysis, (b) product design and rating, and (c) training and education on behalf of CNAAS and the participating private commercial insurers. The TSU would also be a key institution in the pilot testing of the proposed departmental Area-Yield Index Program and the Crop Weather Index Program.

6.25 ***The Government could act as a reinsurer of last resort***. Catastrophe reinsurance can be very expensive or even be unavailable for the very infrequent risk layers. The Government could complement private reinsurance capacity by covering top risk layers. An appropriate risk financing strategy, including for example a contingent line of credit and other risk transfer options like weather derivatives, should be designed to limit the fiscal exposure of the Government to excessive losses. Additional capacity could be offered through a regional drought insurance pool, similar to the recently established Caribbean Catastrophe Risk Insurance Facility, where drought risks faced by Western African countries could be pooled in a regional facility and then transferred to the international reinsurance and capital markets.

6.26 ***Should the Government of Senegal want to provide premium subsidies, it should be targeted to small and marginal farmers as a social tool.*** The public subsidy program should target small and marginal farmers. It should be designed as a social program and should limit the distortion of market-based insurance premiums.

6.27 ***The insurance code CIMA should be amended to further support agricultural insurance.*** The insurance code CIMA, which regulates Western African countries, should be applicable to agricultural insurance, but should allow for different provisions for agricultural insurance, where appropriate, through regulations. The insurance code CIMA should also allow

index-based products, such as area-yield crop insurance and weather index based crop insurance products, to be classified as insurance products where there is reasonable correlation between the index and the insured's agricultural loss, and when the principle of insurable interest is met.

Glossary

Accumulation	The concentration of similar risks in a particular area such that an insured event may result in several losses occurring at the same time.
Actuarial	Branch of statistics dealing with the probabilities of an event occurring. Actuarial calculations, if they are to be at all accurate, require basic data over a sufficient time period to permit likelihood of future events to be predicted with a degree of certainty.
Ad hoc Response	Disaster relief arranged in the aftermath of a disaster. Ad hoc responses are generally less efficient than planned responses or a well-designed risk management framework.
Adverse Selection	Adverse selection occurs when potential insurance purchasers know more about their risks than the insurer does, leading to participation by high-risk individuals and non-participation by low-risk individuals. Insurers react by either charging higher premiums or not insuring at all, as in the case of floods.
Agricultural Insurance	Insurance applied to agricultural enterprises. Types of business include crop insurance, livestock insurance, aquaculture insurance, and forestry insurance, but they normally exclude building and equipment insurance, although these may be insured by the same insurer under a different policy.
Area-Based Index Insurance	The essential principle of area-based index insurance is that contracts are written against specific perils or events (such as area-yield loss, drought, or flood) defined and recorded at a regional level (for example, at a county or district level in the case of yields, or at the local weather station in the case of insured weather events). Indemnities are paid based on losses at the regional level rather than farm level.
Asset Risk	Risk of damage or theft of production equipment and assets.
Asymmetric Information	An information imbalance due to one party in a transaction possessing more or better information than the other party (parties), such as knowledge of hidden costs or risky behavior. Buyers of insurance products typically have better information about their level of risk exposure, which they may hide from insurers in order to gain lower premium rates.
Basis Risk	The risk with index insurance, that the index measurements will not match individual losses. Some households that experience loss will not be covered, for example, and some households that experience no loss will receive indemnity payments. As the geographical area covered by the index increases, basis risk will increase as well.
Capacity	The maximum amount of insurance or reinsurance that the insurer, reinsurer, or insurance market will accept.
Catastrophe	A severe, usually sudden, disaster that results in heavy losses.
Ceding company	A direct insurer that places all or part of an original risk on a reinsurer.
Claim	An insured's application for indemnity payment after a covered loss has occurred.

Cognitive Failure	In the case of decision making in risk management, cognitive failure occurs when decision makers fail to account for the possibility of infrequent catastrophic risks.
Coinsurance	1. A situation where the insured is liable for part of each and every loss, which is often, expressed as a percentage of the sum insured. 2. When each of several insurers cover part of a risk.
Collective Policy	A policy issued on behalf of a number of insurers or a policy covering a number of items, each being insured separately.
Commission	A proportion of the premium paid by the insurer to the agent for services in procuring and serving the policyholder.
Correlated Risk	Risks that are likely to affect many individuals or households at the same time, such as a fall in commodity prices. For example, coffee growers in the same community are likely to be simultaneously affected by a decrease in price. Futures and options markets can be used to transfer these risks to parties outside the local community. Another example is a widespread drought, which can damage agricultural production over an entire region.
Country Risk Profile	The level of risk exposure of a country, determined by the occurrence of events such as price shock and adverse weather events that impact major private and public assets and economic activities within a country at the micro, meso, and macro levels.
Crop Insurance	Provides financial compensation for production or revenue losses resulting from specified or multiple perils, such as hail, windstorm, fire, or flood. Although most crop insurance pays for the loss of physical production or yield, coverage is often available for loss of the productive asset, such as trees in the case of fruit crops.
Deductible (Excess)	An amount representing the first part of a claim, which an insured has to bear as stated in the policy. The deductible is frequently expressed as a percentage of the sum insured, but may just as often be a monetary amount.
Default	Failure to fulfill the obligations of a contract.
Direct Premium Subsidy	A subsidy which is calculated as a percentage of the insurance premium paid. Such a subsidy is problematic, because it disproportionately benefits high-risk farmers who pay higher premiums. Attracting higher-risk farmers can significantly increase the costs of insurance.
Disaster-Index Insurance	An insurance contract in which payments are triggered by extreme weather events. Disaster-index insurance is a form of weather insurance, which covers catastrophic weather events or the extreme tail of the probability distribution of weather events for a region or country. *See also Index Insurance.*
Drought	One of the most commonly requested peril covers by farmers, but it is also one of the most difficult perils to insure because of problems of definition, isolation, and measurement of effects on crop production. In contrast to most weather perils, drought is a progressive phenomenon, in terms of an accumulating soil moisture deficit for plant growth, and its impact on crop production and yields is often extremely difficult to predict, measure, and isolate from other non-

	insured causes.
Due Diligence	The responsibility of an external reviewer to perform an investigation of risk associated with a potential client, considered prudent and necessary for an adequate assessment of that client's level of risk. The process associated with "due diligence" in insurance includes underwriting, contract design, rate making, and adverse selection and moral hazard controls.
Endogenous Market Factor	A factor occurring within the market which impacts market transactions, such as fluctuations in local supply or demand or political instability within a country.
Ex ante Risk Mechanism	Action taken prior to a potential risk event. Making preparations before a disaster helps avoid inefficient, quick-response coping decisions. If ex ante strategies are not in place, resort will be to short-term coping strategies that have no significant benefit in the long run.
Ex post Risk Mechanism	Risk management strategies that are developed in reaction to an event, without prior planning. Although ex post strategies have a role to play in a risk management program, risk management mechanisms can be more effective when introduced ex ante.
Exposure	The amount (sum insured), exposed to the insured peril(s) at any one time. In crop insurance, exposure may increase, and then decrease, during the coverage period, following the growth stages of the crop from planting to completion of harvest.
Exogenous Market Factor	A factor occurring outside the market which impacts transactions within the market, such as a shift in the global demand for a commodity.
Financial Intermediary	An institution (such as an insurance company, bank, or microfinance institution) that serves as a middle man or acts as a go-between for sellers and buyers of financial services such as credit or insurance.
Financial Risk	Risk that income will not reach expected levels, or that the invested value in a crop will be lost due to adverse changes in weather and price. Many agricultural production cycles stretch over long periods of time, and farmers must anticipate expenses that can only be recouped once the product is marketed, leading to cash-flow problems that can be made even more severe by a lack of access to credit, or the high cost of borrowing in rural areas.
Fondo	According to Mexican laws, fondos are nonprofit organizations constituted by the farmers as civil associations without the need to provide any capital endowment, except their willingness to associate among themselves. From a risk-financing perspective, fondos pool crop-yield risks from farmers with similar risk profiles.
Franchise	An amount of loss which has to be reached before the insurer will pay a claim, and once this threshold is met, the insurer has to pay the claim in full. For example, a farmer insures his crop for $1,000 with a franchise of $100. If the claim is for $99, then this is borne by the farmer. If the claim is for $101, however, then the whole amount of the $101 is paid by the insurer.
Gross Net Premium Income	Gross written premium of a primary insurer, minus cancellations, refunds, and reinsurance premium paid to other reinsurers.

Guaranteed Yield	The expected physical yield of a crop stated in the insurance policy, against which actual yields will be compared when adjusting any losses.
Hazard	A physical or moral feature that increases the potential for a loss arising from an insured peril or that may influence the degree of damage.
High-Probability Low-Consequence Events	High-probability, low-consequence risks are frequent risks that cause mild to moderate damage. Insurance products for high-frequency, low-consequence losses are seldom offered, because the transaction costs associated with frequent loss adjustment makes the insurance cost prohibitive for most potential purchasers. These high transaction costs are in part due to information asymmetries that cause the problems of moral hazard and adverse selection. *See also Moral Hazard and Adverse Selection.*
In-Between Risk	Agricultural production risks, such as natural disasters, that lack sufficient spatial correlation to be effectively hedged using exchange-traded futures or options instruments. At the same time, they are generally not perfectly spatially independent, and therefore traditional insurance markets cannot cover these risks. Skees and Barnett (1999) refer to these risks as "in-between" risks. Because of their unique characteristics, in-between risks require more innovative instruments.
Indemnity	The amount payable by the insurer to the insured, in the form of cash, repair, replacement, or reinstatement in the event of an insured loss. This amount is measured by the extent of the insured's pecuniary loss. It is set at a figure equal to but not more than the actual value of the subject matter insured just before the loss, subject to the adequacy of the sum insured. For many crops, this means that an escalating indemnity level is established as the growing season progresses.
Independent Risk	Risks such as automobile accidents, fire, or illness that generally occur independently across households. Such statistical independence allows effective risk pooling across entities in the same insurance pool, making insurance possible. For independent risks, the law of large numbers suggests that, on average, the insurance indemnity paid to claimants in a particular year can be offset by the premiums received from clients who did not experience indemnifiable losses. *See also Risk Pooling.*
Index Insurance	Index insurance makes indemnity payments based not on an assessment of the policyholder's individual loss, but rather on measures of an index that is assumed to proxy actual losses. Two types of agricultural index insurance products are those based on area-yields, where the area is some unit of geographical aggregation larger than the farm, and those based on measurable weather events. *See also Weather-Index Insurance.*
Informational Constraint	Limited access to or availability of reliable data can be a significant constraint to the development and performance of risk transfer markets.
Institutional Risk	Institutional or regulatory risk is generated by unexpected changes in regulations, especially in import and export regimes, and influences producers' activities and their farm profits.

Insurability	The conditions that determine the viability of insurance as a method of managing a particular risk.
Insurable Interest	An insurance policy is valid only if the insured is related to the subject matter insured in such a way that he or she will benefit from its survival, suffer from loss or damage caused to it, or may incur liability in respect of it.
Insurance	A financial mechanism that aims to reduce the uncertainty of loss by pooling a large number of uncertainties so that the burden of loss is distributed. Generally, each policyholder pays a contribution to a fund in the form of a premium, commensurate with the risk he introduces. The insurer uses these funds to pay the losses (indemnities) suffered by any of the insured.
Insurance Agent	The person who solicits, negotiates, or implements insurance contracts on behalf of the insurer.
Insurance Broker	The person who represents the insured in finding an insurer or insurers for a risk and negotiating the terms of the insurance contract. A broker may also act as an agent (that is, for the insurer) for the purposes of delivering a policy to the insured and collecting premium from the insured.
Insurance Policy	A formal document (including all clauses, riders, and endorsements) that expresses the terms, exceptions, and conditions of the contract of insurance between the insurer and the insured. It is not the contract itself but evidence of the contract.
Insured Peril	The cause of loss stated in the policy, which on its occurrence entitles the insured to make a claim.
Layer	The term used to define a range of potential loss that is covered by insurance. For example, an insurance contract may pay indemnities only for losses within a specified range of magnitude. *See also Risk Layering.*
Livestock Risk	The risk of death, injury, or disease to livestock.
Loss Adjustment	Determination of the extent of damage resulting from occurrence of an insured peril, and settlement of the claim. Loss adjustment is carried out by the appointed loss adjuster who works on behalf of the insurer.
Loss Ratio	The proportion of claims paid (or payable) to premium earned. A loss ratio is usually calculated for each class of business in which an insurer participates. Analysis of loss ratios can be useful in assessing risks and designing appropriate insurance structures.
Low-Probability High-Consequence Events	Low-probability, high-consequence risks are events that occur infrequently yet cause substantial damage. Decision makers, including agricultural producers, tend to underestimate their exposure to low-probability, high-consequence losses, because people forget the severity of the loss experienced during infrequent extreme weather events. Thus, an insurance product that protects against these losses is frequently discounted or ignored altogether by producers trying to determine the value of an insurance contract.
Macro Level	The economic level at which countries and large donor agencies working with these countries experience risk of weather-induced

	humanitarian crises or economic instability caused by price volatility.
Market Failure	The inability of a market to provide certain goods at the optimal level because market prices are not equal to the social opportunity costs of resources. The high cost of financing catastrophic disaster risk prohibits most private insurance companies form covering this risk, resulting in market failure.
Market Risk	Input and output price volatility are important sources of market risk in agriculture. Prices of agricultural commodities are extremely volatile as a result of both endogenous and exogenous market shocks, and some commodities experience shocks more frequently than others.
Meso Level	The economic level at which banks, microfinance institutions, producers, traders, processors, and input providers experience risk due to the vagaries of weather and price.
Micro Level	The economic level at which individual farm households experience risks due to shocks, such as adverse weather events, price fluctuations, or disease.
Microclimate	The climates of localized areas, which may differ considerably from the climate of the general region. These climate variations are caused by geographical differences in elevation and exposure.
Moral Hazard	In insurance, moral hazard refers to the problems generated when the insured's behavior can influence the extent of damage that qualifies for insurance payouts. Examples of moral hazard are carelessness, fraudulent claims, and irresponsibility.
Non-proportional Treaty Reinsurance	An agreement whereby the reinsurer agrees to pay all losses which exceed a specified limit arising from an insured portfolio of business. The limit is set by the reinsurer and may be monetary (for example, excess of loss) or a percentage (for example, stop loss). The rates charged by the reinsurer are calculated independently of the original rates for the insurance charged to the insured.
Personal Risk	The risk to an individual of personal injury or harm.
Premium	The monetary sum payable by the insured to the insurer for the period (or term) of insurance granted by the policy. Premium = premium rate x amount of insurance Also, the cost of an option contract—paid by the buyer to the seller.
Premium Rate	The price per unit of insurance. Normally expressed as a percentage of the sum insured.
Probable Maximum Loss	The largest loss believed to be possible for a certain type of business in a defined return period, such as 1 in 100 years, or 1 in 250 years.
Proportional Treaty Reinsurance	An agreement whereby the insurer agrees to cede and the reinsurer agrees to accept a proportional share of all reinsurances offered within the limits of the treaty, as specified on the slip. Limits can be monetary, geographical, by branch, class of business, and so forth. The reinsurer has no choice of which risks to accept or decline; he is obliged to accept all good and bad risks that fall within the scope of the treaty.
Quota Share Treaty	An agreement whereby the ceding company is bound to cede and the

Reinsurance	reinsurer is bound to accept a fixed proportion of every risk accepted by the ceding company. The reinsurer shares proportionally in all losses and receives the same proportion of all premiums as the insurer, less commission. A quota share often specifies a monetary limit over which the reinsurer will not accept to be committed on any one risk—for example, 70 percent each and every risk, not to exceed $700,000 any one risk.
Rapid-Onset Shock	A sudden large shock, such as a flood, hurricane, frost, freeze, excess heat, high wind speed, storm, or commodity price shock. Rapid-onset events are easier to identify than slow-onset shocks, and their impact can be easier to determine.
Rate On Line	A rate of premium for a reinsurance which, if applied to the reinsurer's liability, will result in an annual premium sufficient to meet expected losses over a number of years.
Regulatory Risk	Institutional or regulatory risk is generated by unexpected changes in regulations, especially in import and export regimes, and influences producers' activities and their farm profits.
Reinsurance	When the total exposure of a risk or group of risks presents the potential for losses beyond the limit that is prudent for an insurance company to carry, the insurance company may purchase reinsurance (that is, insurance of the insurance). Reinsurance has many advantages, including: (1) Leveling the results of the insurance company over a period of time; (2) limiting the exposure of individual risks and restricting losses paid out by the insurance company; (3) possibly increasing an insurance company's solvency margin (percent of capital and reserves to net premium income), hence the company's financial strength; and (iv) enabling the reinsurer to participate in the profits of the insurance company, but also to contribute to the losses, the net result being a more stable loss ratio over the period of insurance.
Risk Aggregation	The process of creating a risk-sharing arrangement that gathers together or pools risks, thereby reducing transaction costs and giving small households or other participants a stronger bargaining position.
Risk Assessment	The qualitative and quantitative evaluation of risk. The process includes describing potential adverse effects, evaluating the magnitude of each risk, estimating potential exposure to the risk, estimating the range of likely effects given the likely exposures, and describing uncertainties.
Risk Management	Care to maintain income and avoid or reduce loss or damage to a property resulting from undesirable events. Risk management involves identifying, analyzing, and quantifying risks and taking appropriate measures to prevent or minimize losses. Risk management may involve physical mechanisms, such as spraying a crop against aphids, using hail netting, or planting windbreaks. It can also involve financial mechanisms such as hedging, insurance, and self-insurance (carrying sufficient financial reserves so that a loss can be sustained without endangering the immediate viability of the enterprise in the event of a loss).
Risk Mitigation	Actions taken to reduce the probability or impact of a risk event, or to

	reduce exposure risk events.
Risk Retention	Risk retention is the process whereby a party retains the financial responsibility for loss in the event of a shock.
Risk Transfer	Risk transfer is the process of shifting the burden of financial loss or responsibility for risk financing to another party, through insurance, reinsurance, legislation, or other means.
Risk Coping	Strategies employed to cope with a shock after its occurrence. Some examples of risk-coping strategies include the sale of assets, seeking additional sources of employment, and social assistance.
Risk Financing	The process of managing risk and the consequences of residual risk through products such as insurance contracts, CAT bonds, reinsurance, or options.
Risk Layering	The process of separating risk into tiers that allow for more efficient financing and management of risks. High-probability, low-consequence events may be retained by households to a certain extent. The market insurance layer is characterized by the ability of the market to manage risks through insurance or other contracts. Low-probability, high-consequence events characterize the market-failure layer, and at this layer of risk, government intervention may be necessary offset the high losses.
Risk Pooling	The aggregation of individual risks for the purpose of managing the consequences of independent risks. Risk pooling is based on the law of large numbers. In insurance terms, the law of large numbers demonstrates that pooling large numbers of roughly homogenous, independent exposure units can yield a mean average consistent with actual outcomes. Thus, pooling risks allows an accurate prediction of future losses and helps determine premium rates.
Shock	An unexpected traumatic event such as death in the family or loss of land and livestock, which can be caused by catastrophic weather events or other unexpected phenomena. Price shocks occur when the price of a commodity changes dramatically due to changes in local or global supply and demand, affecting the livelihood of households dependent on this commodity, for either income or caloric intake. Economic shocks can occur at the micro, meso, and macro levels and can have long-term consequences for the economic well-being of actors at each level.
Slow Onset Shock	A shock that unfolds slowly, such as drought; it starts unnoticed, and its impact is difficult to assess or may not be recognized until high losses are realized.
Social Safety Net	Various services, usually provided by the government, designed to prevent individuals or households from falling below a certain level of poverty. Such services include free or subsidized health care, child care, housing, welfare, and so on.
Stop Loss	This term, usually applied to the reinsurance business, refers to a policy that covers claims once they have exceeded a certain amount. A policy with a stop-loss provision is a non-proportional type of reinsurance, where the reinsurer agrees to pay the reinsured for losses that exceed a specified limit, arising from any risk or any one event.

	For example, a reinsurer may agree to pay claims of $200,000 in excess of $100,000. If the claims are more than $300,000, the reinsured (that is, the insurer) will have to bear the remainder of the claims or make additional financing arrangements to cover the remaining risk exposure.
Subsidy	A direct or indirect benefit granted by a government for the production or distribution (including export) of a good or to supplement other services. Generally, subsidies are thought to be production- and trade-distorting and to cause rent-seeking behavior, resulting in an inefficient use of resources.
Transaction Costs	Transaction costs are the financial costs or efforts required to engage in business transactions, including the cost or time spent obtaining information. Transaction costs of insurance include those associated with underwriting, contract design, rate making, adverse selection, and moral hazard.
Underwrite	To select or rate risks for insurance purposes.
Weather-Index Insurance	Contingent claims contracts for which payouts are determined by an objective weather parameter (such as rainfall levels, temperature, or soil moisture) that is highly correlated with farm-level yields or revenue outcomes. *See also Index Insurance*.
Yield Risk	Unique to agricultural producers; like most other entrepreneurs, agricultural producers cannot predict the amount of output that the production process will yield, due to external factors such as weather, pests, and diseases.

List of Technical Notes