DRAFT REPORT – NOT FOR CIRCULATION

Nigeria

Crop Weather Index Insurance

Pre-Feasibility Study Report

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Table of Contents

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ABBREVIATIONS

AET	Actual evapotranspiration
AICI	Agricultural Insurance Company of India Ltd
ARMT	Agricultural Risk Management Team of the World Bank
AYII	Area Yield Index Insurance
CADP	Commercial Agriculture Development Project
CRMG	Commodity Risk Management Group
FAO	Food and agricultural Organization of the United Nations
GDP	Gross Domestic Product
GoN	Government of Nigeria
ICEED	International Centre for Energy, Environment and Development
IFC	International Finance Corporation (World Bank Group)
LIC	Loss of Investment Costs (crop insurance policy)
MARD	Ministry of Agriculture and Rural Development
MPCI	Multiple Peril Crop Insurance
NACRDB	Nigerian Agricultural and Cooperative Rural Development Bank
NAIC	Nigeria Agricultural Insurance Company
NAIS	Nigeria Agricultural Insurance Scheme
NIMET	Nigerian Meteorological Agency
PML	Probable Maximum Loss
WHC	Water Holding Capacity
WII	Weather Index Insurance
WRSI	Water Requirement Satisfaction Index

Executive Summary

Context

1. ***Nigeria is Africa's most populous nation*** with a population of 158 million people, Gross Domestic Product, GDP of 194 billion and GDP per capita of US$ 1,222 in 2010. Agriculture is a very important source of employment and livelihoods and income in Nigeria: overall 50.2% of the population was classified as rural in 2010 and agriculture contributed for 33% of 2007 GDP and 45% of total employment in 2004[1]. Nigeria has a total land area of 910,770 km2[2] of which 86% is classified as agricultural land. Agriculture is subject to a combination of climatic perils including biological perils (pests and diseases), excess rain and flooding, droughts, and natural perils (including wild fires).

2. ***Agricultural insurance was introduced in Nigeria back in 1987 through the creation of the Nigerian Agricultural Insurance Scheme (NAIS).*** The Nigerian Agricultural Insurance Company Limited, a private limited company, was incorporated in 1988 with the mandate to underwrite and implement the NAIS, but in 1993, the NAIC was dissolved and replaced by a public-sector corporation, the Nigerian Agricultural Insurance Corporation, NAIC. Currently in 2011, NAIC writes a portfolio of crop, forestry, livestock, poultry and aquaculture insurance and also non-life commercial insurance lines. NAIC has received government support both in the form of the initial capitalization of the company and 50% premium subsidies on most classes of agricultural crop, livestock, poultry and aquaculture insurance (however, commercial plantation crops, cash crops and bloodstock do not qualify for premium subsidies). NAIC's agricultural insurance scheme is closely linked to public sector credit provision: farmers accessing crop or livestock loans from national banks have to purchase compulsory agricultural insurance cover to protect the loans.

3. ***The NAIC requested technical assistance from the World Bank in order to develop index-based crop insurance products to complement its traditional indemnity-based loss of investment cost, LIC, policy***. NAIC wants to explore the feasibility of index insurance as an alternative product which could be offered to small and with marginal farmers, potentially at much lower operational and administrative costs than the individual grower LIC policy. The World Bank Technical assistance on index based insurance is closely linked to the World Bank funded Commercial Agriculture Development Project (CADP). The CADP project is operating in the states of Kaduna, Kano, Lagos, Enugu and Cross River and with eight crop commodity value chains. The crop index insurance technical assistance aims to assess pre-feasibility for the viability of index insurance for cocoa, oil palm, rice, and maize in the five CADP states.

4. ***The objective of this study is to conduct a pre-feasibility study for the development of crop Weather Index Insurance (WII) for selected crops grown in selected States in Nigeria.*** The specific objectives include: (i) to conduct a review of NAIC's existing crop insurance scheme and to assess the technical, financial and operational performance of the scheme based on information and statistics made available; (ii) to assess the availability and quality of crop production and weather data for the purposes of developing weather index insurance (WII) products for two crops, maize and rice, in the five selected states; (iii) to use the crop and weather data collected by the local consultants for the five states to assess the viability of developing WII;

[1] World Bank indicators for Nigeria: http://data.worldbank.org/country/nigeria
[2] This compares with the total surface area of 923,770 km2

(iv) and finally to conduct an initial assessment of the legal and regulatory, institutional, operational and financial issues and challenges which would need to be addressed under a feasibility study for WII in the five selected states. The study into the feasibility or otherwise of designing and implementing WII for the maize and rice in the five selected states of Nigeria draws where relevant on the international experience with WII in other countries.

Features and Results of the Nigerian Agricultural Insurance Scheme (NAIS)

5. ***Agricultural insurance in Nigeria operates under the Nigerian Agricultural Insurance Scheme (NAIS)***. The NAIS has four main objectives, which are: (i) to provide financial support to farmers on the aftermath of the occurrence of natural hazards; (ii) to stimulate the provision of rural credit by financial institutions; (iii) to promote agricultural production by giving enhancing investment; and (iv) to minimize the need for Government of Nigeria (GoN) to provide ad hoc assistance. The NAIS establishes agricultural insurance as mandatory for all agricultural loans or agricultural projects and programs that are funded from public funds including all direct, on-lending and investment loans disbursed by the Nigerian Agricultural and Cooperative Rural Development Bank (NACRDB). Government provides financial support to the NAIS in the form of of 50% premium subsidies for most classes of agricultural insurance. Subsidies are provided for food crops, cereals and root crops, but not for commercial plantation crops and cash crops: similarly premium subsidies are applicable to most classes of livestock, poultry and fisheries (aquaculture), but not for bloodstock insurance. This subsidy is financed by the Federal and respective State governments in the ratio of 37.5% and 12.5%. NAIC is the sole insurance company in Nigeria entitled by NAIS to receive agricultural insurance government support for the provision of agricultural insurance. Finally, the NAIS sets out the provision for the Federal Government to accept the liability for catastrophe losses incurred by NAIC in excess of 200% of the premium income.

6. ***The Nigerian Agricultural Insurance Corporation (NAIC) is the executing Agency of the Nigerian Agricultural Insurance Scheme (NAIS)***. NAIC was created in 1993 in response to the need for a specialized agricultural insurance company to provide insurance to farmers. NAIC has a wide portfolio of agricultural insurance products. NAIC is currently offering the following products: (a) Multiple peril salvage-based[3] loss of investment crop insurance (21 crops items), (b) livestock insurance (9 livestock items), (c) fisheries insurance, (d) forestry insurance, (e) poultry insurance, and (e) snail insurance. In addition to agricultural insurance, NAIC is also participating in other l*i*nes of insurance business, such as property fire insurance, motor, and marine. NAIC has an operational presence all over the country. NAIC's network includes branch offices in 36 States of the Federation, five Zonal Supervisory offices in line with the agro-ecological zones of the Nation, and a Head Office in Abuja.. In 2010 NAIC's total gross written premium income GWP amounted to NGN 866.5 million (US$ 5.7 million)[4] of which slightly over half or 51% of GWP was generated by subsidized and non-subsidized agricultural insurance lines and the remaining 49% of GWP was generated by commercial lines.

7. ***Agricultural insurance penetration in Nigeria remains very low.*** NAIC's coverage is less than 1% of all farmers in Nigeria after 23 years of Operations. Over the 4 year period 2007 to 2010 NAIC has insured an average of about 35,000 food crop and commercial crop farmers each year with corresponding insured area of about 100,000 Ha: this represents less than 1% of

[3] The salvage-based loss of investment cost policy insures farmers for loss of their production costs invested in growing the crop up to the time of the loss: the policy indemnifies losses when the expected value of any residual crop which can be harvested (the salvage) falls short of the insured production costs. Further details of this policy are presented in Chapter 2.
[4] At a 2010 average exchange rate of Nigerian Naira (NGN) 152 = US$ 1.00

Nigeria's farmers and also less than 1% of the total cultivated area of 39 million Ha. In the case of livestock an average of about 12,000 livestock owners have been insured per year and a total of about 2.5 million head of livestock and poultry which again represents only a very small fraction of the total livestock population in Nigeria. NAIC has not been able to expand its crop insurance coverage for a number of reasons including: (1) the budgets for Federal and State government 50% crop and livestock insurance premium subsidies are very restricted and it is understood that there are major delays of several years in NAIC receiving these subsidy payments, (2) NAIC's main source of business is crop-credit insurance through NACRDB and because NACRDB's seasonal lending is very restricted today, NAIC's business is correspondingly restricted, and (3) it appears that the voluntary demand by Nigerian farmers for NAIC's agricultural insurance products is very low. These issues are reviewed in detail in the report.

8. ***NAIC has achieved very profitable technical underwriting results over the past 7 years with an average loss ratio of only 17% on its agricultural insurance portfolio***. Between 2004 and 2010, NAIC has achieved a long-term average loss ratio of only 17% with range from a low of 4% loss ratio in 2004, to a high of 43% in 2010 (It is not possible to report the results separately for the crop and livestock portfolios). These results are extremely favourable for an agricultural insurance program which provides multiple peril crop insurance including potentially catastrophe perils of drought and flood and pests and diseases of crops and which carries a very low average premium rate of only 2.64% over the past 7 years. There is no other major crop and livestock insurance program in the world which can demonstrate such good technical results as the NAIC. NAIC, however, faces very high business operating expenses (made up of acquisition costs, management expenses and other underwriting expenses) which exceed 50% of the total premium receipts and as a result the Combined Ratio is much higher at about 70%.

Suitability of Crop Weather Index for Nigeria

9. ***Under this study two types of Crop Weather Index Insurance WII Prototype Contracts were investigated for rice and maize in the selected states, first a rainfall deficit contract and secondly an excess rainfall contract.*** Full details of the prototype contract design and rating procedures and modeled outputs and results are contained in Chapter 4 of this report and Annex 4.

10. Crop Weather Index Insurance, WII, is a simplified form of insurance, where payments are made based on a weather 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. The most common application of WII 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 indemnity scale set out in the insurance policy. The sum insured is normally based on the production costs for the selected crop and indemnity payment are made when actual rainfall in the current cropping season as measured at the selected weather station falls below pre-defined threshold levels.

11. In the light of international experience, a series of preconditions should be met in order to develop WII. These preconditions include: (1)the weather perils (hazards) to be insured must be capable of being indexed: index insurance is most suited to slow-onset hazards (such as drought) which can be measured through a continuous rainfall deficit index with defined trigger and exit rainfall levels, as opposed to sudden-event climatic perils (such as hail, flood or windstorm); (2). the existence of reliable time series weather data and crop data; (3) the existence of a high degree of correlation between the evolution of the weather variable on which the index product is based and the crop yields; (4) the existence of a weather station network dense enough to avoid high basis risk in the coverageLast but not least, it is important to consider that, while weather index insurance might be suitable to transfer risk for a single crop, WII is not suitable to transfer risk of crops that are grown under intercropping production systems.

12. The main perils affecting crop production in Nigeria are not suitable for WII indexation. According to NAIC's agricultural insurance results for the 4 year period 2007 to 2010, the main cause of losses in crop production isdisease followed in third place by fire and these perils are not suitable to be indexed. The most **important cause of loss** on NAIC's agricultural insurance portfolio is **disease** (and which does not lend itself to indexation under a WII product save where there is a very close correlation between say rainfall and relatively humidity levels and incidence of fungal diseases in particular crops). This was followed by **flood** claims, but river flood is very difficult to index because historical river flow gauge data is often lacking and it is a complex task to relate river flow data to crop damage. The third most importan**t so**urce of claims on the NAIC program during this period was **fire** but this peril cannot be indexed under a conventional WII index. **Drought** is the only climatic peril insured by NAIC which is relativel***y*** easy and potentially suitable to insure under a WII product. Drought has accounted for 3% of all claims and 9% of the total value of claims and this is the only cause of loss on the NAIC crop scheme which l***en***ds itself to indexation under a rainfall deficit index cover**.**

13. In Common with many developing countries, especially in Africa, there is limited access to reliable weather and production statistical data series in Nigeriat. **Crop data.** The available time-series data on maize and rice crop production and yield information is not very suitable for the design and rating of a WII policy because the lowest level of disaggregation of Maize and rice yields available is at the state level. None of the agencies dealing with agricultural data was able to provide maize and rice yields with at a localized level of disaggregation, such as at local government administration (LGA) level. At a State-level any crop production and yield data is aggregated over too large a geographical area to try to establish causal relationships between weather and crop yields and which vary at a local level. The constraints over the lack of suitable location specific crop production and yield data have severely limited the ability to design and rate WII contracts for the 4 selected weather stations in the selected states. In addition to the issue on the level of disaggregation for the data, the study was unable to get more than 8/9 years of crop yield statistics for rice production in Lagos, and Cross River. **Rainfall data**. A minimum of 25 to 30 years uninterrupted daily rainfall data with a maximum of 2% to 3% missing data and data outliers is normally required to design and rate rainfall deficit contracts (World Bank 2005). Kano NIMET rainfall data exhibits major inconsistencies and could not be analyzed further for WII contract design purposes. However, the NIMET daily rainfall data for the remaining 4 states/weather stations in Kaduna, Cross River (Calabar station), Enugu and Lagos (Ikeja station) was found to meet the minimum data requirements for WII, and has therefore been used to design and rate prototype WII rainfall contracts for maize and rice.

Relationship between crop yields of maize and rice and too much and too little rainfall

14. ***There is no significant correlation between state-level rice and maize crop yields and rainfall in the weather stations selected for the study.*** Under this pre-feasibility analysis the 16-years State level rice and maize crop production yields in Kaduna, Cross River, Lagos, and Enugu States were correlated against the cumulated rainfall in each of the weather stations selected for the analysis during the respective crop periods[5]. The results of the analysis showed that, in all

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[5] Kano was not selected for the correlation analysis owing to the fact that the data did not meet the minimum quality to be used for weather index insurance purposes.

cases except for Lagos, there was no significant correlation between cumulated rainfall during the crop season and state level annual average yields. It is stressed, however, that the lack of correlation between rainfall and yields may be mainly due to fact that the only available yield data are at state-level and which may bear little or no relationship to actual average yields in the vicinity of the selected weather stations.

15. ***For maize, rainfall and yields are negatively correlated in two of the four states, Cross River and Kaduna or in other words the problem for maize production in these states appears to be too much rain as opposed to rainfall deficit (drought)***. This finding suggests there is a need to develop WII contracts to cover both possible rainfall deficit and excess rainfall for maize grown in these 4 states of Nigeria.

16. ***For rice, the state-level yield data is much more restricted to only 9 or 10 years data for Cross River and Enugu and this data is inadequate to establish clear causal relationships between yields and rainfall***. The correlations at all stations between June to October seasonal rainfall for rice (including mainly lowland rice, but also some upland rice) and rice yields show very poor correlations. The same tendency is observed for both rice and maize in terms of the inverse correlations between rainfall and yield in Kaduna and Cross River implying that in these states too much rainfall leads to reduced yields, while in Enugu and Lagos, rice yields are positively correlated to rainfall.

17. ***There is a much clearer inverse relationship between the number of days of excess rain (> 50 mm per day) and maize and rice yields.*** With one exception namely, maize grown in Lagos (Ikeja), maize and rice yields are inversely correlated with the number of days excess rainfall > 50 mm/day with the highest correlation of -0.754 for maize grown in Kaduna state. The correlations for rice and excess rain are, however, generally weak.

Prototype WII Rainfall Contracts

18. ***A prototype WII three-vegetative phase rainfall deficit contract based on the FAO's Water Requirements Satisfaction Index model was tested for maize and rice in the 4 selected states***[6] In the past decade WRSI has been used in many countries to the design and rating of rainfall deficit WII contracts. The beauty of this simple but robust FAO designed crop water balance model is that it can be used to predict accurately the impact of rainfall deficit on crop production and yield at any stage of the plant growth cycle from sowing through to harvest of the crop. (A detailed description of the WRSI Model and its application to rainfall deficit contract design in this Nigerian study is contained in Annex 4, Appendix 4.1).

19. ***The WRSI-based rainfall deficit model did not capture any significant rainfall deficit events over the past 30 years for maize and rice in any of the four states***. In Kaduna and Cross River the WRSI calculated water requirements at each phenological growth stage were more than satisfied by actual rainfall in each and every of the past 30 years for both maize and rice. The modeling produced one payout in maize at Lagos (Ikeja), but on further investigation this payout appears to be due to missing rainfall data during that vegetative phase and a single payout in Enugu which is not validated by any corresponding reduction in the state-level average yield in that year. There were no correlations between the WRSI calculated potential crop yield and the actual state level yields. These results tend to indicate that in view of the high and relatively

[6] The contract design is based on the standardized deficit-rainfall insurance contracts that have been developed by the Agricultural Risk Management Team, ARMT (former Commodity Risk Management Group, CRMG), of the World Bank, in conjunction with IRI Earth Institute at Columbia

stable crop season rainfall in both Kaduna and in Cross River that drought per se is not the key variable affecting rice and maize yield variability.

20. ***While Rainfall-deficit contracts have been extensively tested and refined during the past decade, WII Excess Rainfall Contracts are still at a developmental stage***. Very few of the micro-level individual farmer WII programs developed to date include excess rainfall[7] and there is no consensus up to now on which or the following parameters represents best the impact of excess rain on crop production and yields: the quantity of torrential or excess rainfall recorded in a single day, or the number of days continuous rainfall, or the cumulative amount of excess rainfall recorded during a defined phase or phases of crop growth. Under this Nigeria pre-feasibility study some preliminary research has been conducted into Excess Rainfall Contracts for Maize for the 4 selected weather stations - Kaduna, Cross River (Calabar), Enugu and Lagos (Ikeja). In the absence of a specific Excess Rain-yield model, a simple approach was adopted based on the amount of cumulative rainfall in each crop physiological growth stage in maize. As such, the excess rainfall index tested under this study is a 3-phase cumulative excess rainfall index for maize which replicates as closely as possible the rainfall deficit model outlined above for maize. The excess rainfall model was tested in detail for maize in Enugu and produced a high number of WRSI modeled payouts. However there was no correlation at all between the excess rain payout years and actual and the actual state-level time-series yields for maize grown in Enugu from 1994 to 2010. In other words, if one were to offer a three-phase cumulative excess rainfall cover in Enugu, it is possible that the payouts triggered by the rainfall index may have no correlation whatsoever with maize crop yield and revenue losses on the ground. As such the Prototype Excess Rain contract appeared to be very prone to basis risk.

21. ***The results from this pre-feasibility WII contract design and rating analysis suggest that the three-phase rainfall-deficit model does not perform very well under the high rainfall conditions*** experienced in most of the selected states/weather stations and that in the case of the excess rain contracts that there is a drawback of high basis risk. At this stage it is not possible to recommend the introduction of individual grower WII rainfall insurance to transfer drought and excess rain risks for maize and rice in Kaduna, Cross River, Lagos, and Enugu.

Other Issues related to Crop WII in Nigeria

22. The weather station network density in Nigeria is currently insufficient for the implementation of any commercial and scaled up weather index insurance program. The Nigerian Meteorological Agency (NIMET) has a weather station network that currently consists of 53 synoptic weather stations, 20 agro meteorological stations, 40 automatic weather stations, and 500 rainfall gauges distributed all over the country and covering almost all the agro ecological areas. While the 53 synoptic weather stations can apparently provide uninterrupted daily time series rainfall and temperature data for more than 25 years for the design and rating of weather index insurance products, it is understood that very few of the agro-meteorological and or the rainfall gauge stations can provide such historical rainfall data. This network, considering the area of the country and the fact that – according to the international experience – the measurement of (for example-) rainfall is normally valid for up to 25 kilometers radius around the weather stations, is totally insufficient for the commercial operation of WII.

23. A significant portion of crop production in Nigeria is performed through inter-cropping, which is not suitable to be insured through WII products. Mixed cropping or

[7] India is an important exception, where the Agricultural Insurance Company AIC has since 2007 offered both rainfall deficit and excess rainfall for Kharif (summer monsoon crops) under its Weather-Based Crop Insurance Scheme

intercropping is practiced by many small-holder farmers in much of the sub humid zone of Nigeria. Farmers' reasons for growing a mixture of crops which are planted at different dates are to minimize climatic risk, spread labor inputs, and reduce disease problems (Evans, 1960; Norman, 1974). Under sorghum, maize and soya mixed cropping, the maize crop in typically planted at the start of the wet season in late April or early May. Sorghum is then intercropped 2 to 3 weeks later and finally soya is planted in mid-June. For WII purposes it is not possible to offer three separate indexes for 3 different crops grown in the same plot of land and which have different planting dates (and therefore different inception dates for WII cover), different soil moisture water requirements (hence the need for different rainfall deficit indexes and indemnity payouts for each crop) and different risk profiles (and therefore different technical premium rates). WII is best suited to mono-cropping, but in the context of Nigeria, might possibly be developed for intercrops where coverage is provided for the main crop only.

Conclusions

The principle conclusion that can be drawn from this WII modeling exercise is that rainfall deficit (drought) is not the principle cause of maize and rice production and yield loss in the 4 selected states and that the 3-phase rainfall deficit model does not perform well for situations where average monthly rainfall during the growing season is relatively high and stable year on year and fully meets the water requirements of the crop**.** While these results are unexpected, they tend to match both the NAIC crop insurance results which show that drought has only accounted for about 9% of the total value of claims across the MPCI program over the past 4 years and also the diagnosis of the CADP management that drought was only a key exposure in Kano state and that the major causes of loss in the other states were pests and diseases and flood.

The preliminary modeling or excess rainfall exposure in maize using a three phase cumulative excess rainfall contract design produced a high number of modeled payouts, but these payouts bore no relationship at all to the actual yields recorded in each year. The results demonstrate the danger of basis risk where the excess rain payouts triggered by the weather index bear no relationship to the actual crop yield outcomes in the insured area. The relatively high inverse correlations between number of excess rainfall days with rain in excess of 50 mm/day and maize and rice yields suggest that further research should focus on a daily rainfall excess trigger rather than accumulated rainfall in each crop vegetative phase.

Although flood is the third most important cause of loss on the NAIC scheme, flood is a very difficult peril to index and to date there are no micro-level individual farmer flood crop index insurance programs in commercial implementation***.***

24. The pre-feasibility study into the design of WII rainfall contracts for maize and rice in 4 of the 5 CADP States has produced inconclusive results about the applicability or usefulness of these contracts. WII is only suitable to situations where there is a high degree of correlation between the weather variable and crop production and yields. This study has not been able to demonstrate this relationship. It must, however, be recognized that the absence of disaggregated weather-station location specific rice and maize crop production and yield data has precluded a more in-depth analysis of rainfall and yield correlations.

25. The implementation of WII for maize and rice in Kano, Kaduna, Enugu, Cross River, and Lagos is not technically feasible in the short term. The reasons for the non suitability of WII in Nigeria are multi-fold. The first reason is because the main risks faced by agricultural production in these selected states of Nigeria (pest and diseases, fire, and flood) are not subject of being indexed. The second reason is because, according to the analysis made during study, there is no significant correlation between weather variables that can be indexed –such cumulated rainfall or WRSI – and crops. The third reason because the implementation of a WII scaled up program cannot be implemented in the short term is because of the lack of an adequate weather station network density in Nigeria. Last but not least, most of the crop production in Nigeria (particularly the one performed by small and marginal farmers in central Nigeria) is performed under intercropping systems which are not suitable for WII

26. ***The applications of remote sensing technology can potentially be helpful for overcoming the problem of the lack of weather stations***. The uses of indexes based either on normalized deviation vegetation indexes (NDVI) and or on estimations of rainfall and evapo-transpiration based on satellite measurements, may help to overcome the problem of the lack of weather stations in Nigeria. This approach could be fundamentally in the semi-arid and arid regions of northern Nigeria. However, the authors believe that the applications of the remote sensing technology are most likely limited to meso and macro level applications of WII products. In the authors view, the application of remote sensing based WII on micro-level individual farmer insurance is not practical because of the difficulties of establishing tangible weather parameters that would generates the payouts for the coverage.

Recommendations

27. ***In order to create the basis for the development of weather index insurance by NAIC in Nigeria, weather station infrastructure and data information systems need to be improved.*** If significant investment were to be made in installing automated weather stations today, in the next 5 to 10 years these stations could hopefully provide sufficient weather data to begin constructing crop weather indexes for these stations. In conjunction, the agricultural crop production and yields data collection systems should to be urgently improved and data collected at the LGA level. Like for weather statistics, the process of generating crop production statistics is a long term goal.

28. ***To investigate possible applications of remote sensing for the development of NDVI/WII meso and macro level crop insurance applications in the northern arid and semi-arid areas of the country.*** The use of remote sensing methodology to satellite technology to measure drought conditions has been developing very fast in the recent times. Although its applications to crop index insurance need more research and product refinement, these methodologies offer the possibility of overcoming the problem of the lack of weather station network for the development of WII. The application of these technologies for weather index insurance purposes is currently being researched in Niger and other Sahel countries. The authors believe the macro level applications of WII based on remote sensing can be useful in the context of semi-arid and arid areas of north Nigeria. .

29. NAIC can promote the development of WII by promoting and financing research and development on WII product for agricultural activities and areas on which this product might be suitable. The NAIC can assign part of the annual budget to fund agro-meteorological research leading to product design and by supporting regular monitoring, evaluation, and impact studies.

30. The process of development of WII in Nigeria should actively involve NAICOM.

Chapter 1: Introduction and Objectives of the Study

Agriculture in Nigeria

Nigeria is Africa's most populous nation with a population of 158 million people, Gross Domestic Product, GDP of 194 billion and GDP per capita of US$ 1,222 in 2010. Agriculture is a very important source of employment and livelihoods and income in Nigeria: overall 50.2% of the population was classified as rural in 2010 and agriculture contributed for 33% of 2007 GDP and 45% of total employment in 2004[8].

Nigeria has a total land area of 910,770 km2[9] of which 86% is classified as agricultural land. The area of arable land is 37.5 million hectares (41% of land area) or an average of 0.25 hectares per person[10]. Approximately 19 million hectares of land are under cereal production. Average farm size is generally small at between 2 to 3 hectares per farming household. Major food crops include yams, cassava, maize, rice, sorghum and millet, cash crops include oil palm, ground nuts, citrus and other tree fruit and nuts[11].

Most of Nigeria's agricultural crops are produced under rain-fed conditions: irrigated agriculture accounts for less than 10% of total cultivated area. Agriculture is subject to a combination of climatic perils including drought, excess rain and flooding, biological perils (pests and diseases) and natural perils (including wild fires). In view of the high risks to agriculture, Nigeria's small and marginal farmers have developed a series of risk-copping strategies including intercropping of crops with different planting dates and soil moisture requirements (e.g. maize, millet and cow peas intercrops), use of local drought resistant seed varieties in preference to hybrid varieties, and low levels of purchased input utilization (fertilizers and plant protection chemicals).

Agricultural Insurance Provision in Nigeria

Agricultural crop (and livestock) insurance is often regarded as a risk transfer mechanism which will enable small farmers to access institutional credit with which to purchase production and yield enhancing technology (seeds, fertilizers etc) thereby enabling them to increase their farm incomes and consumption and savings.

In Nigeria a national agricultural insurance scheme was introduced by the Federal and State governments in 1987 under the Nigerian Agricultural Insurance Scheme (NAIS). In 1987 the Federal Government of Nigeria enacted legislation to create the Nigerian Agricultural Insurance Company Limited, a private limited company, with the mandate to underwrite and implement the NAIS. Under a 1993 amendment to the Act, the National Insurance Company Ltd was dissolved and replaced by a public-sector corporation, the Nigerian Agricultural Insurance Corporation, NAIC. Under the Act, NAIC was provide exclusive rights to underwrite subsidized agricultural crop, forestry, livestock, poultry and aquaculture insurance in Nigeria. NAIC was also licensed to underwrite non-life commercial insurance lines. The NAIS has received government support both in the form of the initial capitalization of the company and 50% premium subsidies on

[8] World Bank indicators for Nigeria: http://data.worldbank.org/country/nigeria
[9] This compares with the total surface area of 923,770 km2
[10] World Bank ibid
[11] FAOStat

agricultural insurance. NAIC's agricultural insurance scheme is closely linked to public sector credit provision: farmers accessing crop or livestock loans from national banks have to purchase compulsory agricultural insurance cover to protect the loans.

The NAIS has now been implemented for more than 20 years. The crop insurance scheme offers multiple-peril crop insurance protection against climatic and biological perils under a Loss of Investment Cost (LIC) Policy which indemnifies losses when the value of the remaining harvest (often termed the salvage) is inadequate to cover the costs invested in growing the crop. In practice the NAIC usually insures only the value of the credit loaned to the farmer and which is considerably lower than the total costs of production. Although the NAIS crop and livestock insurance programs have been offered throughout Nigeria for many years, the schemes have failed to achieve wide uptake and coverage of Nigeria's small and marginal farmers. The NAIC finds it very difficult to recover arrears of premium subsidies from government and in turn suffers from very high overhead fixed costs which amount to more than 50% of total premium. The crop insurance scheme has proved to be very costly to implement with individual farmers and NAIC has therefore in recent years actively been seeking to expand and diversify the range of products and services it offers to Nigeria's predominantly small and marginal farmers.

NAIC Request to the World Bank for Technical Assistance to Design Crop Index Insurance

In 2009, the NAIC requested technical assistance from the World Bank in order to develop index-based crop insurance products to complement its traditional indemnity-based loss of investment cost, LIC, policy. At that time, NAIC were seeking World Bank assistance to develop Area-Yield Index Insurance, AYII, which was seen as an appropriate product to offer to small and with marginal farmers at much lower operational and administrative costs than the individual grower LIC policy. The key distinguishing feature of AYII is that it both insures and indemnifies insured farmers against an area-based yield (the index) as opposed to indemnifying yield loss at the individual farmer-level and because pre-inspections and in-field loss assessment area not required, major cost savings in O&A costs can be realized.

The index insurance pre-feasibility study is closely linked to the World Bank funded Commercial Agriculture Development Project (CADP) which is operating in the five states of Kaduna, Kano, Lagos, Enugu and Cross River and with eight crop commodity value chains. The crop index insurance pre-feasibility study aims to assess the viability of index insurance in the five CADP states: four crops out of the eight were selected by local project management for study including rice, maize (corn), oil palm and cocoa.

A World Bank Mission to Nigeria was held in June 2009. The Mission noted that the development of AYII in Nigeria was highly dependent on (i) the availability of historical time-series local area (e.g. district or country) sown and harvested area, production and yield data: a minimum of 10 to 15 years area-yield data is required for setting the AYII insured yields and for rating purposes, and (ii) an accurate system for recording crop area, production and yields within each defined area. In Nigeria, two organizations are responsible for collecting crop production and yield data namely the Nigerian Bureau of Statistics (NBS) and The Ministry of Agriculture (MoA). Although these organizations can provide state-level estimates of the sown area, production and yields for field crops such as maize and rice, they do not appear to maintain records at a sub-state level, in this case at the Local Government Area (LGA) level[12]. The state is far too large a geographic area over which to operate AYII successfully because soil types, climate and crop production and yields vary widely across the states: AYII only works in smaller areas with homogenous cropping systems, production and yields. Reference to Table 1.1 shows that the geographical size of the 5 selected pilot States and total cultivated areas of maize and rice is very variable ranging from a low in Lagos State of 3,475 Km2 and less than 10,000 Ha of rice, to a maximum in Kaduna of 46,053 km2 and nearly 450,000 Ha of maize and 146,000 Ha of rice.

The main conclusion arising out of the 2009 Mission was that AYII could not be successfully implemented in Nigeria. In the absence of a nation-wide systematic and accurate procedure for recording crop sown and harvested area, crop production and yields at the LGA level, it was concluded that AYII could not be introduced successfully into Nigeria.

Table 1.1. State and LGA Areas and 2009 Planted Area of Maize and Rice, Pilot States

State	Area (Km2)	2009 State Maize Area (Ha)	2009 State Rice Area (Ha)	No. Local Government Areas (LGA)	Average Area per LGA (Km2)
Kaduna	46,053	449,000	146,000	23	2,002
Kano	20,131	185,000	106,000	44	458
Lagos	3,475	750	9,200	20	174
Cross River	20,156	143,000	66,400	18	1,120
Enugu	7,161	75,000	22,000	17	421
All Nigeria	**923,768**	**3,335,860**	**1,788,200**	**774**	**1,193**

Source: Administrative Area data from Wikipedia; Maize and Rice Production data collected from the state governments by the local consultants under this study

Scope and Objectives of the 2011 Weather Index Insurance Pre-Feasibility Study

In 2011, the World Bank has provided further technical assistance to the NAIC to conduct a pre-feasibility study for the design and implementation of weather index insurance (WII) in the five selected states. The specific objectives of this technical assistance include:

(1) To conduct a review of NAIC's existing crop insurance scheme and to assess the technical, financial and operational performance of the scheme based on information and statistics made available by NAIC;

(2) To assess the availability and quality of crop production and weather data for the purposes of designing and rating and implementing pilot weather index insurance (WII) in the five selected states and to advise whether the weather station measurement and recording systems and procedures meets the standards required by international reinsurers for operating WII insurance;

[12] In Nigeria the following administrative areas are recognized: (1) States: in 2011 there are 36 states and Abuja the Federal Capital Territory. The states are divided into 774 Local Government Areas (LGU) and then each LGU is further sub-divided into Wards. There is an average of 10 to 15 Wards per LGU.

(3) To use the crop and weather data collected by the local consultants for the five states to assess the viability of developing weather index insurance, WII, prototypes for rice and maize grown in these pilot states and to present the findings;

(4) To conduct an initial assessment of the legal and regulatory, institutional, operational and financial issues and challenges which would need to be addressed under a feasibility study for WII in the five selected states.

(5) On the basis of this study to advise on the feasibility or otherwise of designing and implementing WII in the five selected states of Nigeria.

A second Mission to Nigeria was carried out between March 20 and March 24 2011. During this Mission, meetings were held with NAIC and other key stakeholders including most notably the Nigerian Meteorological Agency (NIMET) in order to access time series daily weather data for selected synoptic meteorological stations in the five states. Meetings were also held with the World Bank funded Commercial Agricultural Development Project, CADP, management to brief them on the aims and objectives of the WII Pre-feasibility study and to confirm with them that the study would be limited to two cereal crops rice and maize for which WII might be an appropriate crop insurance product (as such oil palm and cocoa were removed from the scope of this study)[13]. In addition, meetings were held with the local appointed consultants, the International Centre for Energy, Environment & Development (ICEED), and a work program agreed with them. Subsequent to the Mission there were major delays in the collection of local weather and crop production data which has delayed the preparation of this report. Data quality issues are identified as a major constraint to the implementation of this Pre-Feasibility study.

The current WII pre-feasibility study is being financed by the Global Index Insurance Facility, GIIF, which is managed by the International Finance Corporation (IFC) for market-focused activities and the IBRD for policy and regulatory capacity building.

Report Outline

This report is set out in five chapters including this Introductory Chapter. Chapter 2 provides a review of NAIC's crop and livestock insurance scheme based on data which has been made available by the company. As the terms of reference for this study did not include a review of field based operating systems and procedures, these aspects are not covered in this review. Chapter three presents a review of weather index insurance in Africa and the issues and lessons which are relevant to Nigeria and highlights the issues and challenges for introducing WII into Nigeria. This is followed in Chapter 4 by a preliminary assessment of the suitability of WII products for rainfall deficit and excess rainfall cover in rice and maize grown in the five pilot states, using the World Bank's training tool IBIS to illustrate WII contract design and rating principles. Finally, Chapter 5 considers the legal, institutional, operational and financial options and issues for the introduction of WII into Nigeria.

[13] During the meetings with CADP the key risk exposures in the four identified crops, rice, maize, oil palm and cocoa were reviewed and it was concluded that WII would <u>not</u> be appropriate for (i) oil palm where the key risk exposure is fire and (ii) in the case of cocoa, pests and diseases including most importantly black pod disease: neither of these perils lend themselves to indexation. It was therefore agreed to restrict the study to rain-fed maize and rice. This decision was subsequently approved by NAIC

Chapter 1: Overview of Agricultural Insurance Provision in Nigeria

This Chapter is primarily devoted to a review of the Nigerian Agricultural Insurance Scheme, NAIS which is implemented by the public-sector agricultural insurer, The National Agricultural Insurance Corporation, NAIC. To begin with, however, the Chapter presents a short overview on agriculture in Nigeria and climate and key climatic and other risk exposures.

Agriculture in Nigeria

Agriculture is a very important economic and social sector in Nigeria. Agriculture employs about two-thirds of Nigeria's total labor force, contributed 42.2% of Gross Domestic Product (GDP) in 2007; and provides 88% of non-oil revenue earnings. The agricultural GDP is contributed by crops (85%), livestock (19%), fisheries (4%) and forestry (1%). More than 90% of the agricultural output is accounted for by small-scale farmers with less than two (2) hectares under cropping.

Nigeria is well endowed with natural resources for agricultural production. The country has diverse and rich vegetation capable of supporting a large livestock population. . It is estimated that about 75% (68 million ha) of the total land area has potential for agricultural activities with about 33 million hectares under cultivation. Similarly, of the estimated 3.14 million ha of irrigable land area, only about 220,000 ha (7%) is utilized.

The main cereal crops grown in Nigeria are sorghum (guinea corn), millet, maize (corn), wheat and rice. Millet, sorghum, and wheat are produced in the drier savanna north, and corn is commonly grown in the middle and southern part of the country where there is higher rainfall and two cropping seasons which permits two maize crops to be grown per year. Sorghum is Nigeria's most widely cultivated grain, accounting for more than 45 percent of the total arable area. Sorghum cultivation spans from the north to the middle belt where precipitation and soil moisture levels are low. Nigeria is nearly self-sufficient in sorghum production and it is West Africa's largest rice producer. Rice cultivation is widespread in Nigeria, extending from the northern to southern zones, and most rice is grown under upland or lowland production systems in the eastern and middle belt of the country.

Nigeria's climate permits the cultivation of a variety of crops in a pattern that emerged in earlier centuries in response to local conditions. As in other West Africa states, rainfall is heaviest in the south, where the forests and savannas benefit from abundant precipitation and relatively short dry seasons. The staples are root crops, including cassava, yams, taro (*cocoyams*), and sweet potatoes. Tree crops--cocoa, oil palm, and rubber--constitute the area's main commercial produce. Cocoa grows mostly in the southwest. Oil palm cultivation predominates in the southeast and in the south-central area of Nigeria. Rubber plantations are common in south-central and south-eastern Nigeria. The northern third of Nigeria, which experiences a dry season of five to seven months, during which less than twenty-five millimeters of rain falls, lies mostly in the Sudan savanna and the arid Sahel zone. There, the staples are millet, cowpeas, and a drought-resistant variety of sorghum known as guinea corn. Maize is also cultivated, as well as rice in suitable lowland areas. The north's principal commercial crops are cotton and groundnuts. Between the arid north and the moist south lies a Guinea savanna region sometimes referred to as the middle belt. This area produces staples such as yams, sorghum, millet, cassava, cowpeas, and corn, with rice an important crop in some places. The middle belt's southern edge represents the lower limits of the northern grain-dominated economy. The most significant commercial crop of the middle belt is sesame.

The performance of Nigeria's agriculture has been mixed over several decades. Productivity has not grown sufficiently, due largely to underinvestment in new technology, slow adoption of existing improved technologies, constraints associated with the investment climate, and lagging infrastructure. Public interventions to accelerate agricultural growth have targeted poor producers engaged in largely subsistence production with modest interaction with markets.

Climate and Key Risk Exposures to Agriculture

Climate

The climate of Nigeria is determined by two main drivers including: (i) tropical convection (the annual migration of the Inter Tropical Convergence Zone ITCZ) and (2) the West African Monsoon (WAM) both of which determine the seasonal patterns of temperature and rainfall. There is a third but more irregular influence namely that of the El Niño Southern Oscillation (ENSO). El Niño is associated with droughts and La Niña with cold wet weather. The migration of the ITCZ north and south leads to 4 distinct climatic zones in Nigeria:

- Tropical moist climates with ~2000 mm of rain distributed through the year that support the equatorial rainforest
- Tropical climates with 1000-2000 mm annual rainfall that alternate between wet summers(brought by the ITCZ) and short dry winters;
- Tropical semi-arid climates, with rainfall of 300-800 mm with a marked summer rainy season and with a long dry season of six months, at the northernmost limits of the ITCZ
- Arid climates located 30°-40° north and south, with less than 250 mm year rainfall (Conway 2009).

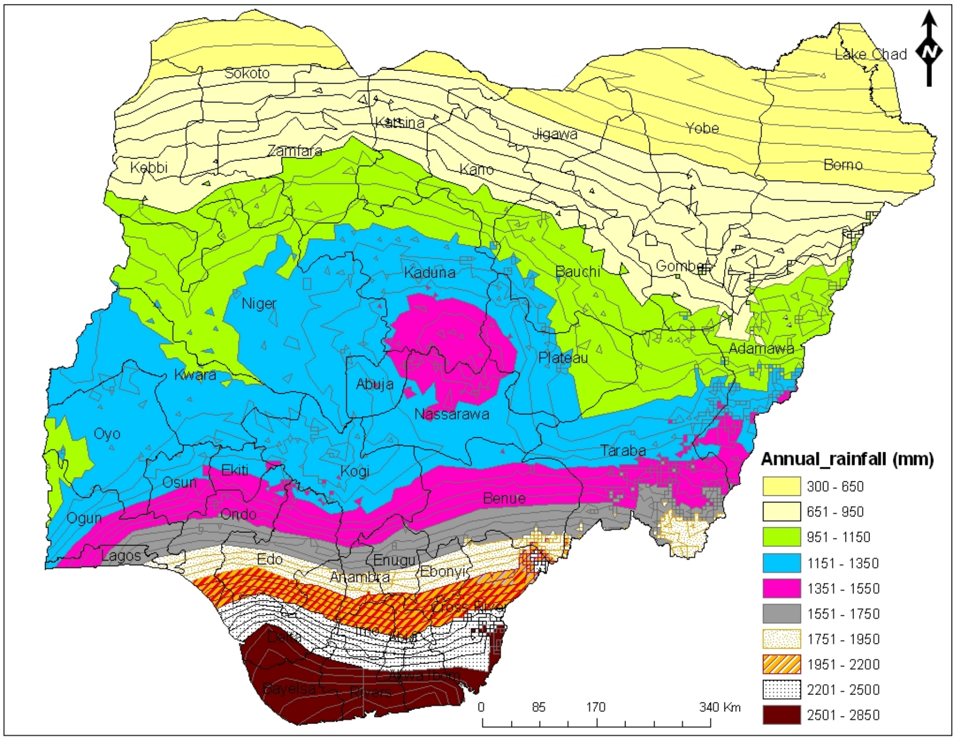
In Nigeria there is a marked declining rainfall gradient from south to north. In the south bordering the Gulf of Guinea and the Atlantic Ocean, annual average rainfall is between 2,500 mm and 3,000 mm while 100 km to the north rainfall is between 350 mm and 650 mm per year (Figure 2.1). Omogba (2010) classifies Nigeria into 6 homogeneous rainfall zones, with Cross River (Calabar) and Enugu falling in the South East Rainfall Region and Kano and Kaduna into the Northern 2 Region.

Table 2.1. Homogeneous Rainfall Zones, Nigeria

No.	**Rainfall Region**	**Weather stations**
I	Northern Region 1	Sokoto, Kastina, Potiskum, Maiduguri
II	Northern Region 2	Minna, **Kaduna**, **Kano**.
III	Northern Region 3	Jos, Bauchi, Yola
IV	Northern Region 4	Markudiri, Lokoja, Ilorin
V	South West Region	Oshogbo,
VI	South East Region	Benin, **Enugu**, Port-Harcourt, **Calabar**

Source: Omogbu 2010

Figure 2.1. Rainfall Isohyets May of Nigeria (mm)



Source: ICEED 2011

Climate and rainfall patterns vary widely in the 5 CADP selected states for this WII study. The annual average rainfall for the 5 states is shows in Table 2.2 and Figure 2.2. Cross River State enjoys a tropical moist climate with annual average rainfall of 2,871 mm per year and a peak of 3,771 mm in 2005, while the four remaining states Enugu, Lagos (Ikeja) and Kaduna have tropical climates with rainfall between a low of 1,036 mm/year (Kano) and 1,719 mm (Enugu) per year.

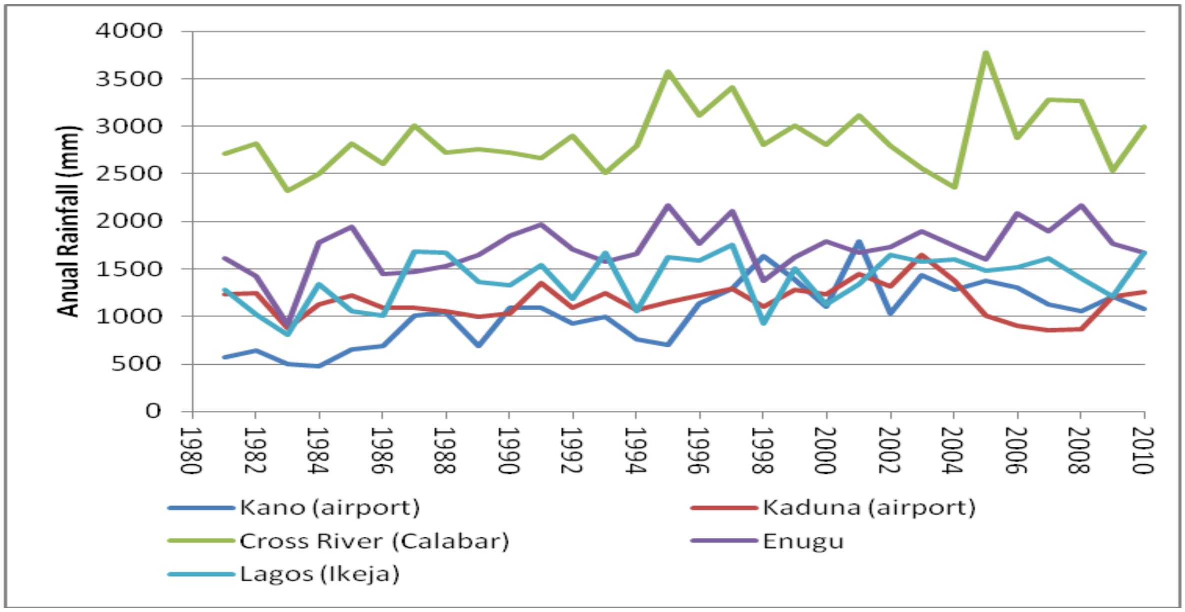
There have been no significant rainfall trends over the past 30 years at the selected station save for Kano airport which exhibits an unexplained average increase in rainfall since 1995. The Kano rainfall data contain many inconsistencies and the major increase in annual average rainfall of nearly 70% since 1995 is inconsistent with all other stations including Kaduna.

Table 2.2. Annual Rainfall statistics, selected stations, 1981 to 2010 (mm)

Item	Kano (airport)	Kaduna (airport)	Cross River (Calabar)	Enugu	Lagos (Ikeja)
Average	1,036	1,165	2,871	1,719	1,387
Stdev	329	178	340	261	265
COV %	32%	15%	12%	15%	19%
Min	474	856	2,319	917	804
Max	1,789	1,643	3,771	2,171	1,750

Source: NIMET rainfall data

Figure 2.2. Annual Rainfall Selected Weather Stations 1980 to 2010 (mm)

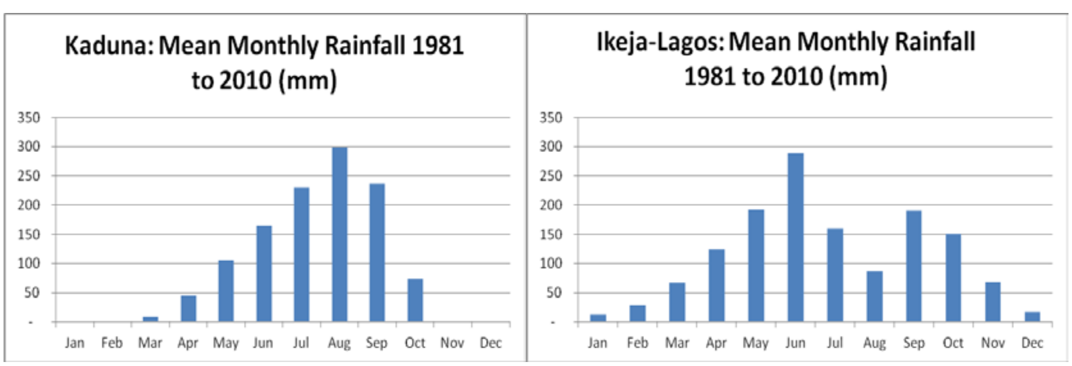


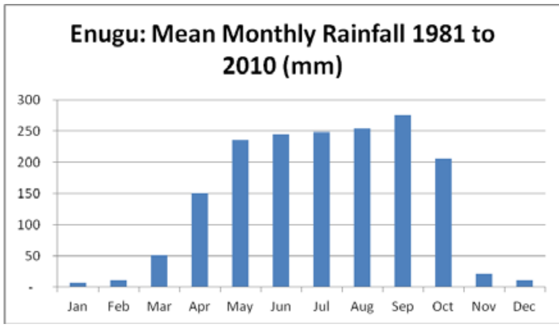
Source: NIMET

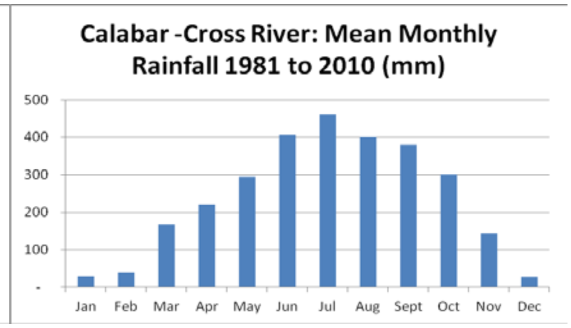
Climate and Cropping Seasons

The summer monsoon starts in southern Nigeria at the end of March start of April and migrates north reaching Kaduna and Kano in May before retreating again in September/October. In Kaduna and Kanu there is only a single cropping season from May to September followed by a marked winter dry season from November through to March. (Figure 2.3) these two northern states there is only a single cropping season. Conversely in the southern states which have a longer rainy season from March to October, double cropping is available: the first season is from April to end July followed in Lagos State (Ikeja Station) by a marked dry month of August and then increased rainfall from September to November permitting a second crop to be sown (Figure 2.3). Rainfall at Enugu and Cross River (Calabar) is also distributed from March to end October and this again permits two annual crops to be grown. The latter two states do not exhibit a dry August.

Figure 2.3. Mean Monthly Rainfall Selected Weather Stations 1981 to 2010 (mm)







Source: NIMET

Climate Fluctuations and Climate Changed

The Sahel Region is known for being subject to significant fluctuations in rainfall levels lasting for several decades. The period 1970 to 1990 saw declining annual rainfall in the Sahel region by as much as 15% to 30% and the shift of the Sudanese and Guinean ecological zones 25 to 35 km south with the loss of valuable grassland and savannah lands and other natural resources (Conway 2009; Abaje et al 2010). Since the mid-1990s there has been a trend for increased average rainfall in the Sahel area.

Climate change in West Africa is predicted to lead to significant increased in temperatures over the next 50 years and also to lead to an increase in the frequency and severity of droughts and floods. For example, in 2007 severe flooding occurred in across the Sahel in July and August. The floods were caused by heavy rainfall and thunderstorms within the rain belt of the Inter Tropical Convergence Zone, ITCZ, which was much further north than usual. Much of the land was dry from previous years of drought and the record level of rainfall resulted in high levels of run-off and flooding (Conway 2009).

In West Africa agriculture will be adversely affected by higher temperatures and more erratic and reduced rainfall. High temperatures and lowered rainfall will reduce crop production and yields and will also shorten the growing period thereby reducing the chances of a second crop in some areas and even the viability of a single crop in the most northerly regions (Conway 2009, Care 2007). As 90% of Nigeria's agriculture is rainfed, increased temperatures and reduced rainfall is likely to lead to changes in cropping patterns in the more northern regions with a reduction in the cultivated area of maize and millet and a switch to more drought tolerant crops such as sorghum and cow-peas. Root/tuber crops are very important in the farming systems of Ghanaian farmers, both as a staple crop and for cash income: adverse climate change impacts (which include increased pest incidence in drought years) may significantly reduce cassava and cocoyam production. Tree crops such as cocoa are also susceptible to drought which kills the seedlings and reduces productivity and yields and erratic and excess rainfall may lead to higher incidence of pests and diseases of cocoa.

Key Risk Exposures to Agriculture

The majority of agriculture in Nigeria is rain fed and suffers from the cumulative effects of climatic, biological, and natural events. There is very limited information in Nigeria on crop area and production losses dues to different perils. However, the National Agricultural Insurance Corporation, NAIC maintains information of the causes of loss on its multiple peril crop insurance program. The main cause of insured losses to agricultural production in Nigeria is **pest and diseases**, followed in second by **floods** which are associated with excess rainfall. This is followed in third place by **fire** (which is often influenced by man-made factors) and **drought** in fourth place. The relatively low drought exposure is related to the fact that much of Nigeria enjoys a Tropical climate and therefore rainfall levels are high and drought is not a major risk exposure.

Weather Index insurance, WII is best suited to insuring against excess rainfall or deficit rainfall (drought). ***WII*** is not able to insure against fire in crops or pests and diseases (See Chapters 3 and 4 for further discussion).

Features of the Nigerian Agricultural Insurance Scheme (NAIS)

Legal Framework

The origins of agricultural insurance in Nigeria date back to the formation of the Nigerian Agricultural Insurance Company in June 1988 as a private insurance company to underwrite crop and livestock insurance.

Under the Decree No. 37 of 1st June 1993[14], the Nigerian Agricultural Insurance Company was dissolved and replaced by a public sector entity, the Nigerian Agricultural Insurance Corporation (NAIC) which is wholly government owned. The decree set out the legal and regulatory framework and corporate and financial structure of NAIC and the conditions under which agricultural crop and livestock insurance would operate in Nigeria. The decree authorized the NAIC to underwrite crop and livestock insurance and also other classes of non-life insurance business.

The NAIC is responsible for implementation of public-sector subsidized agricultural insurance in Nigeria under the Nigerian Agricultural Insurance Scheme (NAIS). This Scheme was established in 1987 as part of the government's efforts to enhance and sustain food production in Nigeria. The NAIS has four main objectives**.** The first objective is to provide financial support to farmers where a loss to crops and livestock production arises from the occurrence of natural hazards. The second objective is to stimulate the provision of rural credit by financial institutions as the insurance cover acts as added collateral to the rural credit. The third objective is to promote agricultural production by giving farmers confidence to accept new/ modern innovations and inputs. The fourth and last objective is to minimize or eliminate the need for Government to provide ad hoc assistance to farmers during natural disaster affecting agricultural production.

Under the NAIS farmers taking credit from Government, banks or other financial institutions must mandatorily take out agricultural insurance. The NAIS establishes agricultural insurance as mandatory for: (a) all agricultural loans; (b) all agricultural projects/ programmes that are assisted , supported or fully funded from public funds; (c) all direct and on-lending loans taken by Federal, State or Local government for disbursement to farmers; (d) all forms of loans for agricultural marketing purposes by all banks and non-bank lending agencies; and (e) all direct, on-lending and investment loans disbursed by the Nigerian Agricultural and Cooperative Rural Development Bank (NACRDB).

The Decree of 1993 established the provision by government of premium subsidies for agricultural insurance, whereby the farmer pays 50% of the chargeable premium while the

[14] Nigerian Agricultural Insurance Corporation Decree No. 37 of 1993, Laws of the Federation of Nigeria

balance of 50% is shared between the Federal and respective State governments in the ratio of 37.5% and 12.5% for policies that fall under the subsidized category of (NAIS). Subsidies are provides for food crops, cereals and root crops, but not for commercial plantation crops and cash crops: similarly premium subsidies are applicable to most classes of livestock, poultry and fisheries (aquaculture), but not for commercial livestock insurance such as horses and dogs. (See Annex 1 for full list of subsidised and non-subsidised crops and livestock).

The decree also sets out the provision for the Federal Government to accept the liability for catastrophe losses incurred by NAIC. Article 12 stipulates that NAIC is responsible for settling losses up to 200% of the premium income for each class of insurance covered, and that Federal Government will settle all losses above 200% of the premium. In other words, the Decree commits the Federal Government to provide "free" (i.e. at no premium charge) excess of loss reinsurance for any losses greater than a loss ratio of 200%.

Organisation, Management and Staffing

NAIC has an operational presence all over the country. NAIC's network includes branch offices in 36 States of the Federation, six Zonal Supervisory offices in Abeokuta, Bauchi, Katsina, Minna, Owerri and Asaba, in line with the agro-ecological zones of the country, and a Head Office in Abuja. The total staff complement is more than 500 persons but because of the restricted premium volume, a high percentage of NAIC's premium is consumed by administration and operating overhead expenses[15]. The composition of NAIC's headquarters staff for the past two years is shown in Table 2.3 and it is understood that there are a comparable number of staff in NAIC's zonal and state-level offices.

Table 2.3. NAIC Headquarters Staff complement 2009 and 2010

Year	Managerial	Senior	Junior	Total
2009	17	125	73	215
2010	20	150	75	245

Source: NAIC Annual Reports 2009 and 2010.

Institutional Linkages with Credit

NAIC's main linkage is with the banks and other credit institutions operating in the rural areas. The main credit institution is the National Agricultural Cooperative and Rural Development Bank (NACRDB), but NAIC also has business relationships with other national and state-level banks. Bank lending to agriculture in Nigeria remains low, despite agriculture's central importance to the Nigerian economy. To illustrate this point, only 1.4% of Nigeria's total bank lending goes to agriculture, in spite of agriculture accounting for approximately 40% of Nigeria's GDP, and 60% of Nigeria's employment. The recently launched Nigerian Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL) which is being implemented by the Central Bank of Nigeria (CBN) aims to stimulate bank lending to agriculture by de-risking the agricultural financing value chain. The program aims to create an additional US$ 3 billion of lending to agriculture by 2015 (discussed further below).

Under the Decree No 37 of 1st June 1993 farmers accessing crop and livestock credit are obliged to purchase crop and livestock insurance protection on these loans. According to

[15] According to figures presented in NAIC's 2009 Annual Report and Accounts, NAIC's Management Expenses amounted to a very high percentage of Total Gross Premium namely 53% (2009) and 62% (2008)

NAIC the rationale for making the scheme compulsory for farmers obtaining institutional credit centres on:

(a) Institutional lenders would be encouraged to lend more for agricultural production because of added security of insurance for the loans

(b) Farmers will be encouraged to take more credit for increased agricultural production when provided with insurance cover against natural hazards

(c) Bank loan repayment will improve because of added supervision of farmers' activities by the insurance company and other institutions participating in the operation of the Scheme.

(d) Administration of the Scheme is made simple because:

- **(i)** Services of existing financial institutions will be utilized
- **(ii)** Premium will be built in and deducted straight from the loan for remittance to the insurance company. (Yusuf 2010).

NAIC's zonal and state-level offices have close links to the banks operating in their areas. Their main channel for policy sales is through the Banks which automatically issue the farmers with a crop or livestock insurance policy at the time of authorising their loans. NAIC proposal forms are intended to be completed by the bank loan officers and these are then forwarded to NAIC for processing and policy issuance (FAO 1994, NAIC 2010).

NAIC Crop and Livestock Insurance Products and Programs

NAIC's agricultural insurance activities are divided into three main categories: crop insurance, livestock (including poultry and fisheries) insurance and commercial lines. In addition, the company underwrites a large non-life general insurance portfolio. This section reviews the main features of these programs.

Crop Insurance

In the case of crops, NAIC offers a single salvage-based Loss of Input Cost (LIC) crop insurance policy that provides multiple-peril crop insurance (MPCI) protection against a wide range of natural, climatic and biological perils including fire, drought, flood, windstorm and pest and diseases perils for arable crops, fruits and horticulture (Table 2.5.). In the event of a claim, the payouts of the input cost insurance contract are determined by the difference between the input costs invested by the Insured farmer up to the moment of the loss and the value of the actual remaining harvestable production (or the salvage) obtained by the Insured on its Insured unit. During the period 2007 to 2010 premium rates paid by the farmer for crop insurance varied from 2 percent of the sum insured for subsidized crops (average gross rates of about 4.0%) and 1.5 percent for unsubsidized commercial crops.

Livestock Insurance

Livestock insurance covers the death or injury due to accident, disease, fire, lightening, storm, and flood. The sum insured for livestock insurance is defined by the value of the animal at inception plus the input cost invested by the Insured in the insured animal during the policy period. Premium rates for subsidized livestock insurance are about 2.5 percent of which the livestock owner pays about 1.25% (50% subsidy).

Table 2.5. Insured Perils by Class of Agricultural Insurance

Class of Business	Insured Perils
CROPS*	Fire, Lightning, Windstorm, Flood, Drought, Pests and Diseases
LIVESTOCK	Death or injuries to the livestock due to Accident, Disease, Fire, Lightning, Storm and Flood
FARM PRODUCE	Fire and Special Perils, Transit Risk and Burglary

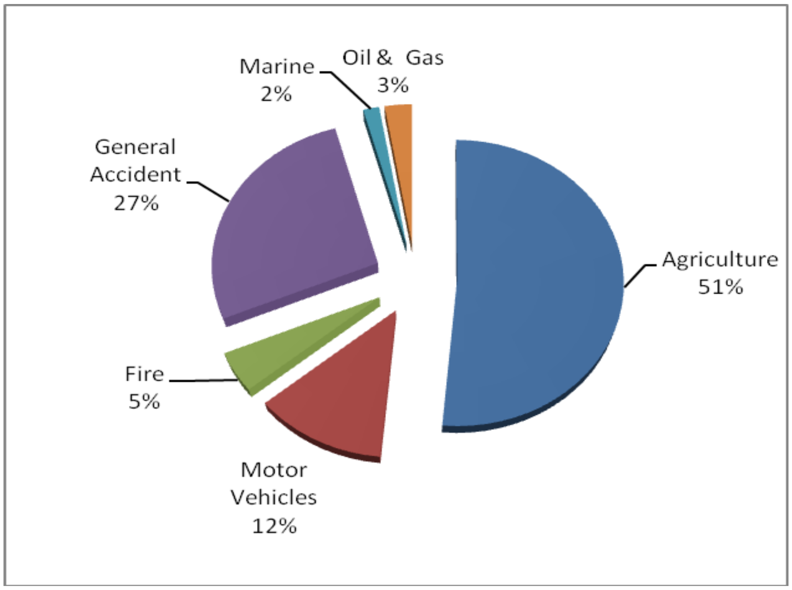
Source: Yusuf 2010[16]

Note: * According to Decree 37 of 1993, Crop cover included pests, but diseases are not mentioned and one additional peril, "invasion of the farm by wild animal"

Business Premiums

In 2010 NAIC's total gross written premium income GWP amounted to NGN 866.5 million (US$ 5.7 million)[17] of which slightly over half or 51% of GWP was generated by subsidized and non-subsidized agricultural insurance lines and the remaining 49% of GWP was generated by commercial lines of which general accident was the most important (27% of GWP), followed by Motor (12% of GWP) and fire (5% of GWP). (See Figure 2.4 for details).

Figure 2.4. NAIC 2010 Gross Written Premium, GWP, by Class of Business (% of total GWP)



Source: NAIC 2010 Accounts

[16] Yusuf, K.K. 2010. *Insurance Options in Risk Management in Agriculture Finance*. Paper presented on the Occasion of the AFRACA Conference in Abuja. May 2010.
[17] At a 2010 average exchange rate of Nigerian Naira (NGN) 152 = US$ 1.00

NAIC Crop and Livestock Insurance Operating Systems and Procedures

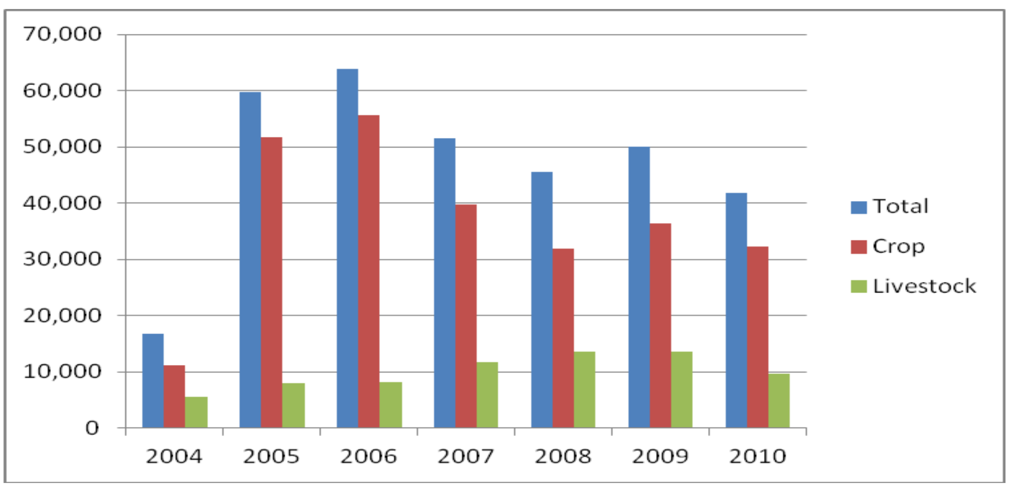
NAIC has a very comprehensive set of Underwriting Manuals and Operating Procedures forms. Over the past 23 years, NAIC has developed a very comprehensive series of agricultural insurance policy wordings, and underwriting forms and procedural manuals which conform to international best practices. The Salvage-based loss of investment costs crop insurance policy ("Investment cost policy" for short) is a well known product which has been extensively underwritten in Mexico for many years and also several other countries use this policy. The main advantage of the Loss of investment cost policy is that it can be implemented in situations where conventional loss of yield MPCI cannot be offered because of a lack of individual farmer time series yield data on which basis to construct an insured yield. The Loss of Investment cost cover is also popular with farmers because it provides comprehensive multi-peril cover including protection against uncontrollable pests and diseases.

NAIC Crop and Livestock Insurance Uptake and Coverage

Policy Sales

The development of policy sales over the past 7 years (2004 to 2010) is shown in Figure 2.5. At its peak in 2006, NAIC sold a total of nearly 64,000 crop and livestock insurance policies to Nigerian farmers, but since then total sales have declined to slightly over 40,00 in 2010. The volume of sales of crop insurance policies is about three times the number of livestock policy sales. It is not possible to report the numbers of insured farmers, because NAIC advise than often a single policy may include between 100 and 500 farmers[18].

Figure 2.5. Number of crop and livestock insurance policy sales (2004 to 2010)



Source: World Bank Survey 2008 and NAIC 2011

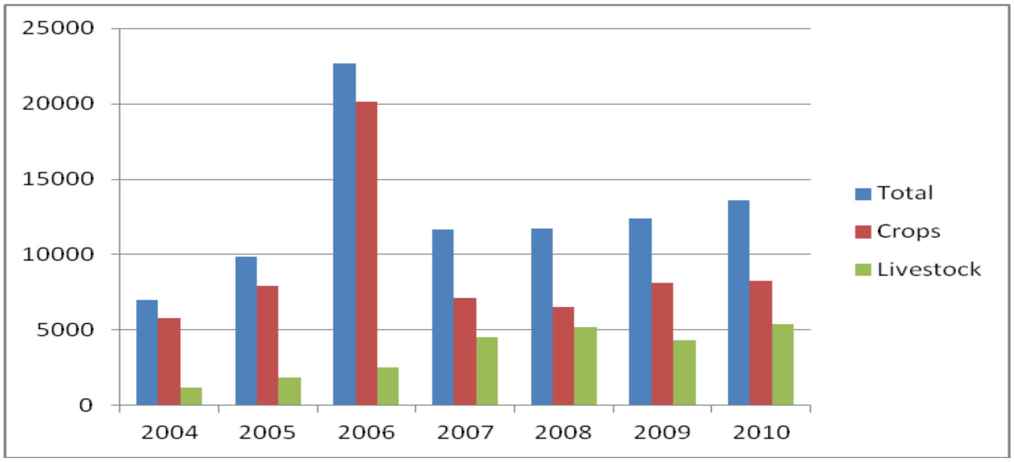
NAIS Liability (Total Sum Insured)

According to NAIC's figures over the past 7 years, the total liability on the NAIS peaked at Naira 22.7 billion (about US$ 177 million) in 2006 before levelling out at between Naira 12 billion and Naira 13.5 billion over the past four years Figure 2.6). The major increase in scheme liability in 2006 applied only to the crop insurance program where the average sum insured per hectare was

[18] NAIC 2008 replies to World Bank Agricultural Insurance Survey.

nearly double that of the previous year at an average of nearly Naira 106,000 per hectare (US$ 825/Hectare). Over the 7 year period the average sum insured per hectare has been Naira 66,000 per hectare (US$ 566/Ha) on the crop insurance scheme which seems very high for a program which predominantly underwrites cereals and food crops.

Figure 2.6. NAIS Total Sum Insured by Year and Class of Agricultural Insurance 2004 to 2010 (Naira Million)

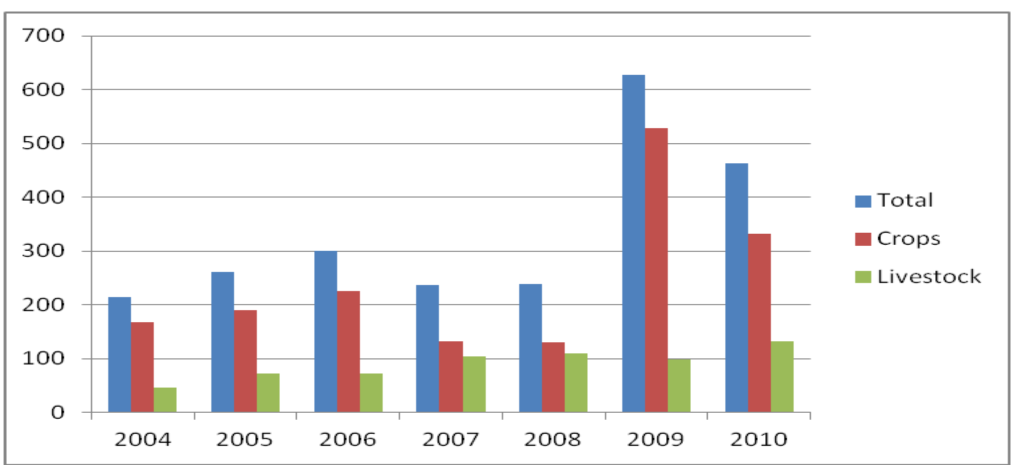


Source: World Bank Survey 2008 and NAIC 2011

NAIS Premium and Average Premium Rates

There has been a very significant increase in the agricultural insurance premium volume generated on the NAIS over the past two years with a peak premium of Naira 628 million (US$ 4.2 million) in 2009 and premium of Naira 464 million (US$ 3.1 million) in 2010. This increase in premium has applied specifically on the crop insurance programs where NAIC has increased the average premium rates significantly in the past two years (Figure 2.7.).

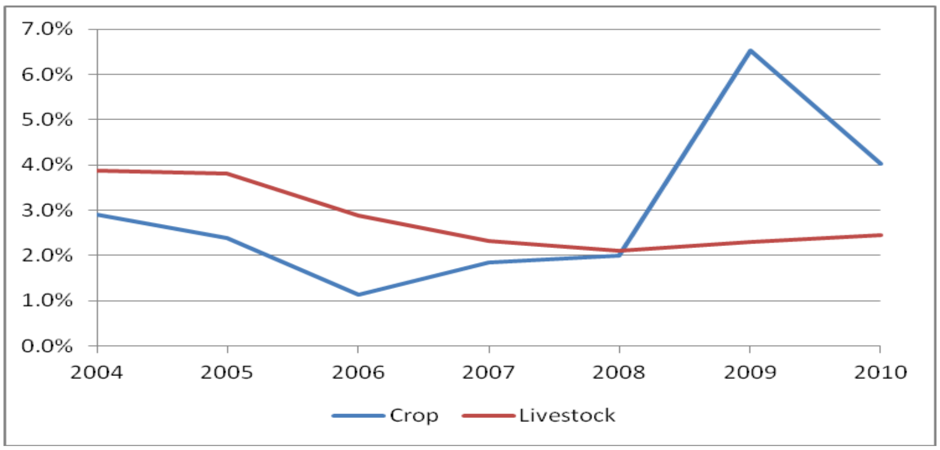
Figure 2.7. NAIS Premium by Year and Class of Agricultural Insurance 2004 to 2010 (Naira Million)



Source: World Bank Survey 2008 and NAIC 2011

The evolution of average annual premium rates for crops and livestock on the NAIS scheme from 2004 to 2010 are shown in Figure 2.8. Between 2004 and 2007 average crop insurance premium rates were below 3.0% but in 2009 the average rate was more than doubled to 6.5% before falling back to an average of 4.04% in 2010. The reasons for the major increase in crop insurance premium rates in the past 2 years is not known because this does not appear to be related to the claims performance in any way. For livestock, the long-term 7-year average premium rate from 2004 to 2010 has been 2.55% with range from an average high of 3.88% in 2004 to an average low of 2.11% in 2008. According to NAIC, the agricultural insurance premium rates were originally fixed arbitrarily by Government and the Corporation hopes that over time with the generation of adequate data by the scheme, the premium rates shall be actuarially determined (Yusuf 2010)[19].

Figure 2.8. Average Annual Premium Rates Crop and Livestock Insurance (% of sum insured)



Source: NAIC 2011 (Full details presented in Annex 1)

NAIC Crop and Livestock Insurance Financial Results

NAIC's agricultural insurance portfolio shows very good technical results over recent years. Table 2.6. presents a summary of NAICs crop and livestock and overall agricultural insurance results for the 7 year period 2003 to 2010. The analysis is based on two sources (i) the data from 2004 to 2006 were provided by NAIC to the World Bank under the 2008 global survey of agricultural insurance provision[20], while the 2007 to 2010 figures were supplied by NAIC in March 2011 under this current study. While the 2003 to 2006 figures provide a breakdown of claims by crops and livestock, for the period 2006 to 2010 NAIC could only provide total crop and livestock insurance claims. As such it is not possible to analyse the performance of the crop and livestock insurance programs separately.

[19] It is noted that the average premium rates do not appear to relate to the current government fixed premium rates quoted by Yusuf 2010 of 2.5% for livestock, 2.0% for crop and 1.5% for farm produce.
[20] The results of this study are presented in Mahul and Stutley 2010.

1.1 Table 2.6. NAIC Agricultural Crop and Livestock Insurance Results 2004-10

Crops

Under-writing Year	No. Policies (000)	Area (000 hectares)	Sum Insured (Million Naira)	Premium (Million Naira)	Average Premium Rate %	No. Claimed Policies	Paid Claims (Million Naira)	Loss Ratio (%)
2004	11.2	169.0	5,766	167.9	2.91%		5.8	3%
2005	51.7	211.6	7,957	189.3	2.38%		22.4	12%
2006	55.7	190.4	20,117	226.6	1.13%		6.3	3%
2007	39.8	158.7	7,151	132.1	1.85%			
2008	31.9	63.9	6,522	130.0	1.99%			
2009	36.3	60.9	8,112	529.1	6.52%			
2010	32.2	112.4	8,229	332.2	4.04%			
Totals	**258.9**	**966.8**	**63,853**	**1,707.1**	**2.67%**			

Livestock

Under-writing Year	No. Policies (000)	No Insured Animals / Birds (000)	Sum Insured (Million Naira)	Premium (Million Naira)	Average Premium Rate %	No. Claimed Policies	Paid Claims (Million Naira)	Loss Ratio (%)
2004	5.6	167.7	1,216	47.1	3.88%		3.7	8%
2005	8.1	3,773.0	1,883	71.8	3.81%		4.5	6%
2006	8.2	181.2	2,542	73.4	2.89%		16.6	23%
2007	11.8	2,530.9	4,506	104.8	2.33%			
2008	13.6	3,454.5	5,185	109.4	2.11%			
2009	13.7	4,272.7	4,304	99.0	2.30%			
2010	9.7	1,530.9	5,362	131.4	2.45%			
Totals	**70.6**	**15,911.1**	**24,998**	**636.9**	**2.55%**			

Total Agriculture

Under-writing Year	No. Policies (000)		Sum Insured (Million Naira)	Premium (Million Naira)	Average Premium Rate %	No. Claimed Policies	Paid Claims (Million Naira)	Loss Ratio (%)
2004	16.9		6,982	215.0	3.08%		9.5	4%
2005	59.8		9,840	261.2	2.65%		26.9	10%
2006	63.9		22,659	300.0	1.32%		22.9	8%
2007	51.6		11,657	236.8	2.03%		63.4	27%
2008	45.5		11,707	239.4	2.05%		102.1	43%
2009	50.0		12,416	628.1	5.06%		127.5	20%
2010	41.9		13,591	463.6	3.41%		104.8	23%
Totals	**329.5**		**88,851**	**2,344.0**	**2.64%**		**397.8**	**17%**

1.2 Source: 2004 to 2006 figures World Bank 2008 survey; 2007 to 2010, NAIC 2011

Over the past seven years NAIC has underwritten a total of slightly over 329,000 agricultural crop and livestock insurance policies with Total Sum Insured TSI of Naira 89 billion (US$ 669 million) against total premium of Naira 2.3 billion (US$ 17.1 million) with an implied average premium rate of 2.64%. Over this same period the company has paid out a total of Naira 398 million in claims with a 7-year long-term loss ratio of only 17%.

The most striking feature of NAIC's results are that over the past 7 years the company has charged a very low average premium rate of only 2.64% over its agricultural insurance

portfolio, but has been able to achieve an average loss ratio of only 17% on a portfolio which is predominantly comprised of catastrophe-peril crop insurance. Over the 3 years 2004 to 2006 for which claims are available for NAIC's crop portfolio, the company incurred annual loss ratios of between 3% and 12% maximum which makes it the World's most technically successful individual-grower multiple peril crop insurance program which insured catastrophe perils such as drought, flood, pests and diseases. There is no other major crop MPCI program in the World which can boast results as good as this: indeed under the World Bank Survey 2008 average premium rates for MPCI business were in the order of 7.5% to 10% on average no country achieved a long-term loss ratio on its MPCI book of business of less than 75% loss ratio (Mahul and Stutley 2010). Over the whole crop and livestock portfolio, NAIC's annual technical results have been very impressive over the past seven years with range in loss ratio from a low of 4% only in 2004 to a high of 43% in 2008.

Causes of Loss on Crop and Livestock Insurance programs

An analysis of the causes of loss on NAIC crop and livestock insurance programs is presented below. Figure 2.9 presents an analysis of NAIC's paid claims on the agricultural crop and livestock insurance programs for the period 2007 to 2010 in terms of the percentage number of paid claims by cause of loss and the percentage value of paid claims by cause of loss (the full results are shown by year in Annex 1). It is not possible to report the claims separately by crop and livestock and in the case of diseases these may apply both to crops and livestock: theft and accident these apply exclusively to the livestock insurance scheme and in the case of crops, losses are likely to include all drought, fire, pests, windstorm losses as well as the bulk of flood and disease losses.

The major causes of loss on NAIC crop and livestock insurance programs are diseases followed by flood and then accidents in livestock. Between 2007 and 2010, the most important cause of loss on NAIC's agricultural insurance portfolio has been **diseases** accounting for a very high 57% of all claims by number and 46% of all claims by value and which applies both to crops and livestock, followed by **flood** which accounts for 11% of claims and 16% of the total value of claims and then **accident** accounting for 10% of the number of claims 10% of the value of paid claims and which applies exclusively to the livestock insurance program. This is followed by **fire** accounting for 7% of all claims but 12% of claims values. Conversely, **drought** only accounts for 3% of all claims and 9% of the total value of claims. This pattern of losses is very unexpected for a crop MPCI program and where drought is more normally the major cause of loss[21]. The evidence tends to suggest there is a major problem in Nigeria of educating farmers to observe the normal recommended pest and disease prevention and control measures and furthermore that the NAIC may be facing severe moral hazard namely, the fact that the scheme insures pest and disease losses, farmers may be modifying their normal behaviour and rather than expend money on pest and disease control measures they wait for losses to occur and then claim on their policies.

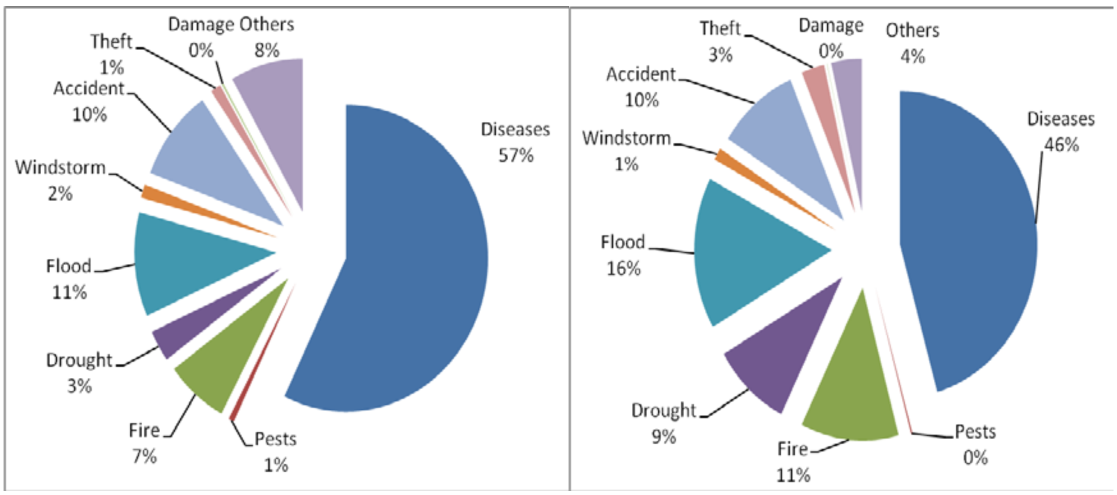
The pattern of losses on the NAIC scheme has several important implications for the design of a possible weather index insurance product. The main cause of losses in crops is **disease** and this does not lend itself to indexation. **Flood** is also an extremely difficult peril to insure either under a conventional indemnity based policy or under an index policy: to date there are no

[21] For example on the USA's Federal Crop Insurance Program, FCIP, which is the World's largest MPCI program over the period 1981 to 1999, drought and heat were the main cause of loss accounting for 47% of claims by value, followed by excess moisture (22%), freeze (13%), hail (9%) flood (2%), but pests and diseases only accounted for 1% and 3% respectively of claims.

commercial crop flood index schemes in implementation anywhere in the World although a pilot product for irrigated rice is awaiting launch in Vietnam. Finally fire which is the third main cause of losses on NAIC's policies cannot be indexed. To date the main applications of weather index insurance (WII) has been to rainfall deficit (drought) programs, but based on NAIC's claims experience, this peril is not a major cause of loss in Nigeria accounting for only 9% of the total value of claims over the past four years. WII is also being used to cover excess rainfall under some scheme and to cover extremes of temperature. (See Sections 3 and 4 for further discussion of the implications of these findings to the design of crop WII in Nigeria).

Figure 2.9. Distribution of NAIC Crop and Livestock Claims by Cause of Loss (2007-10)

(a) Percentage Number of Claims (b) Percentage Value of Paid Claims



Source: NAIC 2011

NAIC's Consolidated Agricultural Underwriting Results 2008 to 2010

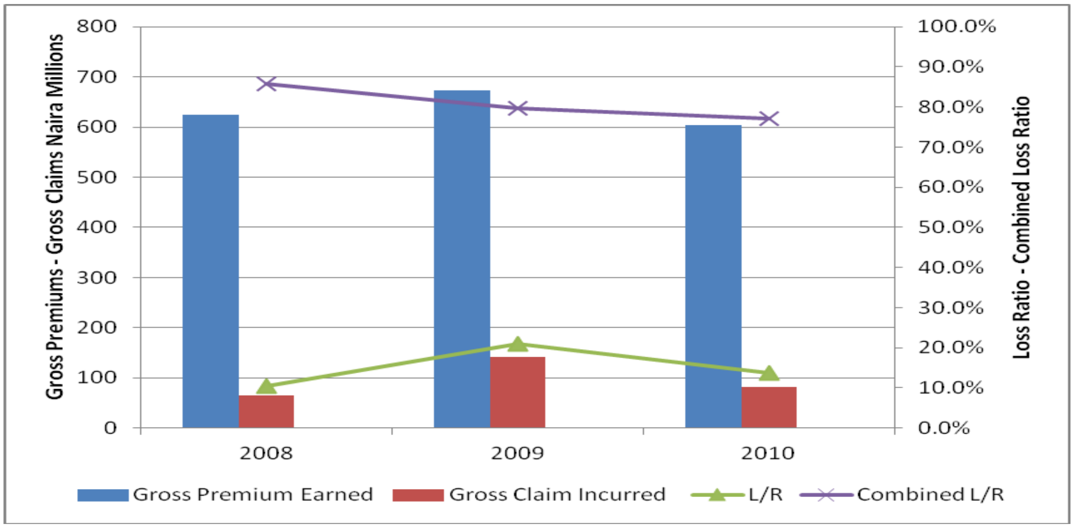
Using the information contained in NAIC's Annual Reports and audited accounts for the period 2008 to 2010, it is possible to analyse further the company's agricultural insurance portfolio results (subsidized and non subsidized agriculture) in terms of the loss ratio (Claims to premium ratio) and then the company's combined ratio (Claims plus acquisition and administration and operating expenses to premium ratio).

The analysis shows that over the three year period 2008 to 2010, the technical underwriting results on NAIC's agricultural insurance portfolio have been very impressive with loss ratios[22] of 10%, 21% and 14% respectively. (The reasons why the agricultural insurance premiums and claims and loss ratios taken from the Annual Reports and shown in Figure 2.10. are different to NAIS's figures in Table 2.6. are not known). However, with the addition of business operating expenses (made up of acquisition costs, maintenance expenses and other underwriting expenses) which are very high varying from a minimum of 59% (2009) to a maximum of 78% (2008) of gross premium earned, the Combined Ratios for the same period 2008 to 2010 are much higher at 86%, 80% and 77% respectively (Figure 2.10. and Annex 1).

[22] The loss ration presented is equal to Gross Claims Incurred divided by Gross Premiums Earned

The issue of the very high operating expenses on NAIC is a subject which is discussed further below.

Figure 2.10. NAIC Agricultural Insurance Loss Ratio and Combined Ratio (2008 to 2010)



Source: Authors analysis of NAIC Annual Report and Accounts 2008 to 2010

Key Issues facing NAIC

Low Coverage and Insurance Penetration

NAIC's coverage is less than 1% of all farmers in Nigeria after 23 years of Operations. Over the 4 year period 2007 to 2010 NAIC has insured an average of about 35,000 food crop and commercial crop farmers each year with corresponding insured area of about 100,000 Ha: this represents less than 1% of Nigeria's farmers and also less than 1% of the total cultivated area of 39 million Ha. In the case of livestock an average of about 12,000 livestock owners have been insured and a total of about 2.5 million head of livestock and poultry which again represents only a very small fraction of the total livestock population in Nigeria.

NAIC has not been able to expand its crop insurance coverage for a number of reasons including: (1) the budgets for Federal and State government 50% crop and livestock insurance premium subsidies are very restricted and it is understood that there are major delays of several years in NAIC receiving these subsidy payments, (2) NAIC's main source of business is crop-credit insurance through NACRDB and because NACRDB's seasonal lending is very restricted today, NAIC's business is correspondingly restricted, and (3) it appears that the voluntary demand by Nigerian farmers for NAIC's agricultural insurance products is very low. These issues are considered further below.

Restricted Premium Subsidy Budget from Government and Arrears of Premiums

There does not appear to be any formal planning process by which NAIC can submit its annual and medium-term business plan and projections to Federal and State Governments in order to establish a budget for premium subsidies which is then allocated to a special fund which can be drawn down on by NAIC in the current crop insurance year and this appears to be a major constraint on NAIC expanding its subsidized agricultural insurance programme. The company also suffers from major delays in receiving premium subsidies from Federal and State Governments and the arrears of premium subsidy again severely restrict the company from expanding its underwriting operations. The Decree of 1993 states that government is responsible for settling the premium subsidies for a particular year in the first quarter of the following year and that where a State Government defaults in its payment to NAIC, that the Federal Government shall deduct the subsidy amount form the funds due to the State and pay this directly to NAIC. In practice, however, this mechanism does not appear to be operating effectively and this has seriously affected NAICs financial position. Over time NAIC has had to draw down on its capital and reserves both to settle claims and to pay staff salaries, and in 2009 the company had to be recapitalized to remain solvent.

Unsustainable Operating Costs

NAIC's business model is not financially sustainable unless it is supported by the Government. NAIC's agricultural insurance operational expenses are extremely high as evidenced by the fact that in the past 2 years NAIC's management expenses have amounted to 53% (2009) and 62% (2008) of Total Gross Premium (NAIC Annual Report 2009). These expense ratios, although decreasing, remain high when compared to the Nigerian insurance industry figures (ranging from 4% to 73% according to NAICOM 2008 figures). Apparently, two factors are causing the scheme to be too costly. First, NAIC is providing agricultural insurance mainly through an indemnity based agricultural insurance coverage that requires a huge operational effort in order to mitigate moral hazard and adverse selection in the form of pre-inspections, monitoring visits during the cover period and in-field loss assessment on individual farms and fields. Second, NAIC's main source of business is the Small and Medium farmers with an average of less than 3 Ha of insured crops per policy with correspondingly low premium per policy (average of US$ 56/ crop insurance policy between 2007 and 2010). The average premium generated by each crop insurance policy is therefore often inadequate to cover NAIC's operational costs for performing in-field risk surveys or loss adjustment activities. NAIC is very dependent on Government finance for its capital and claims reserves, for contributions towards its operating expenses and finally in the form of premium subsidies. If the Nigerian government was to remove the financial support it is currently giving to NAIC it would be very difficult for NAIC to remain in business.

NAIC needs to achieve outstanding technical results in order to cover their operational cost. With insurance administration and operational expenses exceeding 50% of gross premium, NAIC must achieve very low claims to premium ratio's (loss ratios) in order to remain solvent. As noted previously, during the period 2004 to 2007, NAIC's average loss ratio was less than 10% which is exceptionally good for MPCI crop insurance and individual animal insurance[23]. However, NAIC's agricultural insurance premium turnover of US$ 3.1 million per year is not sufficient to justify its structure and to maintain a national network of offices and a large staff complement

Reluctance of the Banks to make their loans subject to compulsory NIAC Agricultural Insurance

[23] Our preliminary analysis of NAIC's results from 2007 to 2010 suggests that over this period the annual average loss ratio was higher at about 14%. These figures have yet to be confirmed with NAIC. In addition, it has not been possible to compare NAIC's underwriting performance with that of the overall industry as information on market profitability over the same period are not available.

It appears that most of Nigeria's Commercial Banks are not willing to oblige their borrowers to take out an agricultural insurance policy with NAIC. According to NAIC, in 2011 only 2 of the 14 commercial banks have so far engaged NAIC to protect their agricultural loans to Nigeria farmers. NAIC has therefore appealed to the Central Bank of Nigeria (CBN) to require that all banks accessing the CBN's new Naira 200 billion (US$ 1.3 billion[24]) agricultural credit initiative termed the Nigerian Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL) comply with the terms of the Decree No. 37 of 1993 and purchase compulsory crop-credit insurance through NAIC. NAIC also noted that in 2011 it is the only agricultural insurer in the country that has the technical capacity and expertise to handle the volume of agricultural loans that farmers across the country may apply for under NIRSAL[25].

Farmers' lack of knowledge and understanding of NAIC

According to feedback received from some organizations met during this Mission, many Nigerian farmers are not aware of the procedures for registering an agricultural insurance claim and in addition that the claims settlement procedures are very cumbersome. NAIC recognizes that levels of insurance literacy in the farming population are very low in Nigeria and identify this as a reason that many farmers do not understand fully how and when to submit an insurance claim on their crop insurance policies. NAIC did not agree, however, that their claims settlement procedures are too cumbersome for farmers to be able to submit claims. In response to the comment that NAIC is perceived in some quarters as a company which does "not pay claims", NAIC management noted that in cases of partial crop loss, the company staff provide crop risk management advice and assistance to the farmers and in many instances this results in the farmer being able to rehabilitate the crop and to achieve a sale value on the salvaged part of their harvest which exceeds the insured input costs and in which case no indemnity would be due. Some farmers incurring partial losses may, however, fail to understand the indemnity formula and therefore complain they did not receive an indemnity, although no payment is due.

Lack of Voluntary Demand for Crop Insurance

Agricultural Insurance in Nigeria is mostly linked to agricultural credit. Most of NAIC's insurance premiums (above 95%) come from insurance policies that are linked on a compulsory basis to loans provided by the banks to the farmers. The voluntary demand for agricultural insurance is almost inexistent, as also asserted by NAIC. NAIC is therefore very dependent for its business on the volume of bank lending to agriculture. Commercial banks in the country are reluctant to engage the specialized services of NAIC in their agricultural loans disbursement. As noted above, only two banks out of the 14 commercial banks in the country have so far engaged NAIC services.

[24] 2011 average exchange rate of Naira 153 = US$ 1.00
[25] Africa News 7 February 2011. Interview with Mr Kwatri Kwagga Yusuf, Managing Direct, NAIC

Chapter 2: Crop Weather Index Insurance for Nigeria

This Chapter starts with a short explanation of weather index insurance (WII) products, their potential advantages and disadvantages over traditional indemnity based crop insurance products and briefly reviews the international experience with WII with specific reference to Africa. This is followed by a review of the issues and challenges for introducing weather index insurance into Nigeria, and then Chapter 4 presents the results of the WII prototype modelling work that it has been possible to conduct under this study.

Features of Weather Index Insurance Contracts and potential advantages and disadvantages

Key Features of Weather Index Products

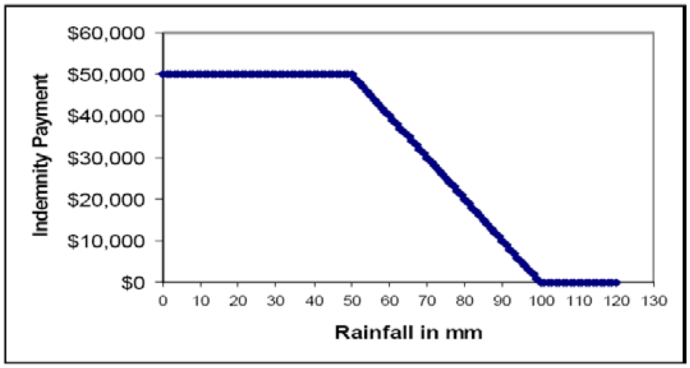
Crop Weather Index Insurance, WII, is a simplified form of insurance, where payments are made based on a weather index, rather than measurement of crop loss in the field. The index is selected to represent, as closely as possible, the crop yield loss likely to be experienced by the farmer. The most common application of CWII 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 indemnity scale set out in the insurance policy. The sum insured is normally based on the production costs for the selected crop and indemnity payment are made when actual rainfall in the current cropping season as measured at the selected weather station falls below pre-defined threshold levels.

WII is potentially a very flexible which can be offered at different levels of aggregation, starting with individual farmers (**micro-level WII**) and then at a regional level, examples including banks or other rural financial institutions providing seasonal crop production credit in a specified area (**meson-level WII)** and then finally at a national level governments are using **macro-level WII** instruments as a form of ex-ante disaster relief insurance against catastrophe perils such as drought which may impact at a national level.**(**discussed further below).

The properties of the parameter that is chosen for a Weather Index include that it must be (a) observable and easily measured (b) objective, (c) transparent, (d) independently verifiable, (e) reported in a timely manner; and (f) consistent over time (World Bank 2005). Drought as measured by a progressive "Rainfall deficit" is a peril which meets these criteria and therefore lends itself to indexation.

Figure 3.1 illustrates the principles of a simple growing season rainfall deficit (drought) index product for a specific crop grown in an area represented by a nominated weather station where actual rainfall is measured during the growing season. The cover is open to any farmer growing the crop in a radius of say no more than 25 kilometers of the nominated weather station. In this hypothetical example, the contract starts to pay an indemnity when actual rainfall falls below 100 mm (this threshold is termed the trigger) and pays a proportional indemnity of $1,000 per mm of rainfall shortfall up to a maximum payout at 50 mm rainfall (termed the exit or limit) of $50,000. The rainfall deficit index should be carefully calibrated such that the trigger point reflects the rainfall level at which crop yield reduction or losses are experienced by the Insured farmers and the exit point should reflect the point at which major crop loss or crop failure occurs. Under this example if actual growing season rainfall during the defined period as recorded at the station was only 60 mm, the indemnity which would be paid out to all insured growers would be 40 mm x $1000/mm or $40,000 (Skees 2003).

Figure 3.1: Payout structure for a hypothetical Rainfall Deficit Contract



Source: Skees, 2003[26]

Many of the micro-level individual farmer WII rainfall deficit policies that have been developed to date adopt a multi-phase payout structure in three or more phases of the crop cycle, (i) sowing and crop establishment, (ii) growth and flowering and (iii) yield formation to harvest. This type of contract was first pioneered by the Indian insurance company ICICI Lombard and sold to farmers for the first time in 2004 (See illustration in Figure 3.2). 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. The design was therefore chosen as the prototype groundnut structure for the first Malawi pilot in 2005 and many of the subsequent African pilots in Kenya, Tanzania, and Ethiopia.

The key features of the multi-stage rainfall deficit contracts include:

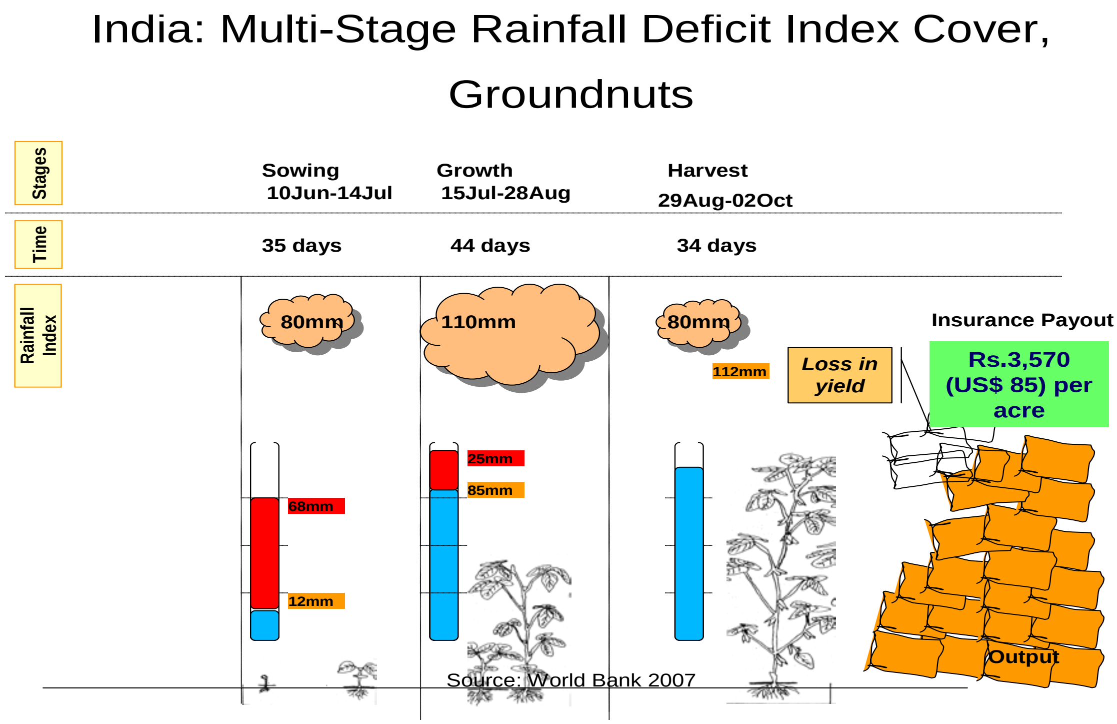
- A **dynamic start date** which is triggered when actual precipitation exceeds a certain threshold which is required for the sowing of that crop and which is designed to reflect as closely as possible real decisions that a farmer would take as to when to sow his crop;
- **Three or more phases** depending 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 suffer from 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

[26] Skees, J. R. 2003. "Risk Management Challenges in Rural Financial Markets: Blending Risk Management Innovations with Rural Insurance." Paper presented at Paving the Way Forward for Rural Finance: An International Conference on Best Practices, June 2–4, Washington, D.C.

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 and which is termed the "**tick**"..

Figure 3.2. India: Three Vegetative Phase Crop Rainfall-Deficit WII Cover



These multi-stage weather index products can be designed to include both excess rainfall and deficit rainfall and additional weather parameters such as temperature or relative humidity.

Key Advantages and Challenges of Crop Weather Index Insurance Products

Crop WII is seen as an attractive approach because of the simplified product concept, the strength in overcoming many supply-side constraints of individual grower MPCI, and the potential to offer insurance coverage for smallholder agriculture more affordably. The main advantage of WII is the elimination of **adverse selection** and **moral hazard** problems which are common to MPCI. Since payouts are made based on an objective measurement of a weather parameter at the reference meteorological weather station, there are few information asymmetries to be exploited, and the behavior of the insured cannot influence the extent of payouts. In addition, weather index insurance reduces **administration costs** (particularly because it does not require in-field inspections or loss adjustment) for the insurer which could make premiums more affordable. WII also offers the potential to make **rapid payouts** after each cover-phase, based on the measured weather station data and this is a major advantage over loss of yield based products where a final adjustment can only be conducted in-field at the time of harvest. WII products are also likely to facilitate risk transfer to the international reinsurance markets. However, whilst index insurance offers opportunities for reduced administration and operating costs, the development phase requires intensive technical inputs, and ongoing technical inputs are required to refine products over time.

The most important challenge for weather index insurance is basis risk which significantly limits the applicability of index instruments. Basis risk is the difference between the payout as measured by the index, and the actual loss incurred by the insured farmer(s). Because no field loss assessment is made under index insurance, the payout may either be higher, or lower, than the actual loss of crop suffered by the farmer(s). Basis risk is lower when the risk is highly correlated i.e. affecting a large geographical area relatively at the same extent and simultaneously. The extent of basis risk can to a certain extent be mitigated by careful index design and by the installation of new weather stations thereby providing more localized precision in the measured climatic peril. Other challenges for weather index insurance include the need for high quality weather data and infrastructure and the currently limited product options, with most applications in developing countries so far concentrated on rainfall indexes. (See Box 3.1. for further information on advantages and challenges of weather index insurance).

Box 3.1: 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)[27]

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

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.

International Experience with Weather Index Insurance

Global Experience with WII

To date most of the experience with WII has been for individual farmer micro-level rainfall-deficit (drought) crop insurance. In 2003, India was the first country to introduce micro-level individual farmer rainfall deficit WII for castor seed and groundnuts in Andhra Pradesh state: this was a private sector crop insurance initiative between BASIX (a local microfinance institution) and ICICI Lombard, a leading private commercial insurance in India. Since then there has been major interest especially from the development community (aid donors, international NGO's etc) in the role of micro-level WII as a weather risk management tool which is better suited to the needs of individual small farmers that traditional indemnity based MPCI and this is seen in the fact that in 2011 there are more than 30 WII projects in about 25 countries (Table 3.1)[28]. It is notable, however, the exceptions of the private and public sector initiatives in India and to a lesser extent the private programs in Thailand, Malawi and Kenya most of these micro-level individual farmer crop insurance schemes are still at a pilot implementation stage and have not yet achieved any degree of scale-ability and sustainability.

2.1. **Table 3.1. International Experience with WII at Different Levels of Aggregation**

Micro level	Weather-indexed insurance for smallholder farmers: Examples: India, Nicaragua, Malawi, Ukraine, Thailand, Kenya, Ghana, the Philippines, China, Indonesia. Over 30 projects in about 25 countries. Scale-up in India, Thailand and to a certain extent in Kenya and in Malawi
Meso level	Weather-indexed portfolio hedge for rural financial institutions that lend to poor farmers Examples: Peru, Ghana, Vietnam (under development) Programs are too new to assess scale-up and sustainability
Macro level	Weather insurance or weather-indexed contingent credit line for governments or international organizations Examples: Ethiopia, Malawi, Mexico (both AYII and WII), Caribbean States (CCRIF - risk pool for hurricanes & earthquake) Mexico has achieved major scale-up across most states in the past decade. CCRIF is insuring 16 Caribbean states.

2.2. *Sources: Dick, W. (2009); authors 2011*

The most relevant experience with micro-level individual farmer WII in Africa comes from Malawi where there are now five full years of experience with piloting micro-WII for rainfall-

[28] For up to date reviews of these WII programs, see Hellmuth et al 2009 and IFAD & WFP (2010).

deficit (drought) in food and cash crops. Details are summarized in Box 3.1. The major lessons which have been learnt from this program include the fact that the demand for crop insurance is potentially low unless this is **bundled** with inputs and seasonal crop production credit, that **farmer education and training** is essential for the success of the program, that the **scaling-up** of weather index insurance takes time and is an on-going process which may require many years and finally that WII is only one tool to mitigate weather risk and is only effective where this is part of an integrated approach to improving small farmer crop production and incomes.

Box 3.1. Malawi: Micro Drought Index Insurance Linked to Credit and Improved Seeds and Fertilizers

Objective: to design a drought-index crop insurance policy for small farmers in Malawi in order to leverage access to credit to purchase improved seeds and fertilizers. Banks have traditionally been very reluctant to provide seasonal production credit to farmers because of the high exposure to drought related crop failure and the high potential for default on loan repayment.

Key Actors: Insurance Association of Malawi and 8 local insurance companies acting as a co-insurance pool; National Smallholder Farmers' Association of Malawi (NASFAM) and 2 lending banks. Close linkages with input suppliers. Product designed by CRMG, World Bank with assistance from Malawi Meteorological service. The pilot program was not reinsured prior to 2007/08 season when the insurers purchased 80% Quota Share reinsurance from SwissRe and ParisRe.

WII Product. 3-phase drought insurance index for groundnuts designed in 2005. Contract triggers and payout in each stage structured using the FAO Water Requirement Satisfaction Index (WRSI). .

Bundled Credit and Insurance: The product is explicitly linked to seasonal production credit provided by 2 banks and crop insurance premiums are included as part of the loan package. The sum insured is based on the amount of credit loaned to the farmer and not the value of crop. The credit was used as part of an improved seed/fertilizer package.

Achievements (Insurance Results):

During 2005/06 892 groundnut farmers insured within 20 Km of 4 weather stations

In 2006/07 coverage expanded to include a 5th weather station and 2 crops groundnut and maize with a total of 1,710 insured farmers.

In 2007/08 the program was scaled-up by switching to large 2 tobacco companies which contract small growers to produce tobacco and a total of 2,600 farmers were insured.

2005/06 and 2006/07 were favorable (above average) rainfall years and payouts were very small. In spite of good weather and high production and yields the banks did not report significantly improved credit repayment rates in the first two years of the pilots.

Over the first 3 years of pilot implementation the program collected total premiums of US$ 24,650 against total claims of US$ 1,380 (loss ratio 6%).

Year	Insured Crop	No. Insured Farmers	Total Sum Insured (US$)	Total Premium (US$)	Average technical premium rate %*	Total Claim (US$)	Loss Ratio %
2005-06	Groundnut	892	37,000	2,530	6.8%	140	5.5%
2006-07	Groundnut, Maize	1,800	102,000	8,620	8.5%	1,245	14.4%
2007-08	Tobacco, Maize	425	310,000	13,500	4.4%	10	0.1%

Source: Mulalo (2008)

* Rates exclude VAT

Key Lessons and Challenges:

The following key lessons were identified by CRMG.

1. A bundled approach to crop-credit insurance appears to be most successful. Indeed farmers' demand for insurance stems from the access this gives them to credit.
2. Education about index based insurance products is essential for all stakeholders.
3. Local expertise in weather index contract design needs to be developed
4. Expanding investment in automated weather stations is required to scale-up the program
5. Need to develop and purchase reinsurance as pilots are scaled-up and capacity requirements increase
6. Need to review regulatory insurance framework
7. Weather insurance is only one tool to mitigate the risks of agricultural finance and supply chain relationships and the problems of low credit repayment rates under the groundnut-pilots indicate a need to strengthen all parts of the supply chain.

Next steps:

There is a need to convert the pilot into a sustained, national initiative. This can be achieved by continued expansion of contract farming for crops which are most important for credit including tobacco, paprika, cotton and tea. There is a need to upgrade and automate more weather stations – it is estimated that if the 53 rain gauges in the tobacco region were automated an additional 200,000 smallholders could be included in a weather index program.

Sources: CRMG (2008); Hellmuth et al (2009); Mulalo (2008); Skees (2008)

In Kenya, there are currently several weather index insurance initiatives which are at a pilot implementation stage and which are showing encouraging results. The largest of these initiatives dating back from 2009 is the Kilimo Salama (Safe Agriculture in Kiswahili) maize excess rainfall and rainfall-deficit index product which was developed by the Syngenta Foundation for Sustainable Agriculture (SFSA) in conjunction with Safaricom (a mobile phone operator in Kenya) and which is underwritten by UAP Insurance company of Kenya. Kilimo Salama is linked to the sales of inputs (maize seeds, fertilizers, chemicals etc) through Kenya's network of Syngenta registered agricultural input dealers. As most Kenyan small farmers have mobile phones, the product is distributed and administered at very low cost by mobile phone by Safaricom which is the largest mobile network provider in Kenya: according to Syngenta the transaction costs of this insurance product are as low as the cost of an SMS (1 Ksh). When a farmer makes a purchase of inputs at his local dealer the stockiest will assist the farmer to register (by mobile phone with UAP), his Kilimo Salama insurance application (sum insured and premium amount etc) and the famer will, in turn, receive a text from UAP confirming his policy details. The dealer is then responsible for collecting the premiums from farmers and for paying these over to UAP for which they receive a small agent's fee. If a payout is triggered for the named weather station, UAP will text the farmer to advise him/her that a payout is due and this payment is effected by mobile directly to the farmer's account. Syngenta are supporting the scheme financially through their investment in automated weather stations and in the provision of 50% premium subsidies to farmers: the farmer therefore pays a flat premium rate of 5% for cover. In 2009 the policy was purchased by 200 maize farmers, but following the major droughts in 2009 in the following year, the Kilimo Salama product was purchased by over 11,000 maize farmers in 5 regions of Kenya, using 30 weather trigger stations[29]. It is understood that local scheme management are targeting 50,000 policy sales of the Kilimo Salama index cover within the next few years.

[29] For further details see: Syngenta website at http://www.syngentafoundation.org/__temp/final_Kilimo_Salama_Factsheet_for_Siakago_Event_September_2010.pdf and IFC 2011.

In Africa Meso-level WII experience is very limited to date with one-off pilots in Kenya, Ethiopia, Mali in 2007 and a new innovative scheme that incepted in Ghana in 2011. In 2007, a meso-level drought index product was piloted under the Millennium Villages Project, MVP, in three villages in Kenya, Ethiopia and Mali in 2007. IRI, in conjunction with SwissRe designed an innovative drought index contract which combined both a remote sensing NDVI index to provide regional level seasonal drought impact on native vegetation and crops and local rainfall gauge data to make the index most robust to local drought impacts. Payouts were designed for 2 levels of drought, a moderate drought (defined by a 1 in 8 years trigger) and catastrophe drought (defined by a 1 in 20 year trigger). Drought indexes were designed for the 12 African villages selected for the MVP in 12 countries of western, central and eastern Africa, but finally the contracts were only implemented in Kenya, Ethiopia and Mali. The premiums were paid by the MPV Villages through donor support. Under this meso-level or village-level product, it was specified that indemnity payments would be used for core development interventions including a school feeding program and financing of replacement agricultural inputs of seeds and fertilizers to enable farm households to get back into production after a severe drought and to avoid them falling back into the poverty trap the MVP was working to remove. There were no insurance payouts in 2007 and since then the MVP Meso-level drought index contracts have not been renewed pending a transition from donor aid to self-financing of the MVP activities. (Hellmuth et al 2009). In **Ghana** starting in 2011, a pool of local insurers under the Ghana Agricultural Insurance Pool (GAIP) have started implementing both micro-level WII and a meso-level drought index product for maize which is targeted at rural banks and input suppliers and which is designed to protect the bank's crop loan portfolio against major regional drought and resulting crop failure which would prevent the rural banks from recovering their loans from the farmers.

In Africa, two countries, Ethiopia and Malawi have experimented with macro-CWII programs which are designed to provide a national food security instrument in the event of catastrophe drought years. Features of these macro-level drought indexes are reviewed below in boxes 3.2. and 3.3.

Box 3.2. Macro-Level Rainfall-deficit WII cover for Government of Ethiopia (2006).

In 2006 the WFP with technical assistance from the World Bank's CRMG, designed a macro-drought index policy for the Government of Ethiopia which was designed as an ex-ante food security risk financing instrument to fund emergency food aid.

A national agricultural drought index contract was constructed on the basis of historical rainfall data for 26 weather stations and showed a very high degree or 80% correlation between major catastrophe drought years and requirements for disaster food aid in the drought affected areas. In 2006, the drought insurance cover was placed as a derivative contract with Axa Re with a Total Sum Insured of US$ 7.1 million which was designed to provide emergency relief funding to 62,000 households in 10 to 15 of the most affected administrative districts of the country and donors funded the insurance premium of US$ 930,000 (implied premium rate of 13%). In 2006, seasonal rainfall was above the level which would trigger an indemnity payment and therefore there was no claim on the contract.

While the Ethiopian macro-drought index contract was not renewed in 2007, WFP noted there were several important lessons from the 2006 pilot project including (i) it is feasible to use market mechanisms to finance drought risk in Ethiopia, (ii) it is possible to design an objective, timely and accurate national rainfall index as a proxy of catastrophe drought induced crop failure and need for food aid, (iii) this ex-ante risk financing mechanism provided the Government of Ethiopia incentives to upgrade its drought contingency planning and finally (iv) the pilot project showed that it is possible to use index insurance to transfer catastrophe drought risks out of developing countries into global reinsurance markets where the risk can be pooled and where diversified risk portfolios can be constructed to reduce the cost of coverage.

Source: WFP 2006

Box 3.3. Macro-level Maize Food Security Index, Government of Malawi 2008

The Malawi macro-level maize drought index product was designed for the Government of Malawi by the World Banks CRMG in conjunction with UK's DIFID which funded the premium costs of the product. The index uses rainfall data from 23 weather stations throughout the country and is based on the Government's own national maize yield forecasting model which in turn is based on the FAO's water balance crop model[30]. In 2008, the macro-drought index for maize was placed as a derivative contract with the World Bank Treasury and backed by reinsurance from a leading reinsurer. The index was constructed such that if the index fell to 10% below the historical average, the Government of Malawi would receive a maximum payout of up to US$ 5 million. The pilot contract was free of claims in 2008/09 and on the basis of this successful local capacity building experience it anticipated that future contracts will be negotiated directly by Government of Malawi with international markets

Source: Hellmuth et al 2009

Current status of Weather Index Insurance in Nigeria

NAIC's vision is to be the pioneer in the provision of Agricultural Insurance products and services in Nigeria including WII. Currently in Nigeria none of the non-life private commercial insurers are offering any form of agricultural insurance, but as several companies have shown interest in WII[31], NAIC is currently facing competition from the private sector in this class of insurance. NAIC is, however, realistic about the issues and challenges of introducing WII into Nigeria (see below for further discussion).

The Central Bank of Nigeria (CBN) is currently analyzing the feasibility for the introduction of private-sector weather index insurance (WII) in Nigeria. Currently in Nigeria the banking sector provides 1.4% only of its total lending to agriculture in spite of the fact that agriculture accounts for about 60% of employment and rural livelihoods and 42%[32] of Nigeria's Gross Domestic Product (GDP). Since 2010 CBN has been partnering with the Alliance for a Green Revolution in Africa (AGRA) to develop a new innovative mechanism to increase rural finance

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[30] The FAO's model is based on the Water Requirement Satisfaction Index (WRSI) which is used to determine the level of water stress endured by a crop during its whole growing season and the expected yield response to water stress.

[31] Several private insurers expressed an interest in underwriting WII at the ICEED and NIMET sponsored conference titled Climate Based Microinsurance Conference: Providing Protection for Nigerian Farmers , Abuja March 22-23, 2011

[32] 2009 Agricultural GDP of N. 300 billion or 41.84% of GDP (ACGSF 2009).

under the Nigerian Incentive-based Risk Sharing System for Agricultural Lending (NIRSAL)[33]. Under NIRSAL, CBN plans to inject US$ 0.5 billion for agricultural loans with a view to leveraging up to US$ 3 billion of commercial loans for agriculture. NIRSAL has 5 integrated components including an agricultural insurance component (US$ 30 million have been allocated by CBN to create an agricultural insurance fund) which is designed to protect bank lending to agriculture. CBS has contracted Mckinsey & Company Ltd and the Alliance for a Green Revolution in Africa (AGRA) as technical design consultants for this major agricultural credit and insurance program (See Box 3.4. for further details of the NIRSAL initiative).

Under the agricultural insurance component of NIRSAL, CBS/ Mckinsey/ AGRA are planning to promote private sector crop weather index insurance, WII, linked to bank lending, starting in 2011. AGRA is responsible for the crop WII component of the NIRSAL project and notes that although they intend to maintain dialogue with NAIC, they plan to promote crop WII through the private commercial insurance companies in Nigeria. The company has a very ambitious target to commence pilot testing and implementation of micro-level individual farmer WII insurance linked to commercial bank lending in the third quarter 2011 for 6 commodities in five states including: tomatoes in Kano, rice in Cross River, maize and soya in Kaduna, cotton in Katsina and cassava in Ondo. Finally livestock insurance will also be included under this program. During the March 2011 Mission the World Bank team noted that there was considerable overlap in the objectives, selected crops and selected pilot states between the NIRSAL WII initiative and the World Bank's WII pre-feasibility study for rice and maize in three of the five states namely, Kano, Kaduna, and Cross River and that it would be important to coordinate the activities of these two WII initiatives. Mckinsey & Company Ltd had intended to publish their feasibility study report by April 2011 with product design and implementation planning starting in the third quarter 2011. CBS advise, that Mckinsey have concluded their consultancy inputs, but that the WII component of the NIRSAL initiative is currently on hold pending CBS decisions to request the National Assembly to repeal the Nigerian Agricultural Insurance Corporation (NAIC) Act in order to permit private insurance companies to underwrite agricultural insurance. In the meantime, CBS is considering the engagement of an actuary to advice on the Insurance Pillar of NIRSAL and is leveraging on the expertise of ICEED and NIMET[34].

Box 3.4. The Nigerian Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL)

THE NIRSAL CONCEPT

NIRSAL is a dynamic, holistic approach that tackles both the agricultural value chain and the agricultural financing value chain. **NIRSAL does two things at once; it fixes the agricultural value chain**, so that banks can lend with confidence to the sector and, **encourages banks to lend to the agricultural value chain** by offering them strong incentives and technical assistance. NIRSAL, unlike previous schemes which encouraged banks to lend without clear strategy to the entire spectrum of the agricultural value chain, emphasizes lending to the **value chain and to all sizes of producers**.

There are five pillars to be addressed by an estimated USD 500 million of CBN money that will be invested as follows:
1) Risk-sharing Facility (USD 300 million). This component would address banks' perception of high-risks in the sector by sharing losses on agricultural loans.

[33] For further details of NIRSAL See CBN (2010), Nigeria Incentive-based Risk Sharing System for Agricultural lending May 2010 (available on the web).
http://www.cenbank.org/out/2011/publications/reports/dfd/brief%20on%20nirsal.pdf
[34] CBN Communication to Authors, 01/11/2011.

2) Insurance Facility (USD 30 million). The facility's primary goal is to expand insurance products for agricultural lending from the current coverage to new products, such as weather index insurance, new variants of pest and disease insurance etc.
3) Technical Assistance Facility (USD 60 million). This would equip banks to lend sustainably to agriculture, producers to borrow and use loans more effectively and increase output of better quality agricultural products.
4) **Holistic Bank Rating Mechanism (USD 10 million).** This mechanism rates banks based on two factors, the effectiveness of their agricultural lending and the social impact and makes them available for the public.
5) Bank Incentives Mechanism (USD 100 million). This mechanism offers winning banks in Pillar four, additional incentives to build their long-term capabilities to lend to agriculture. It will be in terms of cash awards.

CROP VALUE CHAINS AS PILOTS In the first instance, six pilot crop value chains have been identified based on existing crop production levels and potentials in six high-potential breadbasket areas. The crops are: **Tomatoes, Cotton, Maize, Soya beans, Rice Cassava.**

NIRSAL TARGETS:
* Generate an additional USD 3 billion of bank lending within 10 years to increase agricultural lending from the current 1.4 to 7 percent of total bank lending.
*Increase lending to the "pooled" small farmer segment to 50 percent of the total (typically, banks do not reach these producers individually but through "pools", i.e., aggregating mediators, such as MFIs and cooperatives).
*Reach 3.8 million agricultural producers by 2020 through pooling mechanisms such as value chains, MFIs, and cooperatives. Reduce banks' break-even interest rate to borrowers from 14 to 7.5-10.5 percent.

Source: Central Bank of Nigeria 2011

Key Issues and Challenges for Weather Index Insurance in Nigeria

Weather Station Density and Data Availability

In order to operate a weather index insurance program, it is necessary to have an adequate density of weather stations and a minimum of 25 to 30 years of uninterrupted historical daily weather data to design and rate a WII contract. International experience shows that where the objective is to design a rainfall index that one weather station is typically representative of rainfall patterns in an area of a 20 km to 25 km radius[35]. This is a general statement as there are many other factors which will affect rainfall patterns and variability including most importantly topography and in many parts of West Africa farmers argue that rainfall patterns (timing and quantity of precipitation) vary over much smaller distances of a few kilometers only[36]. Nigeria has a total land area of 910,770 Km2 and assuming 1 weather station is representative of a 25 Km radius (or 1,962 Km2) the country would need approximately 465 weather stations to achieve total national coverage for a rainfall index programs. The second requirement for the design and rating of a rainfall WII program is a minimum of 25 to 30 years of uninterrupted daily rainfall data.

The weather station network density in Nigeria is currently insufficient for the implementation of any commercial and scaled up weather index insurance program. The Nigerian Meteorological Agency (NIMET) has a weather station network that currently consists of 53 synoptic weather stations, 20 agro meteorological stations, 40 automatic weather stations, and 500 rainfall gauges distributed all over the country and covering almost all the agro ecological areas.

[35] For temperature indexes, the radius may be expanded up to 30 km or 40 km unless again local topography influences come into play
[36] Author's field experience in Senegal, Ghana and Burkina Faso

While the 53 synoptic weather stations can apparently provide uninterrupted daily time series rainfall and temperature data for more than 25 years for the design and rating of weather index insurance products, it is understood that very few of the agro-meteorological and or the rainfall gauge stations can provide such historical rainfall data. In the five selected CADP states the density of NIMET synoptic weather stations is as follows: Kano (1 station), Kaduna (2 stations), Cross River (5 stations, but several cannot provide adequate data), Lagos (3, but time-series data is only available for 1 station) and finally Enugu (1 station). This network, considering the area of the country and the fact that – according to the international experience – the measurement of (for example-) rainfall is normally valid for up to 25 kilometers radius around the weather stations, is totally insufficient for the commercial operation of WII. In the short-term there is no way this constraint can be overcome, although if significant investment were to be made in installing automated weather stations today, in the next 5 to 10 years these stations could hopefully provide sufficient weather data to begin constructing crop weather indexes for these stations. The quality of the weather data for these stations is reviewed in more detail in the next section.

Crops and Perils that are suitable for WII

To date most WII research and development has been conducted into rainfall deficit (drought) indexes). Index insurance is most suited to slow-onset hazards (such as drought) which can be measured through a continuous rainfall deficit index with defined trigger and exit rainfall levels, as opposed to sudden-event climatic perils (such as hail, flood or windstorm). Low temperature or frost and relative humidity are other perils which are relatively easily indexed for crop insurance purposes. Other perils such as fire and pests and diseases in agriculture do not lend themselves to WII indexation.

Types of crop which are suitable for the design of WII include 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.

***Nearly all development work to date on WII in developing countries has been conducted on single stand or sole crops and a major issue which needs to be addressed in Nigeria is the fact that many farmers practiced intercropping*.** Issues relating to the suitability of WII for mixed intercrops are discussed further below.

Several of the main perils faced by crop producers in Nigeria are not suitable for indexation. At meetings with CADP's regional managers, an assessment was made of the key crops and key perils affecting these crops in the 5 selected states (see Table 3.2 below). On the basis of this assessment it was concluded that oil palm and cocoa should not be included under the WII pre-feasibility study because fire in oil palm is not suitable for an index and the same applies to pests and diseases in cocoa. For rice and maize there appears to be a clear potential need for rainfall deficit cover in Kano state which is affected by severe drought 2 in every 5 years according to the CADP managers. The key climatic risk exposures in rice and maize grown in the other CADP states are less clear-cut.

Table 3.2. CADP Assessment of Key Hazards (Perils) affecting priority crops in the 5 Selected States

State	Main Crop	Key Peril affecting crop	Potentially Suitable for WII

Kano	Maize and Rice (irrigated and rain fed	Droughts every 2 in 5 years	**YES**
Kaduna	Maize	Pests and disease Drought / Excess rain	NO **YES**
Lagos	Rice	Rainfall is normally adequate for rice production	N/A
Cross River	Cocoa Oil Palm Rice	Pest & diseases Fire Excess Rain leading to flooding	NO NO **YES**
Enugu	Rice	Excess Rain leading to flooding	**YES**

Source: CAPD Meetings March 2011

According to NAIC's agricultural insurance experience the main cause of losses in crop production are mainly diseases followed by fire and these perils are not suitable to be indexed. In Chapter 2, an analysis was presented of NAIC's paid claims by cause of loss in crops and livestock for the period 2007 to 2010. This analysis showed that by far the most important cause of loss on NAIC's agricultural insurance portfolio is **diseases** (and which does not lend itself to indexation under a WII product save where there is a very close correlation between say rainfall and relatively humidity levels and incidence of fungal diseases in particular crops. This was followed by **flood** claims, but river flood is very difficult to index because historical river flow gauge data is often lacking and it is a complex task to relate river flow data to crop damage (the area of the crop which will be affected by flooding, the depth of the water and the duration of flooding, factors which will have a direct bearing on the severity of crop losses). Research into flood index insurance is being conducted using remote sensing applications, but currently there are no commercial crop flood index schemes in implementation anywhere in the world[37]. **Excess Rain** is not identified in NAIC's list of causes of loss in crops and livestock, but it is understood that flood claims cover both river flood and excess rain leading to water-logging and localized standing water. Excess rain can be measured at a weather station and is sometimes used as a proxy for flooding, but this has the same caveats as in the case of river flood. To date, a handful of the micro-level WII schemes in India, Thailand, Central America and Africa have attempted to insure "torrential excess rain" for example more than 50 mm in a 24 hour period, but there is a very high potential for basis risk as excess rain damage is highly related to the vegetative growth stage of the crop, local soil type, water holding capacity and drainage etc. The third most important source of claims on the NAIC program during this period was **fire** but this peril cannot be indexed under a conventional WII index.

Drought is the only climatic peril insured by NAIC which is relatively easy and potentially suitable to insure under a WII product. Drought has accounted for 3% of all claims and 9% of the total value of claims and this is the only cause of loss on the NAIC crop scheme which lends itself to indexation under a rainfall deficit index cover**.**

The Issue of Intercropping

[37] For a very good up to date review of the start-of-the art of flood index insurance for agriculture see: Lotsch, A., Dick, W. & Manuamorn, O.P. 2010. Assessment of innovative approaches for flood risk management and financing in agriculture. *Agriculture and Rural Development Discussion Paper 46*, ARD, the World Bank, Washington, DC.

Nearly all development work to date on WII in developing countries has been conducted on single stand or sole crops and major issue which need to be addressed in Nigeria is the fact that many farmers practice inter-cropping. Mixed cropping or intercropping is practiced by small holder farmers in much of the sub humid zone of Nigeria. Sorghum is the principal crop and predominates in the different crop mixtures. Most commonly, it is intercropped with soybean and/or maize, but various other crops, such as groundnut, cowpea, millet, and okra, also feature. According to Alabi and Esobhawan (2005) under traditional farming systems, between 60% and 70% of the cropped land is devoted to mixed crops. Farmers' reasons for growing a mixture of crops which are planted at different dates are to minimize climatic risk, spread labor inputs, and reduce disease problems (Evans, 1960; Norman, 1974). Under sorghum, maize and soya mixed cropping, the maize crop in typically planted at the start of the wet season in late April or early May. Sorghum is then intercropped 2 to 3 weeks later and finally soya is planted in mid-June. For WII purposes it is not possible to offer three separate indexes for 3 different crops grown in the same plot of land and which have different planting dates (and therefore different inception dates for WII cover), different soil moisture water requirements (hence the need for different rainfall deficit indexes and indemnity payouts for each crop) and different risk profiles (and therefore different technical premium rates). WII is best suited to mono-cropping, but in the context of Nigeria, might possibly be developed for intercrops where coverage is provided for the main crop only.

Farmer Demand and Affordability of WII

It is important that policy makers and farmers in Nigeria are made fully aware of the limitations of WII in terms of the fact that the index can only insure against a limited number of climatic perils. From a farmer's viewpoint the key advantage of the existing NAIC salvage-based Loss of investment cost policy is that it insures against all causes of crop production and yield loss including pests and diseases and fire. WII can only insure against a few key climatic perils such as rainfall deficit (drought), excess rain (as a proxy for excess rain and flood), excess or low temperature and possibly wind.

It is important that policy makers in Nigeria recognize that weather index insurance (WII) is not a cheap alternative to traditional indemnity based crop insurance. Although WII does not face such high operating expenses as traditional indemnity based insurance since no pre-inspections are required or in field loss assessment, where WII is designed to insure against catastrophe perils of drought and or flood and or frost, the underlying technical rates for these perils will be just as high as on a traditional indemnity based cover. To date most WII in Africa has been designed for individual farmers to insure against drought and excess rainfall and commercial premium rates are typically between 7.5% and 15% for such cover. It is not known whether GoN will have available funds to provide premium subsidies for any new WII programs that may be developed by public (NAIC) and private sectors in future. However, given the evidence of the very low voluntary demand for NAIC's subsidized Loss of Input Costs crop insurance program with average rates of about 4% (2% to the grower), it is suggested that a starting point for any future WII initiative in Nigeria should be to conduct a detailed farmer demand and affordability study for WII.

The introduction of weather index based insurance products would require important efforts on farmers training and industry capacity building. A recent GIZ study suggests that levels of farmer financial literacy and awareness and understanding of insurance products is very low in Nigeria. NAIC also note that farmers lack of understanding of their crop and livestock insurance products is a major constraint to the expansion of these programs. If WII is to be successfully introduced into Nigeria this is likely to require major investment by public and private sectors in awareness and education programs for farmers. Also given the lack of knowledge or experience with WII by most of the insurance sector in Nigeria, special capacity building and training will be required for the insurance industry

Target Audience and Micro-vs.-Macro WII

In addition to Micro-level WII, the Mission recommends that Planners in Nigeria conduct research and development into the commercial applications of WII at a Meso-level, especially for the rural banking sector and input suppliers. In Africa over the past 10 years most of the first generation pilot WII programs have been developed as micro-level programs for individual farmers. The voluntary demand by individual farmers for these WII programs has generally been very low and few programs have yet to achieve commercial scale-up and financial sustainability. Given the major constraint to rural finance in Nigeria, it is suggested that R&D should focus on developing Meso-level financial credit portfolio WII protection for rural aggregators such as banks, MFIs or credit cooperatives, input suppliers providing inputs on credit against repayment at the time of harvest of the crop.

Summary and Conclusions for WII in Nigeria

The weather station network density in Nigeria is currently insufficient for the implementation of any commercial and scaled up weather index insurance program

Several of the main perils faced by crop producers in Nigeria are not suitable for indexation. Mixed cropping or intercropping is a common practice in Nigeria, mixed cropping or intercropping is not suitable for the development of weather index based insurance products.

The introduction of weather index based insurance products would require important efforts on farmers training and industry capacity building

Chapter 3: Weather Insurance Prototype Design for Rice and Maize

This Chapter is devoted to a technical assessment of the feasibility to establish prototype WII rainfall contracts for individual farmers (micro-level crop insurance) for two crops, maize and rice, grown in the 5 CADP states of Kano, Kaduna, Cross River, Enugu and Lagos. **Two types of micro-level individual farmer WII contract are analyzed, first a rainfall-deficit (drought) cover and then an excess rainfall cover**.

Data Availability and Quality

Rainfall Data Availability and Other Weather Parameters

In order to design and rate rainfall contracts it is necessary to have a minimum of 25 to 30 years uninterrupted daily data with a maximum of 2% to 3% missing data and or data outliers (World Bank 2005, World Bank 2011). The weather data used for this study was provided by NIMET.

There is a very low density of NIMET synoptic weather stations in the 5 CADP selected states which are able to meet the minimum 25 year uninterrupted time-series weather data criterion. Kano and Enugu states have only 1 NIMET station in what are very large states, there are only 2 weather stations in Kaduna state, 2 stations in Lagos and 4 stations in Cross River state. NIMET kindly provided the World Bank team with free access to daily rainfall data and other required data including daily evapotranspiration data and daily temperature data for one station in each state as shown in Table 4.1. Most of the synoptic weather stations are located at the city airports in each state. A detailed review of the daily rainfall data is included in Annex 2.

Table 4.1. List of NIMET Synoptic Meteorological Stations in the 5 Selected CADP states

			Data provided by NIMET for World Bank WII Study				
No. Stations	**State**	**NIMET Meteorological Station**	**Station**	**Years Daily Rainfall Data**	**Minimum Daily Temperature**	**Maximum Daily Temperature**	**Daily Average Evapo transpiration**
1	Kano	Kano Airport	Kano	1981-2010	1981-2010	1981-2010	1981-2010
2	Kaduna	Kaduna	Kaduna	1981-2010	1981-2010	1981-2010	1981-2010
3		Zaria					
4	Cross River	Calabar	Calabar	1981-2010	1981-2010	1981-2010	1981-2010
5		Ikom					
6		Ogoja					
7		Eket					
8	Enugu	Enugu	Enugu	1981-2010	1981-2010	1981-2010	1981-2010
9	Lagos	Ikeja	Ikeja	1981-2010	1981-2010	1981-2010	1981-2010
10		Oshodi					
11		Marine					

Source: Authors based on NIMET Data

Rainfall Data Quality Assessment

The rainfall data were checked for consistency, missing data and outliers. For all 5 stations there was a very low incidence of missing daily rainfall data over the 30 years of data from 1981 to 2010. In order to conduct consistency checks and to adjust for potentially implausible outliers the rainfall data were first checked for maximum daily values. This analysis showed that at most stations there was a high incidence of single day rainfall in excess of 100 millimeters with a maximum daily rainfall value of 237 mm at Ikeja station, Lagos state (See further analysis below of excess rainfall data). It is standard practice in the design of WII contracts to check weather data for consistency and possible abnormal outliers by performing a "buddy check" on the daily weather data with a nearby weather station: under this study, it was, however, not possible to access additional nearly weather station data to perform this task.

The analysis of Kano airport daily rainfall data showed a number of anomalies which meant that this data could not be used for rainfall contract design purposes. There were two key issues with the Kano rainfall data, the first anomaly is that the 1990 and 1991 daily rainfall data are mostly identical indicating that one or other of these years is incorrect. The second problem with the data was that this shows 2 distinct and unexplained rainfall regimes: from 1981 to 1995 the average annual rainfall was only 756 mm/year, but between 1995 and 2010 the annual average was nearly 70% higher at 1,282 mm/year. While it is recognized that rainfall in the Sahel region has shown increasing trends over the past 15 to 20 years, such increases are not borne out by other weather station data available in Kano and for these reasons the data were deemed too inconsistent for weather index rating purposes (Annex 2).

The rainfall data for the other 4 stations was generally consistent and suitable for weather index contract design and rating purposes. The daily rainfall data for Kaduna, Cross River (Calabar), Enugu and Lagos (Ikeja) weather stations was generally of good quality with less than 1% of missing and or questionable data. In the case of Ikeja (Lagos), however, there is a question over the May 1997 rainfall data in that zero rainfall was recorded during this month while in all other 29 years a minimum of 7 days rainfall were recorded in May with average rainfall of 188 mm: the most plausible reason is that May 1997 rainfall data were not inputted into the Ikeja data-base (Annex 2 and Annex 4).

Checking for Rainfall Trends

In order to design a rainfall contract it is necessary to check the time-series rainfall for trends and where necessary to de-trend the data. A simple trend analysis was performed for the 30-years annual rainfall data for Kaduna, Cross River (Calabar), Enugu and Lagos (Ikeja) stations. This analysis did not reveal any significant statistical trends[38] in the annual rainfall data (Figure 4.1).

The correlation between the annual rainfall at the selected weather stations is unexpectedly low. The highest correlation is between rainfall at Cross River (Calabar) and Enugu stations, but in this case the correlation coefficient is only 0.46 which is possibly low for neighboring states and indicates the high degree of spatial variability in rainfall patterns in Nigeria. For other stations the lack of correlation in the 30 year rainfall data is likely to be explained by the large geographical distances between stations in each state and the declining rainfall trend from south to north of Nigeria (Annex 2). The annual rainfall data for the 4 states in Figure 4.1 clearly shows

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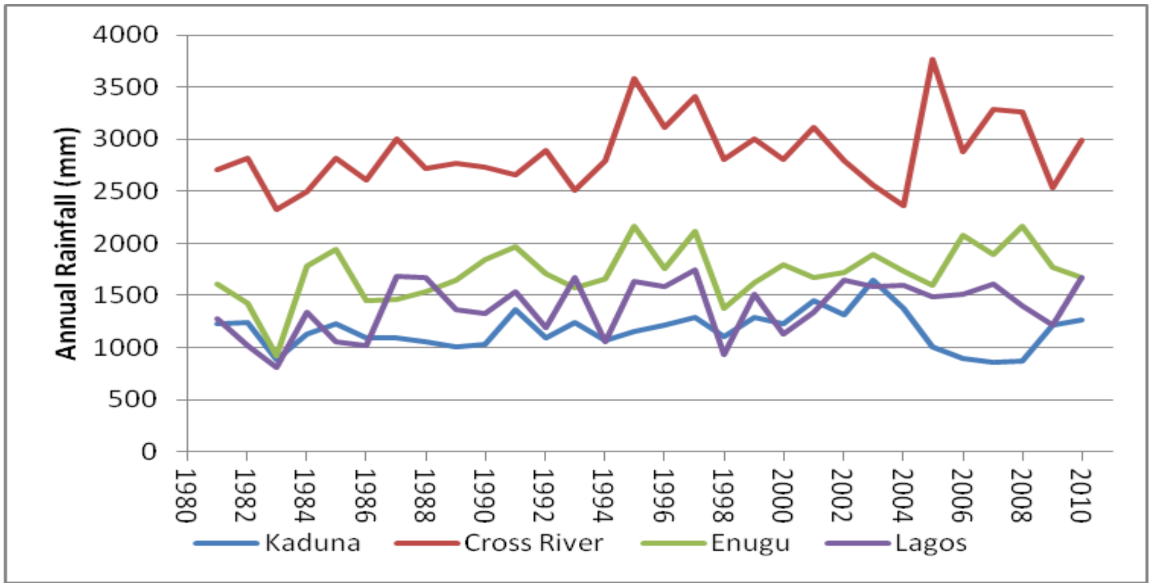
[38] Excel was used to fit trends to the annual rainfall data. None of the fitted distributions show significant increasing or decreasing rainfall trends.

the widespread effects of the 1983 drought which is one of the most severe droughts recorded in the Sahel Region of West Africa and when annual rainfall was reduced across all 4 stations and again in 1998.

Figure 4.1. Annual Rainfall Selected Weather Stations 1981 to 2010 (mm)



Source: NIMET Rainfall data

Crop Production and Yield Data

Under this WII pre-feasibility study, two rain-fed crops, maize and rice were selected for the testing of prototype WII rainfall contracts. As noted in Chapter 1, the CADP originally identified 4 crops, maize, rice, oil palm and cocoa for the WII study, but as the key perils in oil palm and cocoa are related to pests and diseases which are not readily indexable under a WII contract, these two crops were not considered further under this WII pre-feasibility study.

In order to establish whether weather risk exists, it is necessary to collect crop production and yield data in the vicinity of the selected weather station(s) and to test for the degree of correlation between yield and the selected weather variable(s). The most basic pre-requisite for WII is the existence of a weather risk that affects the crop yields in the target area (WFP/IFAD 2011). For rainfall contracts, the accepted guideline is that the rainfall as measured at the weather station is only representative of an area within a 20 Km to 25 km radius of the weather station: beyond this limit rainfall variability is likely to give rise to major basis risk. It is therefore important to access local crop production area and yield data in the vicinity of the selected trigger weather station for as many years as possible. In the case of temperature indexes, the radius can usually be safely extended to 50 km because temperature tends to be more consistent unless there are major topographical influences.

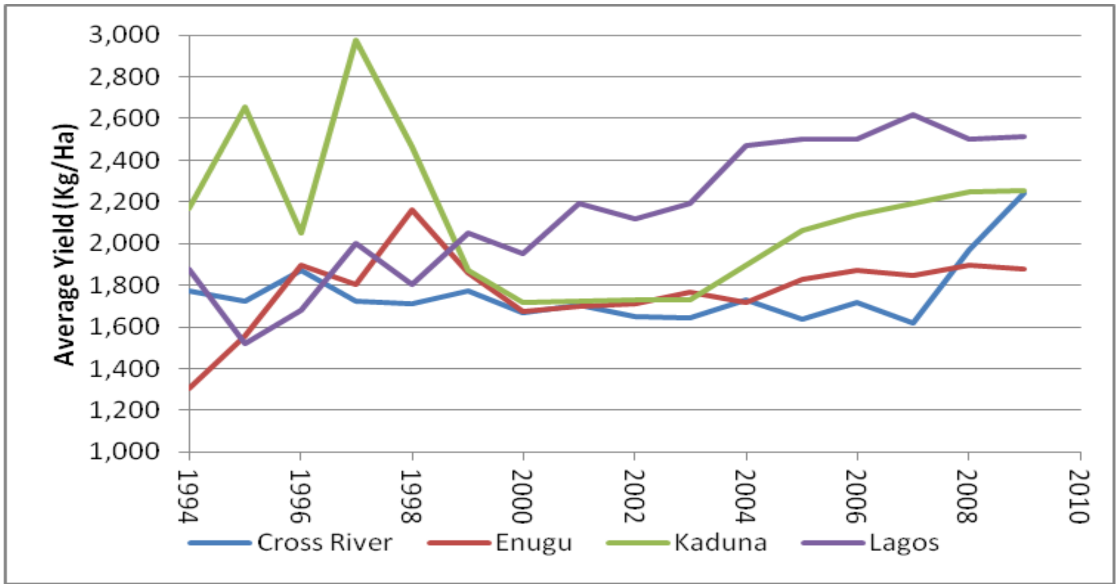
In Nigeria, two main sources of maize and rice crop production and yield data were used under this study for the 5 selected states. The first source of time-series crop production and yield data for maize and rice was provided by the local consultant appointed to the project, ICEED, which in turn is mostly based on Food and Agricultural Organization (FAO), National Agriculture Extension Research and Liaison Service (NAERLS), and the National Program for Agriculture and Food Security (NPAFS) data. The second source for maize and rice yields was the National

Bureau of Statistics (NBS), which is the official source of statistics in the country. The most important sources of survey-census-based official statistics on crops are the National Bureau of Statistics (NBS) and the Livestock Department of the Federal Ministry of Agriculture & Rural Development (Annex 3).

There are severe limitations in the usefulness for WII contract design and rating purposes of the time-series maize and rice crop production and yield information available in Nigeria. The main constraint is that the maize and rice area, production and yields obtained for the study are only available at a state-level. None of the agencies responsible for collecting agricultural data was able to provide maize and rice yields with a lower level of disaggregation, such as at the local government administration (LGA) level. This meant that it was not possible to access crop yield data in the vicinity of the selected weather stations. The state level aggregated data is unfortunately at too large a scale to be able to establish any meaningful relationships between weather and crop yields at the individual weather station level as shown below. Secondly while there is only one maize and rice growing season in Kaduna (June to September) and the crop area, production and yields relate to this one season only, in Cross River, Enugu and Lagos there are two crop seasons the early or main crop season from April to July and the late crop season from September to December) and it is believed that the available state-level maize and rice area, production and yield data in these states are aggregate totals for the 2 crop seasons. This by and large invalidates any analysis of the relationship between seasonal rainfall and crop yields as these cannot be disaggregated into the early or main crop season (April to end July) and late or minor crop season (September to December). Thirdly, only a maximum of 16 years (1994 to 2009) of historical time-series crop production and yield data are available for these two crops compared to 30 years of rainfall data. (Annex 3).

In the case of maize up to 16 years of state-level crop production and yields data were available for the 4 states. The maize yield data is available for a maximum of 16 years from 1994 to 2009: however the data had to be spliced together from different sources (NBS data was available only from 1994 to 1999, followed by other sources including FAO and ICEED from 2000 to 2009) and there appear to be many inconsistencies in this data set including for example in Kaduna, abnormally high average yields in the mid-1990s followed by reduced state level yields during the 2000s. In Lagos average maize yields have increased over the past 16 years from less than 1,800 Kg/Ha to about 2,500 Kg/Ha. In Enugu, average maze yields have remained unchanged at about 1,750 Kg/Ha over the past 16 years, and this also applies to Cross River where yields have not changed save in the past two years. A key feature of the state-level average maize yields is that there have not been any major yield reduction or loss years over the past 16-years with the possible exception of Kaduna in 1996 (Figure 4.2 and Annex 3).

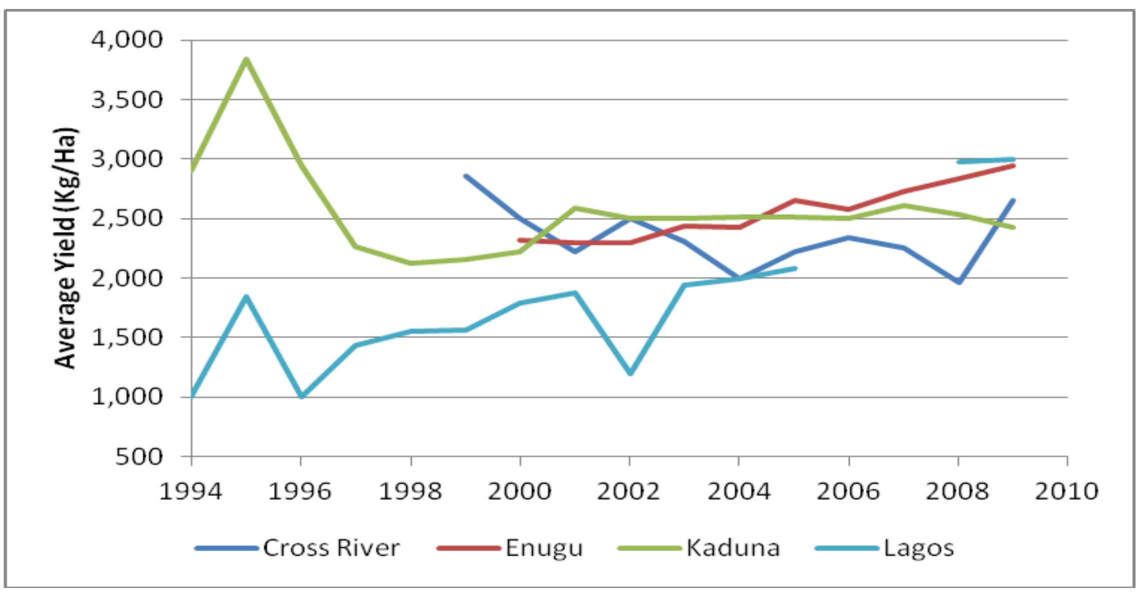
Figure 4.2. Maize Annual Average Yields at State level 1994 to 2009 (Kg/Ha)



Sources: NBS/FAO/ICEED

The available data on rice production and yields in each selected states is very limited. State-level rice production and yield data are available for 16 years (1994 to 2009) in Kaduna and Lagos, but in this latter case data are missing for 2006 and 2007. In Cross River rice yield data is only available since 1999 and in Enugu from 2010. The Kaduna rice data show very high average yields in the 1990s in excess of 3,000 Kg/Ha, but yields have subsequently declined to 2,500 Kg/Ha over the past 10 years and do not appear plausible. Average state-level rice yields are very stable with the exception of Lagos where significant yield reductions were registered both in 1996 and again in 2002 (Figure 4.3. and Annex 3).

3.1 Figure 4.3. Rice Annual Average Yields at State level 1994 to 2009 (Kg/Ha)



Sources: NBS/FAO/ICEED

Crop Financial Data for WII Contract Purposes

In order to value WII contracts, it is common to base the sum insured on either the costs of production invested in growing the crop, or a farmer-gate revenue valuation basis. Under this study, ICEED the local consultant obtained typical per hectare gross margin costs of production and returns (average yield x farm-gate sales price) data for maize and rice in each state and this data are reported in Annex 3.

Crop Yield Response to Rainfall Deficit and Excess Rain in Nigeria

This section reports the results of the correlation analyses conducted for rice and maize yields and rainfall deficit and excess rain for the selected weather stations in the four states. It is, however, stressed that there are major limitations to the correlation analysis that can be conducted because the yield data and daily rainfall data sets are not consistent. The crop yield data is only available for between 10 years and a maximum of 16 years and in this case only at an aggregated state-level, while the 30-years of rainfall data relates to an individual weather station which is only representative of the rainfall regime in a very small area within each state. The key results of the rainfall correlation analysis are summarized below and full results are presented in Annex 3.

Analysis of Rainfall Deficit and Excess Rain Years

An analysis was conducted for each station over the past 30 years of the rainfall deficit and excess rainfall years. For the purposes of this analysis the main cropping season rainfall from May to September was taken and the average calculated. Dry years were then defined according to the following classification: weak drought year, rainfall between -15% and -30% of average; moderate drought year deviation from -30% to -45% and finally strong drought year >-45% reduction on average rainfall. Full details of this analysis are presented in Annex 2 and the results are summarized below in Table 4.2.

Table 4.2. Summary of Drought Years in the 4 Selected States (1981 to 2010)

State	Details of Droughts
Kaduna	6 weak droughts in 1983, 1989, 1994, and then the three years 2006, 2007 and 2008 (frequency 20%; return period 1 in 5 years)
Cross River (Calabar)	4 weak droughts, in 1984 and 1986 and then again in 2003 and 2004 (frequency 13%, return period 1 in 7.5 years);
Enugu	5 drought years with a moderate/strong drought rainfall deficit year) in 1984, with weak droughts in 1983, 1987, 1989 and then 1998 (frequency 17%, 1 in 6 years
Lagos (Ikeja)	7 droughts, with weak droughts in 1982, 1985, 1994 and 2003, moderate droughts in 1983 and 1986 and one strong drought in 1998 with a rainfall deficit of -46%. (Frequency 23%, 1 in 4.3 years

Source: Authors' analysis of NIMET rainfall data

The conclusions that can be drawn from the analysis of the main crop season (May to September) rainfall deficit (drought) years include

- Weak crop-season droughts are a fairly common feature of the selected stations with a one in every five to seven year return period in most states save for Lagos which exhibits the most variable crop season rainfall and where seasonal droughts occur 1 in every 4 years. Cross River has the highest seasonal rainfall of any of the states and lowest exposure to early cropping season drought.

- Moderate to severe drought are a relatively rare occurrence at the 4 weather stations in the four selected states of Nigeria. Over the 30 year period, only one severe drought year was recorded in 1998 at Ikeja, Lagos.

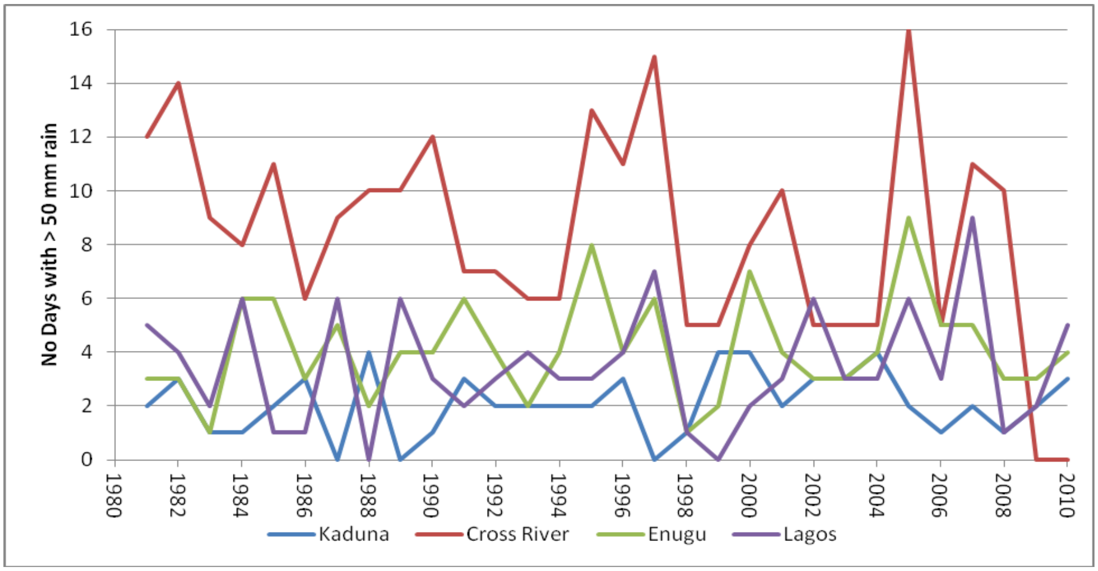
- Finally, it is noted that in 1983 which was a very severe drought year in much of the Sahel Region, weak to moderate droughts were recorded at three of the four stations, the exception being Cross River. This analysis clearly shows the covariate nature of drought in severe rainfall deficit years, or in other words the potential under a rainfall deficit weather index crop insurance program for weather stations across wide geographic areas to be simultaneously affected and for payouts to result.

The definition of an excess rainfall cropping season or year is less clear-cut. The analysis presented in Annex 2, shows that there is no consistent pattern of excess rainfall years across states. The highest excess rainfall anomalies are Enugu in 1981 with seasonal rainfall 81% above average; in Ikeja in 1982 rainfall was 50% above average and in Kaduna, the 2003 crop season rainfall was 41% above average.

The crop season (May to September) rainfall data for these 4 weather station exhibits a high number of days where rainfall exceeds 50 mm per day and indeed it is quite common for rainfall to exceed 100 mm per day. As a rule of thumb, daily rainfall in excess of 50 mm to 100 mm is likely to lead to severe crop damage depending on the growth stage of the crop (especially at the time of germination and harvest of the crop) and other factors such soil texture and infiltration and drainage capacity. An analysis of the average number of excess rain day per month and per year and according to rainfall intensity is contained in Annex 2, and a summary is presented in Figure 4.3. Kaduna has the lowest number of excess rain days or 2.1 days per crop season per year, while Calabar station Cross River has the highest average number or 8.3 excess rain days per season per year. The highest single days rainfall recorded over this period was 237 mm in Ikeja. The correlations between the numbers of excess rain days are very low for all stations with the highest correlation of 0.43 between Enugu and Cross River: in both 1997 and again in 2005 there was a very high incidence of excess rain days in these two neighboring states.

This analysis suggests that excess rainfall leading to physical damage to the crop and or flooding may be a significant problem in these states.

Figure 4.3. Number of Excess Rainfall Days (>50 mm) between May to September by Station and by year (1981 to 2010)



Source: Authors' analysis of NIMET Rainfall data

Effect of Deficit Rainfall on Maize and Rice Yields

In order to test for the existence of growing season rainfall deficit and its possible impact on maize and rice yields, average state-level yields were correlated with crop season cumulative rainfall at each station. The results of this correlation analysis are summarized in Table 4.3.

In the case of maize the main crop season is between May and September and therefore the state-level crop yields were correlated with May to September Rainfall. In the southern states of Lagos, Cross River and Enugu, the main rainy season starts earlier and early maize is planted in mid-April. In the case of Kaduna, due to the later onset of the single rainy season, planting of maize does not usually start until June. Most varieties are 100 to 110 day varieties taking the harvest through to late August / September. For maize the highest correlation between May to September rainfall and yield is at Lagos station with a positive correlation coefficient of 0.494, or in other words nearly 50% of the variation in state maize yields is explained by the variation in crop season rainfall at Ikeja weather station: the positive correlation indicates that higher rainfall is associated with higher yields and that crop yields are affected by rainfall deficit (drought). Calabar station Cross River state exhibits the weakest correlation between rainfall and state-level annual yields of -0.084; for Enugu the correlation between rainfall and maize yields is 0.270 and -0.363 for Kaduna.

For maize, rainfall and yields are negatively correlated in two of the four states, Cross River and Kaduna or in other words the problem for maize production in these states appears to be too much rain as opposed to rainfall deficit (drought). This finding suggests there is a need to develop WII contracts to cover both possible rainfall deficit and excess rainfall for maize grown in these 4 states of Nigeria.

For rice, the state-level yield data is much more restricted to only 9 or 10 years data for Cross River and Enugu and this data is inadequate to establish clear causal relationships between yields and rainfall. The correlations at all stations between June to October seasonal rainfall for rice (including mainly lowland rice, but also some upland rice) and rice yields show very poor correlations. The same tendency is observed for both rice and maize in terms of the inverse correlations between rainfall and yield in Kaduna and Cross River implying that in these states too much rainfall leads to reduced yields, while in Enugu and Lagos, rice yields are positively correlated to rainfall. (Table 4.3.).

Table 4.3. Correlations between Cumulative Seasonal Rainfall and Maize and Rice Yields

State/Station	Kaduna	Cross River (Calabar)	Enugu	Lagos (Ikeja)
Maize	-0.363	-0.084	0.270	0.494
Rice	-0.117	-0.075	0.074	0.068

Source: Authors analysis of NIMET Rainfall data and Various Yield sources (See Annex 3)

1. For Maize Seasonal Rainfall from May to September (5 months)
2. For Rice, Seasonal Rainfall from June to October (5 months)
3. For Maize, 16 years yield data available 1994 to 2009 in all states
4. 16 years rice data available for Kaduna and Lagos (1994-2009), 9 to 10 years for Enugu and Cross River

The correlations between the amount of seasonal rainfall and yields of rice and maize are very weak and do not clearly identify rainfall deficit (drought) as a major cause of yield reduction and loss in the 4 states. This lack of a high correlation between crop yield and rainfall is not unexpected given the fact that the rainfall data refer to a single station in each State while the crop yields are average state-level yields and include early and late sown crops.

Impact of Excess Daily Rainfall on Maize and Rice Yields

There is a much clearer inverse relationship between the number of days of excess rain (> 50 mm per day) and maize and rice yields. With one exception namely, maize grown in Lagos (Ikeja), maize and rice yields are inversely correlated with the number of days excess rainfall > 50 mm/day with the highest correlation of -0.754 for maize grown in Kaduna state. The correlations for rice and excess rain are, however, generally weak (See Annex 3 for full details).

Table 4.4. Correlations between Number of Days Excess Rain* and Maize and Rice Yields

Crop	Kaduna	Cross River (Calabar)	Enugu	Lagos (Ikeja)
Maize	-0.754	-0.395	-0.368	0.230
Rice	-0.032	-0.484	-0.076	-0.345

Source: Authors analysis of NIMET Rainfall data

Note * In this analysis seasonal rainfall is assumed to be from May to September for both maize and rice.

The finding that excess or intensive rainfall is associated with yield reduction suggests that excess rain may be suitable for WII purposes in the 4 states. These findings also tend to validate NIAC's reported claims by cause of loss between 2007 and 2010 with the highest value of claims due to pests and diseases, followed by fire and then flood (which if often associated with intense or excess rainfall) damage, while drought claims were very low.

The next sections examine the contract design features for a crop rainfall deficit cover and also for an excess rain cover for maize and rice grown in the four selected states.

3.2
Rainfall Deficit Contracts: Cover Design Features and Modeled Results

Key Features

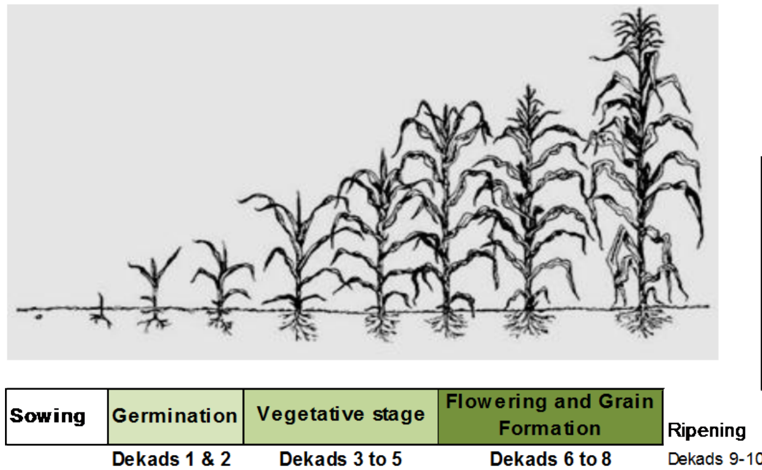
This Section presents one methodology for the design of rainfall-deficit weather index insurance (WII) contract based on the FAO's Water Requirements Satisfaction Index, WRSI. The contract design is based on the standardized deficit-rainfall insurance contracts that have been developed by the Agricultural Risk Management Team, ARMT (former Commodity Risk Management Group, CRMG), of the World Bank, in conjunction with IRI Earth Institute at Columbia.

Over the past decade, WRSI has been extensively applied in many countries to the design and rating of rainfall deficit WII contracts. The beauty of this simple but robust FAO designed crop water balance model is that it can be used to predict accurately the impact of rainfall deficit on crop production and yield at any stage of the plant growth cycle from sowing through to harvest of the crop. (A detailed description of the WRSI Model and its application to rainfall deficit contract design in this Nigerian study is contained in Annex 4, Appendix 4.1).

The most common form of WII rainfall-deficit contract is based on a three phase phonological growth-stage model which usually combines this with a dynamic starting date which is triggered when adequate rainfall has occurred at the start of the growing season for farmers to decide to start planting the crop. These contracts also usually contain a sowing failure cover if rainfall is too low for planting to occur during the recommended sowing window. In each of the subsequent plant growth phases, germination, vegetative growth stage and flowering/grain formation, WRSI is used to calculate the cumulative rainfall requirement of the crop and to define the contract payout parameters, trigger or threshold rainfall level which opens the policy for a payout, exit level when the rainfall deficit is such that severe crop damage or failure will arise and finally the payout rate for each millimeter of rainfall deficit in each phase. For the operation of WII rainfall contracts it is common to use time periods of 10 days termed dekads.

An example of the WII rainfall deficit contract is illustrated in Figure 4.4 below for Maize grown in the vicinity of Enugu Weather station. In Nigeria, most maize varieties are 100 to 110 day varieties (10 to 11 dekads) and the rainfall contracts have been constructed around the first 8 dekads of the crop's growth cycle up to the point of ripening of the maize grain when rainfall is not required. In Enugu, the recommended planting dates for maize are between 11 April (Dekad 11) and 10 May (Dekad 13). Using actual 30 year daily and dekadal rainfall data for Enugu, the WRSI model is used to calculate the amount of rainfall required in each crop growth phase and to set the contract rainfall deficit triggers leading to a payout in each phase. The modeled rainfall deficit triggers and exit levels for each phonological growth stage are shown for Enugu in Figure 4.4 long with the sowing failure rainfall trigger in millimeters.

3.3 Figure 4.4. Three Phase Rainfall-Deficit Contract Model for Maize, Enugu Weather Station, Enugu State, Nigeria



	Millimeters of Rainfall / Phase	
	Drought Triggered if Rainfall Less than	Exit (Maximum Payout if Rainfall less than
Phase 1	40	20
Phase 2	60	40
Phase 3	100	55
Sowing	failed if < 25 mm	

3.4

3.5 Source: adapted by the Authors from ARMT Training Materials

In the case of maize, the WRSI model has been used to test rainfall deficit contracts for all 4 weather stations Kaduna, Cross River (Calabar weather station), Enugu and Lagos (Ikeja weather station) The contract parameters for each phase, basis of valuation and payout rates per phase and maximum payouts per cover period are presented in Annex 4.

Much of the rice grown in Nigeria is produced as lowland rice in valley bottom soils (Fadama) and where rainfall is supplemented by flood water run-off. Under conditions where the amount of rainfall recorded at a weather station is in fact supplemented by rainfall run-off and or irrigation, WRSI cannot be effectively used to design a rainfall deficit contract, nor can rainfall as recorded at the weather station be considered representative of the amount of water actually received by the lowland rice crop. Under this study, the WRSI model was initially tested for rice in all states but with inconclusive results and therefore the more detailed design and rating work was restricted to one station only Kaduna and the contract design features of this contract and modeled results are again presented in Annex 4.

Maize Rainfall Deficit Contract Modeled Payouts and Contract Validation

For maize the WRSI modeled rainfall deficit contracts in Kaduna and Cross River did not generate any payouts in any phase of the maize crop over the 30 year period (1981 to 2010). In Kaduna based on the NIMET rainfall data and the WRSI modeled water balance, there was adequate rainfall in each phase of the 30 year period to fully meet the crop water requirements for maize to achieve a potential yield of 2,300 Kg/Ha, which would imply that rainfall deficiency (drought) is not the primary cause of yield variability or loss in the vicinity of the Kaduna airport weather station. Furthermore there was no significant correlation between the rainfall and WRSI analysis and the Kaduna State-level actual maize yields for the 16 year period 1994 to 2009. This is probably explained by the fact that the state-level aggregated maize area, production and yield data fail to reflect the local variations in maize yields in the vicinity of the Kaduna NIMET weather station. In Cross River (Calabar) annual seasonal crop rainfall is extremely high and again based on the NIMET actual rainfall data and the calculated WRSI modeled water balance, there was adequate rainfall in all 30 years to meet the water requirements of maize to achieve a potential yield of 2,000 Kg/Ha. In other words, the analysis for Kaduna and Cross River indicate that rainfall deficit is not the primary cause of crop production and yield variability and reduction.

The maize rainfall deficit contract analysis for, Enugu and Lagos (Ikeja) produced single payouts both in phase 2 (vegetative growth stage) over the 30 year period 1981 to 2010. In the case of Enugu the modeled payout in 2005 would have led to a full payout in this phase: however, there was no correlation of this WRSI modeled drought loss year and the actual average state yield of maize which was 1,830 Kg/Ha or about 5% above the 16-year average yield of 1,779 Kg/Ha. In the case of Lagos (Ikeja) the phase 2 payout occurred in 1997: however, there is again no correlation between the modeled payout and actual maize yield in 1997 and further investigation shows that the payout coincided with zero rainfall recorded in every day of May 1997 and which appears highly anomalous when compared with the high average rainfall recorded in May for all other 29 years. On this basis it is believed that the May 1997 rainfall data was not recorded and in this case there would have been no payouts over 30 years in Lagos (Ikeja).

3.6 Rainfall Deficit Model for Rice in Kaduna State

3.7

The modeled results for the 30 years of data for the Kaduna Rice-Rainfall deficit contract produced three small phase 1 germination payouts in 1982, 1992 and again in 2006 and then another small Phase 2 vegetative state and flowering in rice payout in 1994. The payouts in all 4 years are very small and the instability of the Kaduna rice model is demonstrated by the fact that if the Phase 1 contract trigger is slightly reduced from 70 mm rainfall to 65 mm rainfall and the Phase 2 contract trigger reduced from 140 mm rainfall to 135 mm rainfall, then all four payouts disappear. The seasonal rainfall and rice yields from 1994 to 2010 do not shown any correlation, save for small negative correlations implying too much rainfall leads to reductions in rice yields[39]. The lack of correlation of rice yields is not unexpected given the fact that Kaduna is a very large state with nearly 150,000 Ha of upland and lowland rice and the state yields may be totally un-representative of yields in the vicinity of Kaduna NIMET synoptic weather station.

This preliminary analysis suggests that the 3-phase WRSI rainfall deficit model is not very well suited to rainfall deficit in rice grown in Kaduna and that in the absence of location specific rice production and yield data it is not possible to properly test and calibrate a rainfall deficit contract for this station.

Excess Rainfall Indexes: Cover Design Features

Key Issues for Insuring Excess Rain in Crops

Drought or plant moisture deficit is a continuous peril and which in many crops has a close linear correlation with yield reduction. A carefully designed three phase rainfall deficit program for a crop such as maize can usually demonstrate a high degree of correlation between reduced rainfall and reduced yield.

[39] This is a similar finding to other parts of West African including Ghana (GIZ 2010).

Conversely the impact of excess rainfall in field row crops (cereals, oilseeds, fibers such as cotton etc) is much more difficult to quantify and measure. Damage due to excess rain can take several forms starting with:

i) **direct mechanical or physical damage** to young plants which may be broken or washed away, or if this occurs at the time of harvest, physical damage to the grain and or cotton bolls etc and or

ii) **secondary or consequential losses** including prevention of access to combine harvesters and delayed harvest during which time overripe crops will shed their grain and or lodge and start rotting in the wet soils through to

iii) **prolonged continuous rainfall** over a period of a dekad or more which exceeds the soil water holding capacity will results in soil water logging and standing water and if these anaerobic soil conditions persist from more than 2 to 3 days the plants will start to die due their inability to transpire /photosynthesis.

iv) **intense torrential rainfall** events whereby 50mm to 100mm or more of rainfall in 24 hours will lead to direct physical damage to crops according to their growth stage and cause further damage by sheet flow and erosion and by water stagnation and flooding.

The timing of the excess rainfall event in relation to the physiological growth stage of the crop will have major bearing on the amount of damage caused to the crop. In Maize excess rain at the time of sowing may lead to soil erosion and soil capping and germination failure: however, the same excess rain event at the vegetative stage when the plants have established a strong root system and are a meter and a half high will have no effect on the crop. Excess rain will have little impact on established wheat and rice crops in the vegetative stage, but excess rain at harvest can be extremely damaging resulting in grain shedding and lodging of the crop and prevention of harvest resulting in the crop rotting in the field.

It is therefore extremely difficult to design an excess rainfall index and to set trigger level which will capture all of the above types of excess rain and the damage that will occur to the crop at different stages of its growth cycle. As such the first generation of excess rainfall index products have proved to be very subject to basis risk under which the outcomes as determined by the index at the weather station have little relation to the actual damage incurred in the crops in the neighboring area.

Excess Rainfall Model Tested for Maize

While Rainfall-deficit contracts have been extensively tested and refined during the past decade, WII Excess Rainfall Contracts are still at a developmental stage. Very few of the micro-level individual farmer WII programs developed to date include excess rainfall and there is no consensus up to now on which or the following parameters represents best the impact of excess rain on crop production and yields: the quantity of torrential or excess rainfall recorded in a single day, or the number of days continuous rainfall, or the cumulative amount of excess rainfall recorded during a defined phase or phases of crop growth. Under this Nigeria pre-feasibility study some preliminary research has been conducted into Excess Rainfall Contracts for Maize for the 4 selected weather stations - Kaduna, Cross River (Calabar), Enugu and Lagos (Ikeja). On the basis of the knowledge of the World Bank's technical team, however, one of the main limitations is that unlike the FAO-WRSI rainfall-deficit-drought model which is widely applied in different parts of the world, there is no physiological (agronomic) model that adequately captures the effects of excess rainfall on crop production and yields. In the absence of a specific Excess Rain-yield model, a simple approach has been adopted based on the **amount of**

cumulative rainfall in each crop physiological growth stage in maize. As such, the excess rainfall index tested under this study is a 3-phase cumulative excess rainfall index for maize which replicates as closely as possible the rainfall deficit model outlined above for maize.

The modeled results for Enugu Maize excess rainfall over the 30-year period 1981 to 2010 there would have been a total of 5 modeled contract payouts relating to excess rain or a frequency of 1 payout in every 6 years. To begin with there would have been a **sowing failure** payout in 2001 due to the very high rainfall in the first dekad of 171 mm or considerably above the 135 trigger threshold resulting in an indemnity of Naira 24,000. This is followed by one full Phase 1 **Germination failure** payout of Naira 24,000 in 1997, one Phase 2, **Vegetative stage** maximum payout of Naira 30,000 and finally two Phase 3 **flowering and yield formation** excess rain payouts in payouts in 1984 and again in 1995 when a maximum payout would have been made.

The major drawback of this excess rainfall analysis for Enugu maize is that there is (1) no correlation at all between the cumulative excess rainfall payouts and the WRSI calculated optimal yields over the 30 year period and (2) there is no correlation between excess rain payouts and the actual state-level time-series yields for maize grown in Enugu from 1994 to 2010. In other words, if one were to offer a three-phase cumulative excess rainfall cover in Enugu, it is possible that the payouts triggered by the rainfall index may have no correlation whatsoever, with maize crop yield and revenue losses on the ground. Similar modeled results are obtained for the excess rain contracts for maize in Kaduna, Cross River (Calabar) Lagos (Ikeja) namely, a high number of modeled excess rainfall claims in each of the phases based on the accumulated per phase rainfall data. However, the modeled results are not deemed safe to recommend the design of maize excess rainfall contracts on this basis.

The full results of the excess rainfall WII contract design exercise for maize are presented in Annex 4.

Conclusions on WII for Nigeria

The principle conclusion that can be drawn from this WII modeling exercise is that rainfall deficit (drought) is not the principle cause of maize and rice production and yield loss in the 4 selected states and that the 3-phase rainfall deficit model does not perform well for situations where average monthly rainfall during the growing season is relatively high and stable year on year and fully meets the water requirements of the crop**.** While these results are unexpected, they tend to match both the NAIC crop insurance results which show that drought has only accounted for about 9% of the total value of claims across the MPCI program over the past 4 years and also the diagnosis of the CADP management that drought was only a key exposure in Kano state and that the major causes of loss in the other states were pests and diseases and flood.

The preliminary modeling or excess rainfall exposure in maize using a three phase cumulative excess rainfall contract design produced a high number of modeled payouts, but these payouts bore no relationship at all to the actual yields recorded in each year. The results demonstrate the danger of basis risk where the excess rain payouts triggered by the weather index bear no relationship to the actual crop yield outcomes in the insured area. The relatively high inverse correlations between number of excess rainfall days with rain in excess of 50 mm/day and maize and rice yields suggest that further research should focus on a daily rainfall excess trigger rather than accumulated rainfall in each crop vegetative phase.

Although flood is the third most important cause of loss on the NAIC scheme, flood is a very difficult peril to index and to date there are no micro-level individual farmer flood crop index insurance programs in commercial implementation***.***

The pre-feasibility study into the design of WII rainfall contracts for maize and rice in 4 of the 5 CADP States has produced very inconclusive results about the applicability or usefulness of these contracts. WII is only suitable to situations where there is a high degree of correlation between the weather variable and crop production and yields. This study has not been able to demonstrate this relationship. It must also be recognized that the absence of disaggregated weather-station location specific rice and maize crop production and yield data has precluded a more in-depth analysis of rainfall and yield correlations.

Chapter 4: Legal, Institutional, Operational and Financial Considerations for WII in Nigeria

This final chapter presents a review of some of the key legal, institutional, operational and financial challenges and issues which would need to be addressed in any future WII program for Nigeria and only once the weather station network has been upgraded and the density of stations significantly increased to permit commercial implementation and scale-up in states and crops which are prone to severe drought and or excess rain/flood damage. The potential roles that the Government of Nigeria, NAIC, and the private commercial insurers might play in the eventual future development of WII in Nigeria are also considered in this section.

Legal and Regulatory implications of WII

WII Index insurance differs from standard indemnity based insurance in several key ways which may require changes or amendments to standard insurance legislation in Nigeria. To begin with the object of insurance that applies under a traditional insurance policy, for example a plot of land with a defined area of an insured crop is replaced by a proxy index, in this case the cumulated rainfall measured on with a pre-agreed methodology in a pre-agreed location (selected weather station) which is designed to reflect as accurately as possible the loss of crop production that occurs in years of extreme weather. Secondly a central feature of any standard insurance policy is that the insured good or object must be subject to physical loss or damage which can be measured and quantified and an indemnity is paid according to the actual amount of loss suffered/incurred by the insured object. Under an index insurance cover, there is no measurement of actual physical loss or damage suffered by the Insured, but rather an insurance payment is made according to a pre-agreed payout procedure once the index threshold leading to a payout has been triggered. A key difference between index and indemnity insurance is that an index may results in payouts to an insured even if the Insured has not incurred a physical loss or damage to the object or good which the index is designed to approximate.

Under an eventual proposal for the implementation of WII in Nigeria, it will be important to review and confirm the legal requirements and procedures for issuing such a cover, with the NAICOM. It will be very important to ensure that the proposed WII policy that is issued and the operating procedures agreed conform to existing insurance legislation and norms and procedures for conducting insurance business as prescribed by insurance regulator.

Institutional (Public vs. Private WII Insurance or PPP)

In case WII would be implemented in Nigeria, there would be three possible organizational structures to be considered: (i) public sector model; (ii) pure private model; and (iii) Public – Private Partnerships. The first WII organizational structure to be considered is the public sector model. A typical example of a public sector model is the current agricultural insurance system under the NAIS in Nigeria. The public sector model is featured by the existence of one single policy wording and one monopolistic insurance provider, usually a national parastatal insurance company such as NAIC, which is responsible for underwriting crop and/or livestock insurance, usually backed-up by public sector reinsurance arrangements. The main advantage of the public sector model is the diversification of risks and the stability of the system, the main disadvantage is the existence of issues with the services. The second model is the pure private model. The pure private model is featured by the existence of multiple policy wordings and multiple insurance companies' competing for the same business. The main advantages of the pure private agricultural insurance markets are the existence of ferocious competition that keeps the prices usually low. The main disadvantage is the poor stability of the system. The largest private sector agricultural insurance markets in 2007 include Argentina (where a group of about 29 commercial and mutual insurance companies compete to underwrite crop hail and a smaller volume of MPCI, forestry, livestock, and aquaculture business). Germany (crop hail and livestock), France (crop hail), Sweden, Australia, New Zealand, and South Africa also follow this model. The third organizational structure for agricultural insurance is the public-private partnership (PPP) model, where agricultural insurance is implemented by the private sector, with assistance from government, usually in the form of premium subsidies but also often reinsurance. Under a PPP there is one single policy wording for the whole market. The most comprehensive PPP arrangements are found under the national agricultural insurance schemes in Spain, Turkey, and South Korea, Box 5.1 summarizes the different public-private institutional frameworks in Agricultural insurance.

4.1 Box 5.1: Public-Private Institutional Frameworks in Agricultural Insurance

1. PUBLIC SECTOR INSURANCE MODELS

Features: A public sector specialist agricultural insurer, which usually operates as the sole or monopoly insurer in the country, and which is reinsured exclusively by government, or government is the main reinsurer.

Examples: **Iran** (1 insurer: government-owned Agricultural Insurance Fund); **India** (the national agricultural insurance scheme, NAIS is implemented by the public agricultural crop insurance company, the Agricultural Insurance Company Ltd of India, AICI), **Nigeria** (the national agricultural insurance scheme, NAIS is implemented by the public agricultural crop insurance company, the Nigeria Agricultural Insurance Corporation, AICI); **Philippines** (1 national insurer responsible for crop and livestock insurance, the Philippines Crop Insurance Corporation), **Canada** (10 provincial government Crop Insurance Corporations which are partly reinsured by the federal government), **Greece** (Hellenic Agricultural Insurance Organization, ELGA, a government entity); **Cyprus** (1 national insurer: Agricultural Insurance Organization of the MOA).

2. PRIVATE SECTOR INSURANCE MODEL WITH NO GOVERNMENT SUPPORT

Features: Private commercial or mutual insurance companies (usual several in each market) which may either be general non-life insurance companies or specialist agricultural insurers actively competing for business, and purchasing proportional and non-proportional reinsurance from international commercial reinsurers.

Examples: Argentina (over 2 private commercial and mutual mainly hail insurers), **South Africa** (7 private commercial and mutual companies and underwriting agencies offering crop and or livestock insurance), **Australia** (15 private companies underwriting crop and or livestock), New Zealand, Germany, Sweden, Hungary, Netherlands.

3. PUBLIC-PRIVATE PARTNERSHIPS WITH GOVERNMENT SUPPORT

(a) National Agricultural Insurance Schemes with Monopoly Agricultural Insurer
Key features: national subsidized private sector crop and livestock insurance implemented through a single entity and offering standard policy forms and uniform rating structure with single entity responsible for loss adjustment. High levels of government premium subsidy support and support for reinsurance.

Examples: Private Coinsurance Pools: AGROSEGURO, Spain, TARSIM Pool, Turkey,
Single national insurer: NACF Cooperative crop & livestock insurer, South Korea

(b) Individual Commercial Insurers competing for business, but often highly controlled in terms of policy design and or premium rating criteria and obligations to offer crop insurance to all farmer types and regions in order to order to qualify for premium subsidies.

Examples: USA (FCIC/MPCI) program implemented by 17 private companies/managing agents; Portugal, SIPAC Crop Insurance scheme underwritten by about 15 private general insurance companies.

(c) Individual Commercial Insurers competing for business, lower public control. Private commercial companies are free to elect which crops and regions and perils they will underwrite and the premium rates they will charge. Governments' main role is providing premium subsidies.

Examples: Italy, France, Mexico, Chile, Brazil, Russia, Poland

Source: Mahul & Stutley (2010).

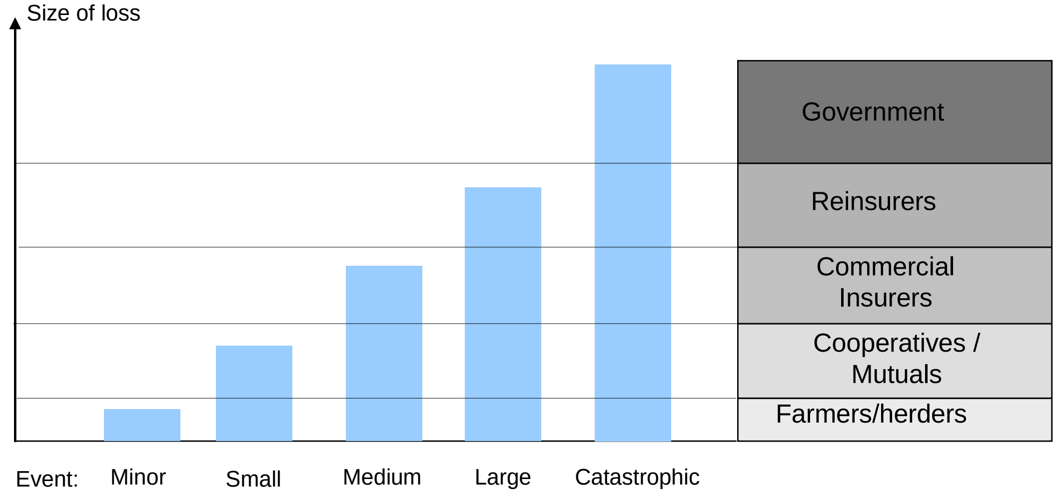
Operational

Whether the GoN or NAIC eventually decide to consider the adoption of WII contracts in the future an investment plan for the installation of weather stations and additional research to investigate the technical and commercial specificities of WII would be recommended. If GoN and/or NAIC eventually decide to consider the adoption of WII in the future to be implemented in Nigeria, the first thing to be considered is a massive investment plan for the installation of weather stations should be considered. As noted before, while preliminary calculations indicates that the country would need approximately 465 weather stations to achieve total national coverage for a rainfall index programs, the current stock (53 synoptic weather stations, 20 agro meteorological stations, 40 automatic weather stations, and 500 rainfall gauges distributed) is far below the number of required weather stations[40]. Secondly, a tamperproof system for the timely transition of weather data should be implemented. Reinsurers would eventually require that the weather information to be used to determine the payouts of the WII to be inviolate. Third, a system of fallback weather station should be implemented to act in case of failures on the measurement of the main system.

Financial, Insurance and Reinsurance

In case WII is implemented in the future, the role of international reinsurance is likely to be crucial. In case WII is implemented in Nigeria, the international reinsurers would have a crucial role both in the provision of technical design assistance and in providing reinsurance capacity. The reinsurance sector is a major source of specialist technical expertise in the design and rating of WII insurance products and it is recommended that the Nigerian insurance companies should aim to seek the involvement of lead agricultural reinsurance companies at the earliest opportunity .The international agricultural reinsurance market for traditional and new WII insurance is dominated by a handful of specialist agricultural reinsurers including SwissRe, MunichRe, PartnerRe, HannoverRe, and SCOR. There are many options for structuring risk financing and reinsurance programs including both proportional and non proportional reinsurance. Figure 5.1. provides an example of a non-proportional insurance and reinsurance structure involving both mutual and private commercial insurers with reinsurance for catastrophe events being provided by international reinsurers and possibly local government.

Figure 5.1. Illustration of Agricultural Risk Layering and Financing



Source: Mahul & Stutley 2010

[40] It should be also noted that, apparently, only the 53 synoptic weather stations are in conditions to provide 25 years historic data.

Role of Government

International experience tends to suggest that implementation of WII insurance is most efficient and effectively managed by the private commercial crop insurance sector[41]. However, where insurance markets and infrastructure are poorly developed, governments 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 a public-private partnership and specifically the roles that the GoN, may wish to consider in order to promote WII. Box 5.2 presents a summary of some of the ways in which governments can assist private insurance companies by enhancing insurance market infrastructure in the start-up phase of a new agricultural insurance programs. Features of these interventions are considered further below in the context of Nigeria.

4.2 Legal and regulatory

GoN can facilitate a review and amendments of the Insurance Regulation and the Decree N037. As previously reported the introduction of WII might require the amendment of the current insurance regulation in order to allow index based insurance products to operate in the country. In addition to assist in the amendment of the current insurance regulation for the inclusion of index based insurance, the GoN might also collaborate on the amendment of the Decree N37 of 1993 in order to allow insurance companies other than NAIC to access to the GoN benefits (premium subsidies, stop loss protection) for the promotion of WII.

Enhancing Data and Information Systems

There appears to be important roles for GoN to further enhance and strengthen the national data base systems for crops and to invest in upgrading the NIMET's meteorological weather station network. This review has identified major gaps in the national systems and procedures for recording reporting and storing of data and statistics for crops and crop losses. GoN can play a major role in funding the creation of new data-base systems and procedures for these sectors and this is already envisaged under the CADP. Further investment is required by the GoN to upgrade the NIMET's national network of synoptic weather stations and rain-gauge stations and to strengthen data recording and transfer.

Product Research and Development

The Nigerian Insurance Industry has no experience with the design and rating of WII. GoN could usefully support the provision of specialist technical assistance from international sources to assist the Nigeria Insurance Association and NAICOM to design and rate and prepare policy wordings for these new agricultural insurance products.

Education, Training and Capacity Building

Governments can play a key role in supporting farmer awareness and education programs and capacity building and workshops and technical training programs for key agricultural insurance staff. Given the fact that there is no agricultural insurance tradition in Nigeria high priority will need to be given to financial and insurance literacy programs for farmers and specific training in the role and benefits of the different crop insurance products. Insurance Company staff will also need specialist training in product design, actuarial and rating, underwriting and claims administration and loss assessment systems and procedures. Similar training also needs to be provided to staff in the banks, MFIs, and input suppliers if these organizations get involved as delivery channels/agents.

[41] See for example, Hazell 1992 and Mahul and Stutley 2010.

Catastrophe Risk Financing

In many countries government is involved in the reinsurance of agriculture. Key territories where government acts as a catastrophe reinsurer (either directly or indirectly through a national reinsurance company) include the USA and Canada, Spain, Brazil, India, South Korea and China. In Nigeria, the government is participating protecting the liabilities of the agricultural risk written by NAIC is excess of 200 percent loss ratio, While it is too early to consider the role if any of government as a reinsurer of last resort for agriculture in Nigeria. It is recommended that the private insurers should first seek to place their reinsurance requirements with international reinsurers and only revert to government in the unlikely case that they cannot place their reinsurance programs.

Premium Subsidies

Premium subsidies are the most widely practiced form of government support to agricultural insurance practiced by over two thirds of countries which have some form of agricultural insurance. As it was noted, the GoN is currently subsidizing 50 percent of the agricultural insurance premiums written by NAIC, In case WII insurance is implemented in Nigeria, it would be advisable that GoN to make extensive this benefit to the insurance sector. (Including insurance companies other than NAIC. Premium subsidies are very controversial for a number of reasons. The provision of non-discriminatory premium subsidies is regressive, as they disproportionately benefit the larger farmers to the detriment of small and marginal farmers. Also subsidies that cover a large part of the overall premium tend to promote moral hazard whereby farmers grow high risk crops which attract high premium subsidies in regions which are not technically suited to the crop. Once premium subsidies have been introduced by governments it is politically very difficult to reduce or to withdraw these subsidies and in many of the countries which operate non-discriminatory premium subsidies the fiscal costs to government are extremely high. It is not known whether GoG is considering providing agricultural insurance premium subsidies for Guyana. However, the World Bank only advocates progressive premium subsidies where a clear social need is identified and where the premium subsidies are targeted at special needs groups for a limited time period.

Box 5.2. Potential Roles for Government in Supporting Agricultural Insurance

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 to enact specific agricultural insurance legislation.

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. GoN can provide an invaluable service by creating national data bases and to then make these data bases available to all interested private commercial insurers either free of cost, or at concessionary rates.

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.

Education, Training and Capacity Building. GoN can play an important role on new agricultural insurance programs by supporting (a) farmer awareness and education programs and (b) capacity building and workshops and technical training programs for key agricultural insurance staff.

Catastrophe Risk Financing. 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 insurance 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.

Public Sector Premium Subsidies. Premium subsidies are the most widely practiced form of government support to agricultural insurance practiced by over two thirds of countries which have some form of agricultural insurance. Governments justify the provision of agricultural insurance premium subsidies on the grounds that they make insurance more affordable for farmers particularly small and marginal farmers thereby increasing the rate of adoption and uptake of agricultural insurance. There are, however, major drawbacks of premium subsidies including the disproportionately benefit larger farmers to the detriment of small and marginal farmers, they tend to promote moral hazard namely to encourage crop production in high risk regions, once premium subsidies once introduced are very difficult to reduce or to withdraw and they represent a major cost to government. This report only advocates premium subsidies where a clear social need is identified and where the premium subsidies are targeted at special needs groups and are provided for a specific period of time and which can be withdrawn once the program has attained a critical mass.

Source: Mahul & Stutley 2010

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List of Annexes

1. NAIS Agricultural Insurance Results

1.1. Insured Crops and Livestock

The NAIS started by insuring 2 crops, rice and maize and 2 categories of livestock, cattle and poultry. Over the past 22 years the programs has expanded to underwrite 22 crops including subsidized crops (cereals, oilseeds and root crops) and commercial crops (mainly tree crops, but also cotton and sugar cane) and a wide range of livestock, including subsidized cattle, pigs and small ruminants, poultry and fisheries (aquaculture) and commercial livestock including horses and dogs (Annex A1.1).

Annex 1.1. NIAC List of Insurable crops and livestock in 2011

Insurable Livestock		**Insurable Crops**	
Subsidised Livestock	**Commercial Livestock**	**Subsidized Crops**	**Commercial Crops**
1. Cattle	1. Horses	1. Rice	1. Cocoa
2. Poultry	2. Dogs	2. Maize	2. Cotton
3.Piggery	3. Others	3. Yam	3. Pineapple
4. Sheep		4. Cassava	4. Plantain
5. Goats		5. Sorghum	5. Citrus
6. Fishery		6. Millet	6. Kolanut
7.Rabbitry		7. Groundnut	7. Cashew
8. Others		8. Irish Potato	8. Oilpalm
		9. Soya Beans	9. Sugarcane
		10. Cowpea	10. Others
		11. Mixed Crops	
		12. Wheat	
		13. Unclassified	

Source: NAIC 2011

1.2. NAIC Agricultural Insurance Results and Overall Consolidated Results including Commercial Lines 2007 to 2010

NAIC's consolidated annual underwriting results for crops, livestock and commercial lines are summarized below for the period 2007 to 2010 in Naira and then in US Dollar equivalents.

Annex 1. 2. NAIC Agricultural and Commercial Non-Life Insurance: No Policies, Sum Insured and Premium 2010 Underwriting Year

NAIC Agricultural Insurance and General Insurance: Written Business 2010 (Naira)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (Naira)	Percent Liability	Premium (Naira)	Percent Premium	Premium rate %
Subsidised Livestock	9,606	1,523,003	5,359,198,105	11%	131,319,967	16%	2.5%
Subsidised Crops	31,665	112,142	7,618,846,134	16%	322,750,011	38%	4.2%
Commercial Livestock	50	n.a.	3,263,500	0%	70,677	0%	2.2%
Commercial Crops	574	240	609,857,716	1%	9,410,310	1%	1.5%
Sub-Total Agriculture	**41,895**	**1,635,385**	**13,591,165,455**	**28%**	**463,550,964**	**55%**	**3.4%**
Commercial Non-Life	**7,973**		**34,725,966,353**	**72%**	**378,625,395**	**45%**	**1.1%**
Total	**49,868**	**1,635,385**	**48,317,131,808**	**100%**	**842,176,359**	**100%**	**1.7%**

NAIC Agricultural Insurance and General Insurance: Written Business 2010 (US$*)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (US$)	Percent Liability	Premium (US$)	Percent Premium	Premium rate %
Subsidised Livestock	9,606	1,523,003	35,967,773	11%	881,342	16%	2.5%
Subsidised Crops	31,665	112,142	51,133,196	16%	2,166,107	38%	4.2%
Commercial Livestock	50	n.a.	21,903	0%	474	0%	2.2%
Commercial Crops	574	240	4,093,005	1%	63,156	1%	1.5%
Sub-Total Agriculture	**41,895**	**1,635,385**	**91,215,876**	**28%**	**3,111,080**	**55%**	**3.4%**
Commercial Non-Life	**7,973**		**233,060,177**	**72%**	**2,541,110**	**45%**	**1.1%**
Total	**49,868**	**1,635,385**	**324,276,052**	**100%**	**5,652,190**	**100%**	**1.7%**

Notes:

Source: NAIC March 2011

*** 2010 exchange rate of US$ 1.00 = Naira 149**

Annex 1. 3. NAIC Agricultural and Commercial Non-Life Insurance: No Policies, Sum Insured and Premium 2009 Underwriting Year

NAIC Agricultural Insurance and General Insurance: Written Business 2009 (Naira)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (Naira)	Percent Liability	Premium (Naira)	Percent Premium	Premium rate %
Subsidised Livestock	13,628	4,272,699	4,294,493,299	15%	98,732,596	12%	2.3%
Subsidised Crops#	35,768	60,622	7,502,160,428	27%	519,651,741	63%	6.9%
Commercial Livestock	34	26	9,320,000	0%	261,250	0%	2.8%
Commercial Crops	574	240	609,857,716	2%	9,410,310	1%	1.5%
Sub-Total Agriculture	**50,004**	**4,333,587**	**12,415,831,443**	**44%**	**628,055,897**	**76%**	**5.1%**
Commercial Non-Life	**2,847**		**15,758,565,616**	**56%**	**200,440,984**	**24%**	**1.3%**
Total	**52,851**	**4,333,587**	**28,174,397,059**	**100%**	**828,496,881**	**100%**	**2.9%**

NAIC Agricultural Insurance and General Insurance: Written Business 2009 (US$*)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (US$)	Percent Liability	Premium (US$)	Percent Premium	Premium rate %
Subsidised Livestock	13,628	4,272,699	29,214,240	15%	671,650	12%	2.3%
Subsidized Crops#	35,768	60,622	51,035,105	27%	3,535,046	63%	6.9%
Commercial Livestock	34	26	63,401	0%	1,777	0%	2.8%
Commercial Crops	574	240	4,148,692	2%	64,016	1%	1.5%
Sub-Total Agriculture	**50,004**	**4,333,587**	**84,461,438**	**44%**	**4,272,489**	**76%**	**5.1%**
Commercial Non-Life	**2,847**	**0**	**107,201,127**	**56%**	**1,363,544**	**24%**	**1.3%**
Total	**52,851**	**4,333,587**	**191,662,565**	**100%**	**5,636,033**	**100%**	**2.9%**

Notes:

Source: NAIC March 2011

*** 2009 exchange rate of US$ 1.00 = Naira 147**

 # Includes Naira 411 million (US$ 2.8 million) of unclassified subsidized crop insurance business

Annex 1. 4. NAIC Agricultural and Commercial Non-Life Insurance: No Policies, Sum Insured and Premium 2008 Underwriting Year

NAIC Agricultural Insurance and General Insurance: Written Business 2008 (Naira)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (Naira)	Percent Liability	Premium (Naira)	Percent Premium	Premium rate %
Subsidized Livestock	13,560	3,454,483	5,147,220,361	25%	108,441,438	16%	2.1%
Subsidized Crops	30,970	62,810	6,147,636,045	30%	123,268,130	18%	2.0%
Commercial Livestock	75		37,885,000	0%	947,125	0%	2.5%
Commercial Crops	911	1,100	374,361,200	2%	6,772,289	1%	1.8%
Sub-Total Agriculture	**45,516**	**3,518,393**	**11,707,102,606**	**57%**	**239,428,982**	**35%**	**2.0%**
Commercial Non-Life	**2,486**		**8,917,380,041**	**43%**	**440,175,115**	**65%**	**4.9%**
Total	**48,002**	**3,518,393**	**20,624,482,647**	**100%**	**679,604,097**	**100%**	**3.3%**

NAIC Agricultural Insurance and General Insurance: Written Business 2008 (US$*)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (US$)	Percent Liability	Premium (US$)	Percent Premium	Premium rate %
Subsidized Livestock	13,560	3,454,483	44,372,589	25%	934,840	16%	2.1%
Subsidized Crops	30,970	62,810	52,996,862	30%	1,062,656	18%	2.0%
Commercial Livestock	75	0	326,595	0%	8,165	0%	2.5%
Commercial Crops	911	1,100	3,227,252	2%	58,382	1%	1.8%
Sub-Total Agriculture	**45,516**	**3,518,393**	**100,923,298**	**57%**	**2,064,043**	**35%**	**2.0%**
Commercial Non-Life	**2,486**	**0**	**76,873,966**	**43%**	**3,794,613**	**65%**	**4.9%**
Total	**48,002**	**3,518,393**	**177,797,264**	**100%**	**5,858,656**	**100%**	**3.3%**

Notes:

Source: NAIC March 2011

*** 2008 exchange rate of US$ 1.00 = Naira 116**

Annex 1.5. NAIC Agricultural and Commercial Non-Life Insurance: No Policies, Sum Insured and Premium 2007 Underwriting Year

NAIC Agricultural Insurance and General Insurance: Written Business 2007 (Naira)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (Naira)	Percent Liability	Premium (Naira)	Percent Premium	Premium rate %
Subsidized Livestock	10,090	873,545	3,170,337,912	13%	79,263,555	14%	2.5%
Subsidized Crops	39,173	157,991	6,858,836,330	27%	127,302,356	23%	1.9%
Commercial Livestock	14		1,135,000	0%	29,875	0%	2.6%
Commercial Crops	618	667	292,104,929	1%	4,759,325	1%	1.6%
Sub-Total Agriculture	**49,895**	**1,032,203**	**10,322,414,171**	**41%**	**211,355,111**	**38%**	**2.0%**
Commercial Non-Life	**2,423**		**14,718,349,315**	**59%**	**337,677,409**	**62%**	**2.3%**
Total	**52,318**	**1,032,203**	**25,040,763,486**	**100%**	**549,032,520**	**100%**	**2.2%**

NAIC Agricultural Insurance and General Insurance: Written Business 2007 (US$*)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (US$)	Percent Liability	Premium (US$)	Percent Premium	Premium rate %
Subsidized Livestock	10,090	873,545	25,362,703	13%	634,108	14%	2.5%
Subsidized Crops	39,173	157,991	54,870,691	27%	1,018,419	23%	1.9%
Commercial Livestock	14	0	9,080	0%	239	0%	2.6%
Commercial Crops	618	667	2,336,839	1%	38,075	1%	1.6%
Sub-Total Agriculture	**49,895**	**1,032,203**	**82,579,313**	**41%**	**1,690,841**	**38%**	**2.0%**
Commercial Non-Life	**2,423**	**0**	**117,746,795**	**59%**	**2,701,419**	**62%**	**2.3%**
Total	**52,318**	**1,032,203**	**200,326,108**	**100%**	**4,392,260**	**100%**	**2.2%**

Notes:

Source: NAIC March 2011

*** 2008 exchange rate of US$ 1.00 = Naira 125**

Annex 1.6. NAIC Agricultural and Commercial Non-Life Insurance: No Policies, Sum Insured and Premium Consolidated Results 2007 to 2010 Underwriting Years

NAIC Agricultural Insurance and General Insurance: Annual Avge. Written Business 2007-2010 (Naira)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (Naira)	Percent Liability	Premium (Naira)	Percent Premium	Premium rate %
Subsidized Livestock	11,721	2,530,933	4,492,812,419	15%	104,439,389	14%	2.3%
Subsidized Crops	34,394	98,391	7,031,869,734	23%	273,243,060	38%	3.9%
Commercial Livestock	43		12,900,875	0%	327,232	0%	2.5%
Commercial Crops	669	562	471,545,390	2%	7,588,058	1%	1.6%
Sub-Total Agriculture	46,828	2,629,892	12,009,128,419	**39%**	385,597,738	**53%**	**3.2%**
Commercial Non-Life	3,932	0	18,530,065,331	**61%**	339,229,726	**47%**	**1.8%**
Total	**50,760**	**2,629,892**	**30,539,193,750**	**100%**	**724,827,464**	**100%**	**2.4%**

NAIC Agricultural Insurance and General Insurance: Annual Average. Written Business 2007-2010 (US$)

Item	No. Policies	Insured Area (Ha) / No. animals	Sum Insured (US$)	Percent Liability	Premium (US$)	Percent Premium	Premium rate %
Subsidized Livestock	11,721	2,530,933	33,729,326	15%	780,485	14%	2.3%
Subsidized Crops	34,394	98,391	52,508,963	23%	1,945,557	36%	3.7%
Commercial Livestock	43	0	105,245	0%	2,664	0%	2.5%
Commercial Crops	669	562	3,451,447	2%	55,907	1%	1.6%
Sub-Total Agriculture	**46,828**	**2,629,892**	89,794,981	40%	2,784,613	52%	3.1%
Commercial Non-Life	**3,932**	**0**	133,720,516	60%	2,600,172	48%	1.9%
Total	**50,760**	**2,629,892**	223,515,497	100%	5,384,785	100%	2.4%

Notes:

Source: NAIC March 2011

2. Climatic Risk Exposures to Agriculture in the Selected States in Nigeria

2.1. Density of NIMET Weather Stations in the 5 Selected States

NIMET (Nigerian Meteorological Agency) maintains a national network of 53 Synoptic meteorological stations in the 37 states of Nigeria, 20 agro-meteorological stations, 40 automatic weather stations and 500 rainfall gauges distributed all over the country. While the 53 synoptic stations can provide uninterrupted daily rainfall and temperature data for more than 25 years for the design and rating of WII covers, it is understood that very few of the agro-meteorological and or rainfall gauge stations can provide uninterrupted 25 year data.

There is a very low density of NIMET stations in the CADP selected states as shown in Table A2.1. below. Kano and Enugu states only have 1 NIMET station; there are 2 in Kaduna (at Kaduna and Zaria), 3 stations in Lagos and 4 in Cross River state.

The stations and the time-series data which was kindly provided by NIMET to the World Bank for the purposes of the Weather Index Contract design and rating study are also shown in Table A2.1. For each of the 5 stations (one per state), NIMET provided 30 years of daily data for rainfall, daily minimum and maximum temperature and average evapotranspiration.

Table A.2.1. List of NIMET Synoptic Meteorological Stations in the 5 Selected CADP states

			Data provided by NIMET for World Bank WII Study				
No. Stations	**State**	**NIMET Meteorological Station**	**Station**	**Years Daily Rainfall Data**	**Min Daily Temperature**	**Maximum Daily Temperature**	**Daily Average Evapotranspiration**
1	Kano	Kano Airport	Kano	1981-2010	1981-2010	1981-2010	1981-2010
2	Kaduna	Kaduna	Kaduna	1981-2010	1981-2010	1981-2010	1981-2010
3		Zaria					
4	Cross River	Calabar	Calabar	1981-2010	1981-2010	1981-2010	1981-2010
5		Ikom					
6		Ogoja					
7		Eket					
8	Enugu	Enugu	Enugu	1981-2010	1981-2010	1981-2010	1981-2010
9	Lagos	Ikeja	Ikeja	1981-2010	1981-2010	1981-2010	1981-2010
10		Oshodi					
11		Marine					

Source: Authors based on NIMET Data

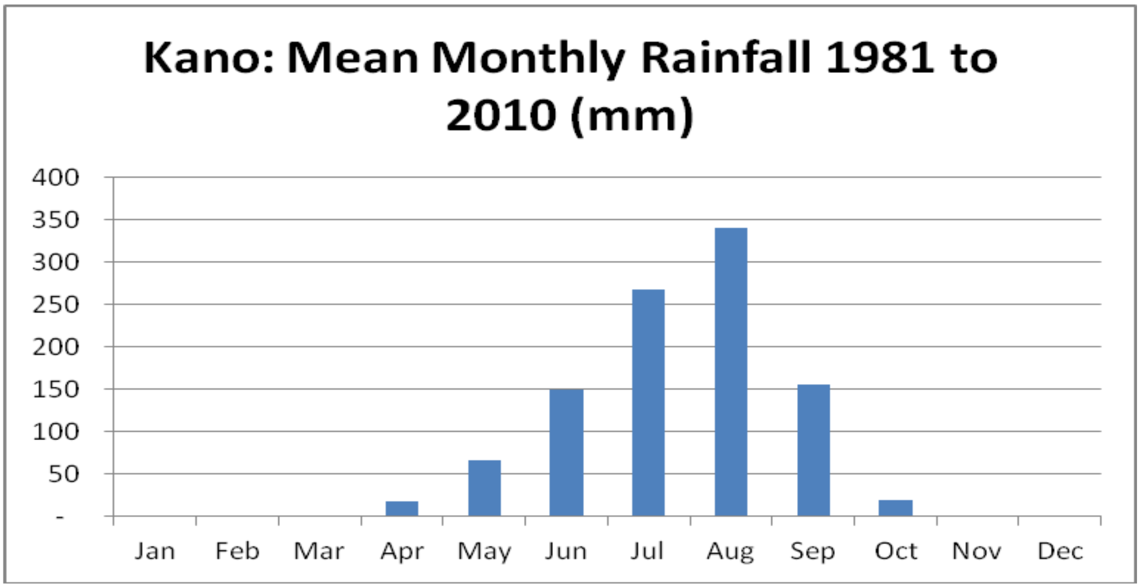
2.2. KANO STATE Rainfall Data analysis

Kano state is within the sudan savanna (North) and northern Guinea savanna (South) agroecological zones of Nigeria with mean annual rainfall of 1,109 mm and which is highly concentrated into a 5/6 month rainy season from May/June to end September (Figures Ax.1. and Ax.2). The cropping season for rainfed crop production commences between late May and June for all the cereals. Cowpea and vegetables are sown later during the rainy season. (ICEED 2011).

In Kano, NIMET has 1 Synopic weather station at Kano Airport (Kano Airport; 12^0 02'N, 08^0 31'E).

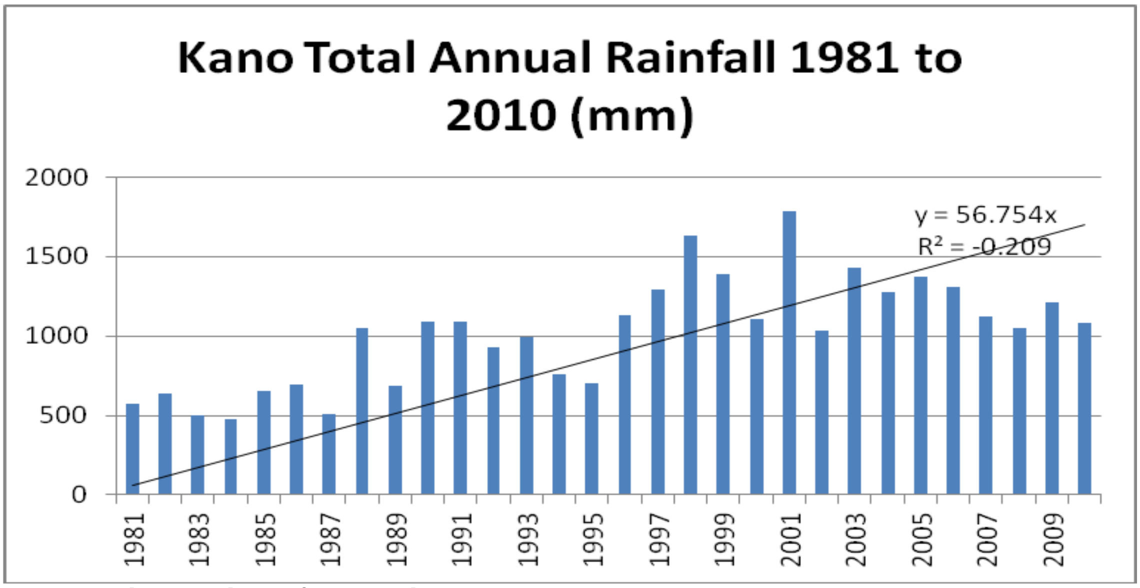
The Kano State Agricultural and Rural Development Authority (KNARDA) established fifteen (15) synoptic weather observatory stations across the state, but according to ICEED data is only available for the past 10 years and the accuracy of the data cannot be guaranteed. Weather data is also available at the ARS, IAR/ABU Kano Station and the IITA, Kano Station. The data at ARS is for period over 30 years while the IITA weather data for Minjibir (46 km north east of Kano) is for about 10 years. While data from ARS are manually collected, the IITA station's weather records are from the Automatic Weather Station. (ICEED 2011).

Figure A2.1. Kano Airport (NIMET Station) Mean Monthly Rainfall (mm)



Source: Authors' analysis of NIMET data

Figure A2.2. Kano Airport (NIMET station) Annual Rainfall (mm)



Source: Authors' analysis of NIMET data

Table A2.2. Kano Airport (NIMET Station) Comparison of 1981 to 1995 Rainfall and 1996 to 2010 Rainfall

Years	Average (mm)	Stdev (mm)	COV (%)	Min (mm)	Max (mm)
1981 to 1995	755.7	218.5	29%	473.7	1,088.0
1996 to 2010	1,282.8	217.1	17%	1,033.7	1,789.4
1981 to 2011	1,019.3	343.0	34%	473.7	1,789.4

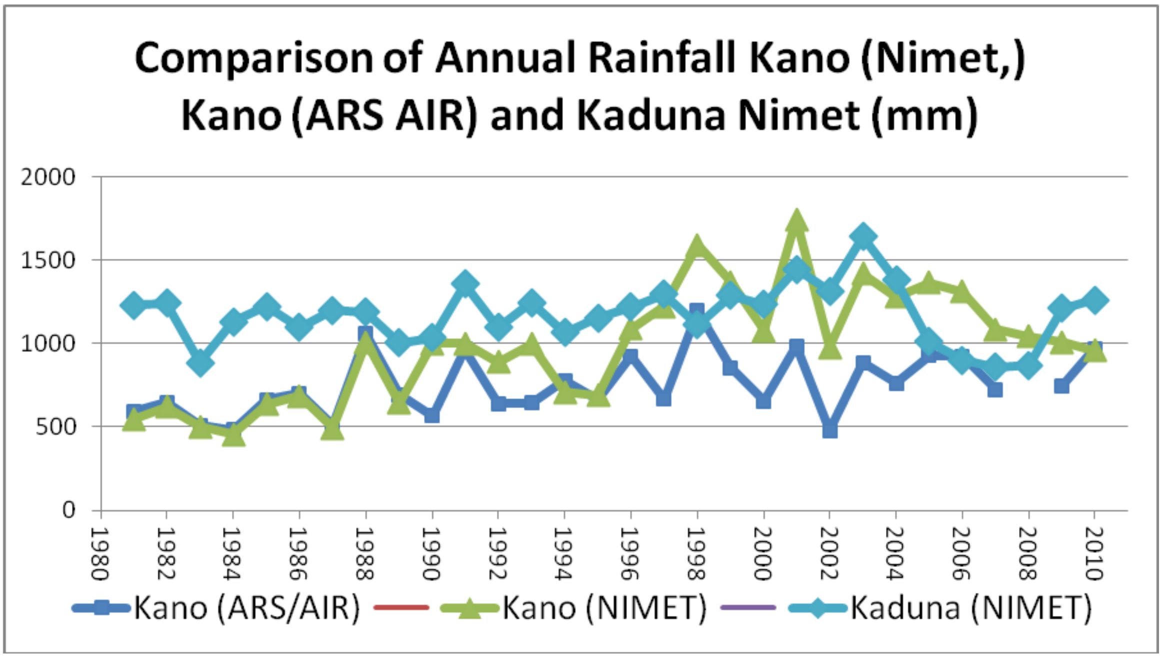
Source: Authors' analysis of NIMET data

There are major unexplained anomalies in the Kano Airport rainfall data including most notably the unexplained differences in the 1981 to 2005 rainfall data with mean of only 756 mm/year and then the second time series from 1996 to 2010 showing an average of 1,282 mm per year or nearly 70% higher. While the Sahel Region has experienced increasing precipitation over this period the increase is implausible and not reflected by similar increasing trends in the neighboring state of Kaduna. Other anomalies in the Kano data include: most of the 1990 and 1991 daily rainfall data are duplicates, but it is not known which year this applies to. Thirdly there appear to be some extremely high and unexplained daily rainfall outlying data such as the 163.8 mm recorded on 25 July 2001.

The Kano NIMET rainfall data is so unreliable that it has not been possible to conduct any further work into designing and rating a crop weather index insurance cover for this station/state.

Alternative rainfall data was obtained by the local consultants for the ARS-AIR weather station in Kano which is about 9 kilometers away from the Kano NIMET station. Reference to Figure Ax.2. below shows there is a very close correlation between the annual rainfall recorded at both Kano stations between 1981 and 1990. Since 1991 the rainfall recorded at these two Kano meteorological stations has been totally different and the Kano ARS-AIR data appear to be more plausible without the dramatic increase which has been recorded at Kano NIMET.

Figure A2.3. Comparison of Annual Rainfall at Kano Airport Station (Nimet) and Kano ARS-AIR and Kaduna Airport (NIMET)



Source: Authors' analysis of NIMET data

Table A2.3. Correlations coefficients for annual rainfall at the 2 Kano Weather Stations and Kaduna

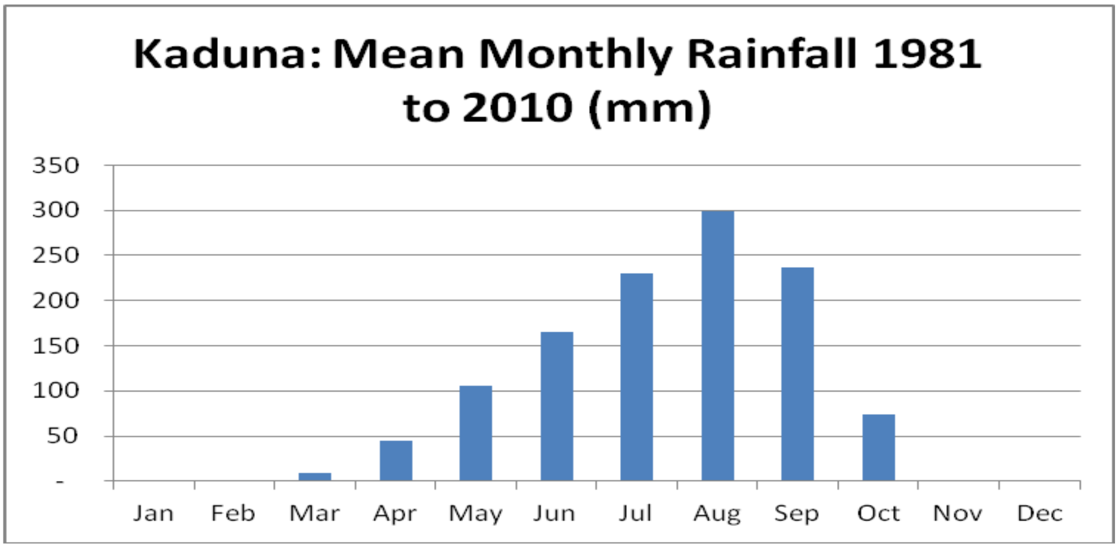
Weather Stations	Kaduna (NIMET)	Kano ARS/AIR)
Kano (ARS/AIR)	0.16	
Kano (NIMET)	0.33	0.70

Source: Authors' analysis of NIMET data

2.3. KADUNA STATE Rainfall Data analysis

There are two marked seasons in the State, the Dry windy (Harmattan) and the Rainy (wet) Seasons. The wet season is usually from April through October with its peak in August and varies greatly North-Wards. On average, Kaduna has a rainy season of about five (6) months, and hence it has only one cropping season for rainfed crop production (Fig. Ax.4). There is relatively heavier rainfall in the southern parts of the state like Kafanchan and northern parts like in Zaria with an average rainfall of about 1016 mm. (ICEED 2011).

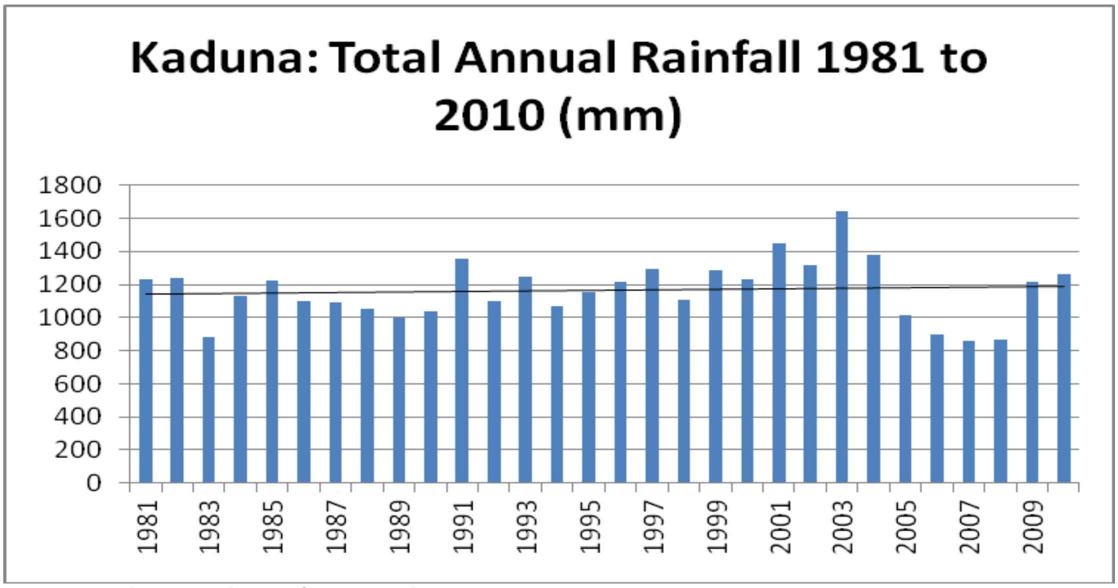
Figure A2.4. Kaduna, Mean Monthly Rainfall 1981 to 2010 (mm)



Source: Authors' analysis of NIMET data

Over the past 30 years, the average annual precipitation recorded at Kaduna has been 1,165 mm per year: annual rainfall is relatively stable as shown by the coefficient of variation (COC) in mean annual rainfall of only 15%. 1983 was a very dry year in Kaduna with total rainfall of only 884 mm or 76% of the long-term average. The period 2006 to 2008 has also been abnormally dry in Kaduna with less than 90 mm in all three years. (Figure A2.5).

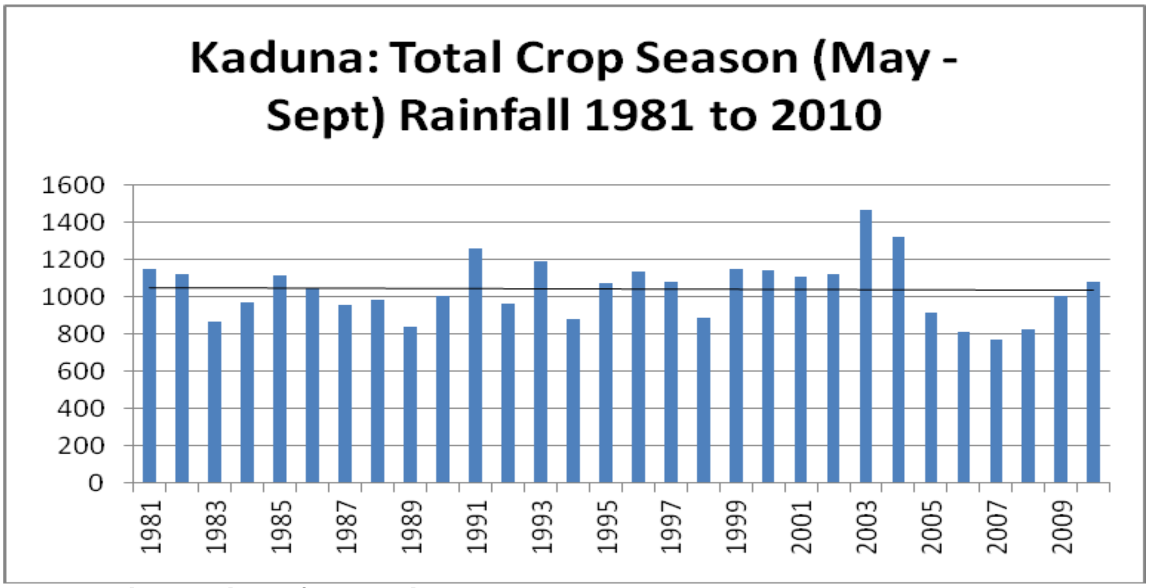
Figure A2.5. Kaduna, Annual Total Rainfall 1981 to 2010



Source: Authors' analysis of NIMET data

Growing season rainfall is shown for Kaduna Station in Figure A2.6, with a 30-year average of 1,142 mm per year: on average 90% of total annual rainfall falls in this 5 month period from May to September.

Figure A2.6. Cropping Season (May-Sept) Rainfall Kaduna 1981 to 2010 (mm)



Source: Authors' analysis of NIMET data

<u>An analysis of the NIMET Kaduna Daily rainfall data suggests the data is generally consistent and plausible and that with one or two minor adjustments of outliers meets the requirements for the Rainfall Deficit WII contract design exercise. Therefore both the 30-year daily rainfall data and daily evapotranspiration data has been used to model prototype WII maize and rice rainfall-deficit covers for this station</u>.

2.4. CROSS-RIVER STATE Rainfall Data analysis for CALABAR Synoptic Station (NIMET)

The northern senatorial district with relatively lower rainfall amounts belong to the Derived savanna agroecological zone while the central and southern senatorial zones with higher rainfall amounts are in the humid forest zone. (Figure Ax.7) (ICEED 2011).

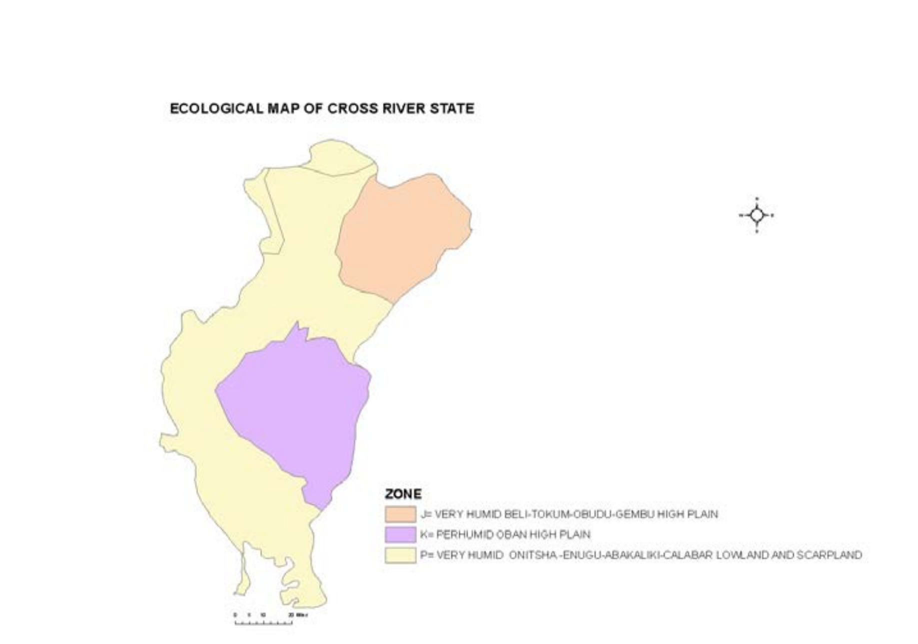
Calabar Meteorological Station (NIMET) is located in the very south of the Province on the sea coast in what is classified as the very humid Onitish-Enugu-Abakaliki-Calabar Lowland and scarpland (Figure A2.7).

Calabar experiences a tropical climate with annual rainfall of 2,871 mm or nearly three times higher than Kano and 2.5 times higher than Kaduna. In contrast to these more northerly semi-arid rainfall states which have marked dry and rainy seasons, in southern Cross River state precipitation is distributed throughout the year with a marked peak in July with a relatively drier season between November and end February. (Figure A2.8).

There are two cropping seasons in southern Cross River State, the major cropping season from March/April (planting) to July/August (harvest) and a second smaller cropping season from August/September (planting) to November/December (harvest).

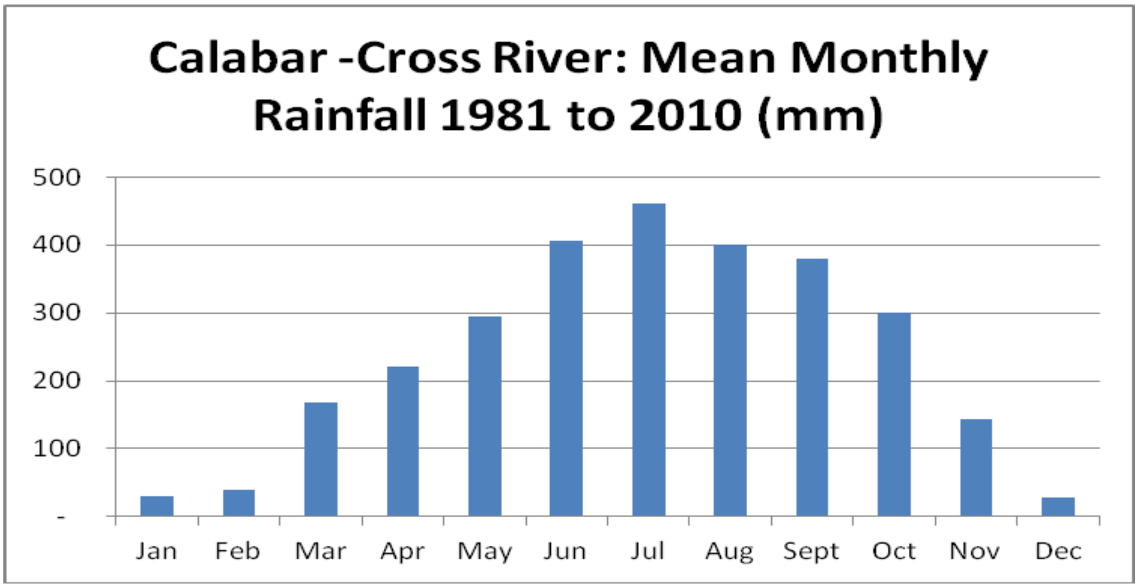
According to ICEED 2011 in Cross River state two maize crops are grown, the first crop is planted in April/May with harvest in June/July and a second crop which is planted in August and harvested in October/November.

Figure A2.7. Climatic - Ecological Zones of Cross River State



Source: ICEED 2011

Figure A2.8. Calabar Mean Monthly Rainfall (mm)

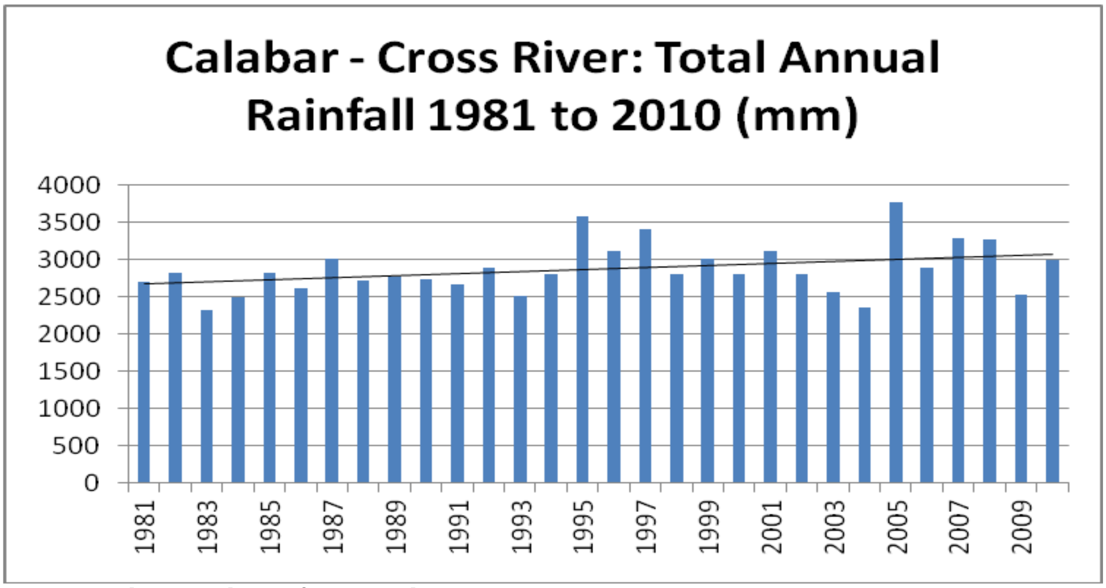


Source: Authors' analysis of NIMET data

Annual rainfall recorded at Calabar meteorological station is very stable with an average of 2,871 mm per year over the past 30 years and 12% COV. Annual rainfall has been less than 2,500 mm (87% of average) in 3 years (10% of years) on three occasions, in 1983 which was the driest year on record with rainfall of 2,319 mm, then in 2004 and again in 2004 (Figure A2.9).

Drought is not a feature of this region of southern Cross River state. Rather there could be an issue of excess rain and flooding. It is quite common for rainfall to excess 125 mm and 150 mm in a day (24 hours).

Figure A2.9. Calabar: Total Annual Rainfall, 1981 to 2010 (mm)



Source: Authors' analysis of NIMET data

An analysis of the NIMET Calabar (Cross River) daily rainfall data and daily evapotranspiration data for the 30 years 1981 to 2010 suggests the data is extremely consistent with no identifiable inconsistencies in the data set. Therefore this data for Calabar station has been used to model a prototype WII main season (April/May to August) maize rainfall-deficit covers for this station

2.5. ENUGU STATE Rainfall Data analysis (NIMET)

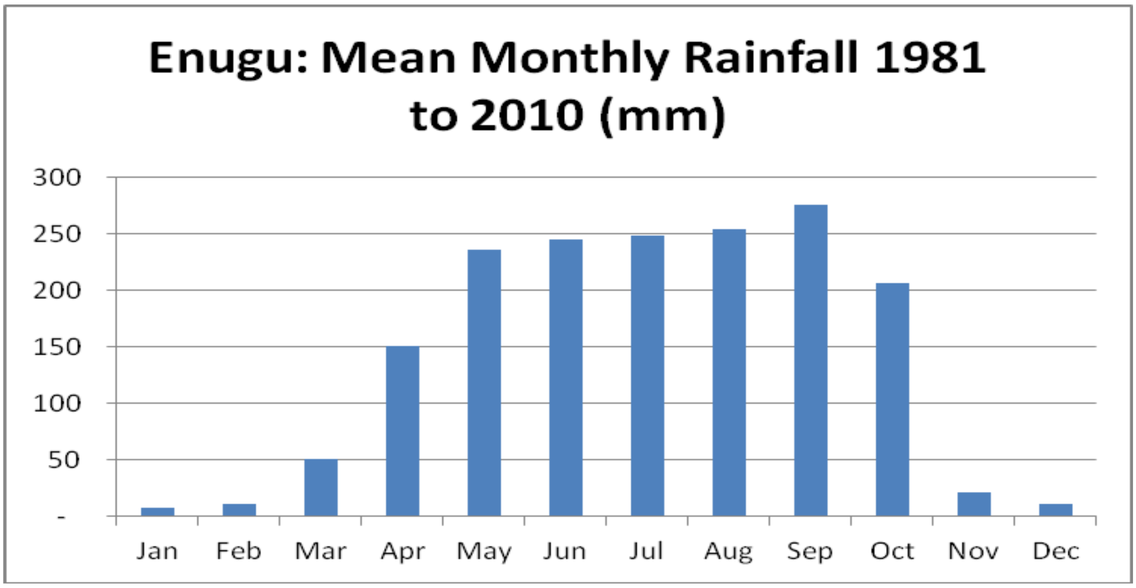
The vegetation type of Enugu state is classified as derived savanna, typical of the degraded humid forest ecology of the southeastern Nigeria.

The climate is characterized by two seasons, namely the rainy and the dry seasons. The former lasts about seven months, starting appreciably from April through October with a short break; in the month of August termed "August break". Mean annual rainfall is about 1,700 mm at Awgu, Nenwe and Ndeaboh and 1,500 mm at Nsukka. Mean monthly relative humidity across the area is high (60-80%) (ICEED 2011).

Enugu Meteorological station has an annual average rainfall of 1,719 mm which is relatively stable year on year (COV 15%). There is a relatively longer 7 month rainy season from April to end October which permits two crops to be sown in the state (Figure A2.10).

In the case of maize, early maize is sown in late March/April and can be harvested green in June/July. Late sown maize in June is harvested in September/October. (ICEED 2011).

Figure A2.10. Enugu: Mean Monthly Rainfall 1981 to 2010 (mm)

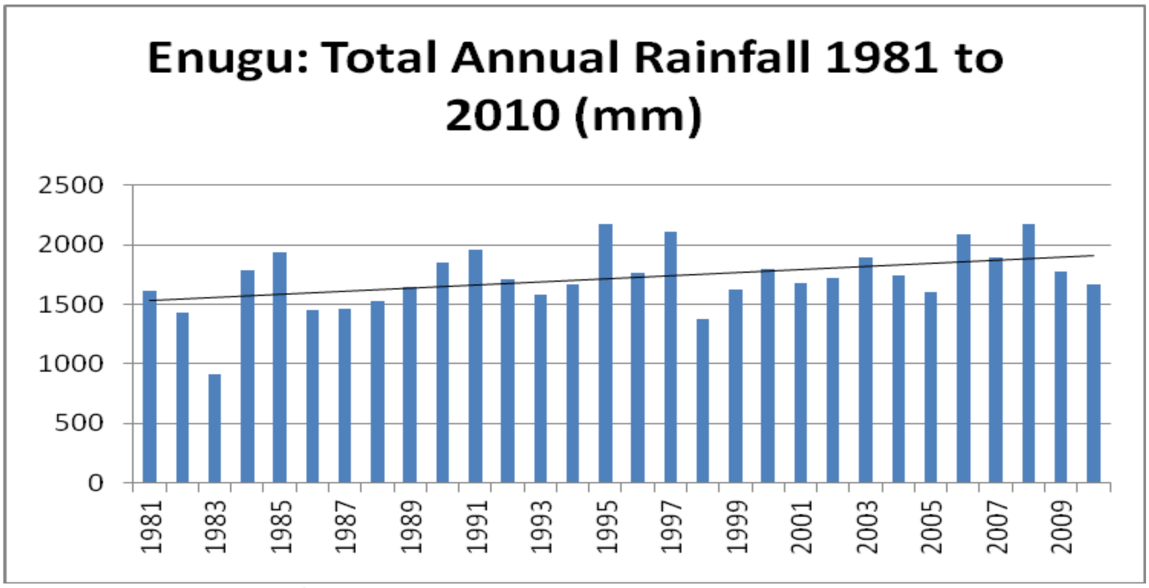


Source: Authors' analysis of NIMET data

Annual rainfall at Enugu weather station is relatively stable with a range from 2,110 mm in 1995 (26% higher than average) and a low of 917 mm in 1998 (47% below average), against the 30-year average annual rainfall of 1,719 mm. (Figure A2.11).

In 1983, the early season rains failed and there was practically no rainfall in March and April or a total of 7.1 mm against a long term average of about 200 mm for these 2 months. Also the late rains failed in October with only 1 day of recorded rain and 24.2 mm of rainfall against a long term average for October of over 200 mm (Figure A2.10 and Figure A2.11).

Figure A2.11. Total Annual Rainfall, Enugu Synoptic Station (NIMET)



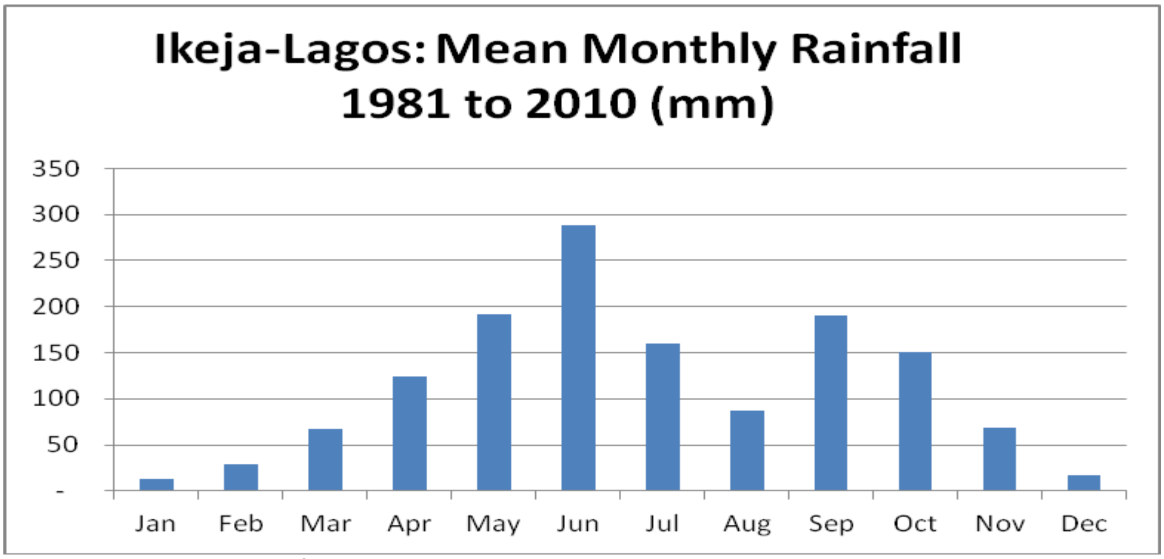
Source: Authors' analysis of NIMET data

The analysis of the NIMET daily rainfall and evapotranspiration data for Enugu meets all data consistency checks with very few outliers and this data is suitable for the analysis of a maize rainfall deficit WII prototype cover for Enugu Weather Station

2.6. LAGOS STATE IKEJA Rainfall Data analysis (NIMET)

Lagos State, located on the Gulf of Guinea coast experiences rainfall throughout the year with two peaks in June and September and a short break in August that separate the year into the early (main crop) and late (minor crop) seasons respectively (Figure A2.12). The early growing season extends from March/April to August and is regarded as the main season while the shorter cropping season from September to December is known as the late season. (ICEED 2011).

Figure A2.12. Lagos: Ikeja Mean Monthly Rainfall 1981 to 2010 (mm)

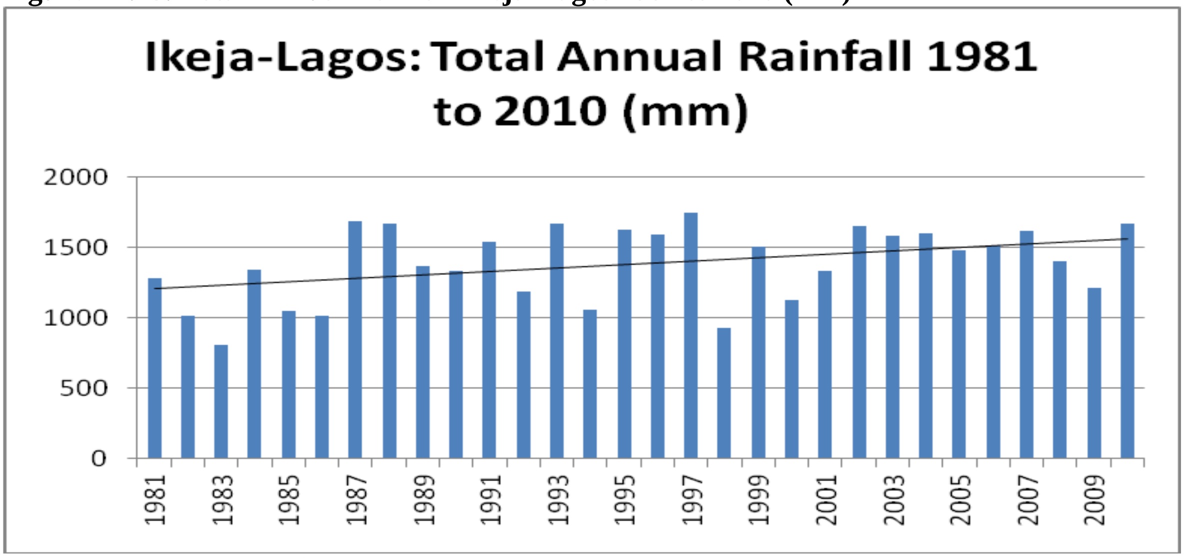


Source: Authors' analysis of NIMET data

Ikeja Meteorological station (NIMET) is located at the Murtala Muhammed International airport in the centre of Lagos city. It is likely that rainfall patterns at the airport are influenced by the city which has a population of more than 15 million and may not be representative of the agricultural areas to the east and west of the State.

Over the past 30 years the annual average rainfall recorded at Ikeja-Lagos has been 1,387 mm/year, but rainfall is highly variable with range for a low of 804 mm (42 below average) in 1983 to a high of 1750 mm (26% above average) in 1997, and with a COV of 19%. Other very dry years when rainfall has been more than 20% below average include 1982, 1985, 1986, 1994 and 1998. (Figure A2.13).

Figure A2.13. Total Annual Rainfall Ikeja-Lagos 1981 to 2010 (mm)



Source: Authors' analysis of NIMET data

The Western zone of Lagos Sate comprising of Badagry and Ojo areas fall within a lower rainfall zone compared to the Eastern zone (Ikeja, Epe and Ikorodu), thus presenting a lower potential for rainfed arable crop production. (ICEED 2011).

The rainfall pattern in Lagos state can be classified into two zones namely the more humid Lagos East and Lagos Far East zones with higher average annual rainfall (1551 mm – 1750 mm) and two distinct rainy seasons (Figure A2.12.), hence the practice of growing early and late maize. The second zone is the relatively dryer Western zone that is made up of Badagry and Ojo areas of Lagos State (Annual average rainfall 1351 mm – 1550 mm). The soil at the Epe and Ikorodu areas are also deep and well drain, hence more suitable for arable crop production, while the soils at Badagry are very sandy with low water retention capacity, deep and poorly drained. The early maize accounts for about 60% of maize produced in Lagos state, while maize produced in Badagry area and the second season in the Ikorodu and Epe areas account for the remaining 40% (ICEED 2011)

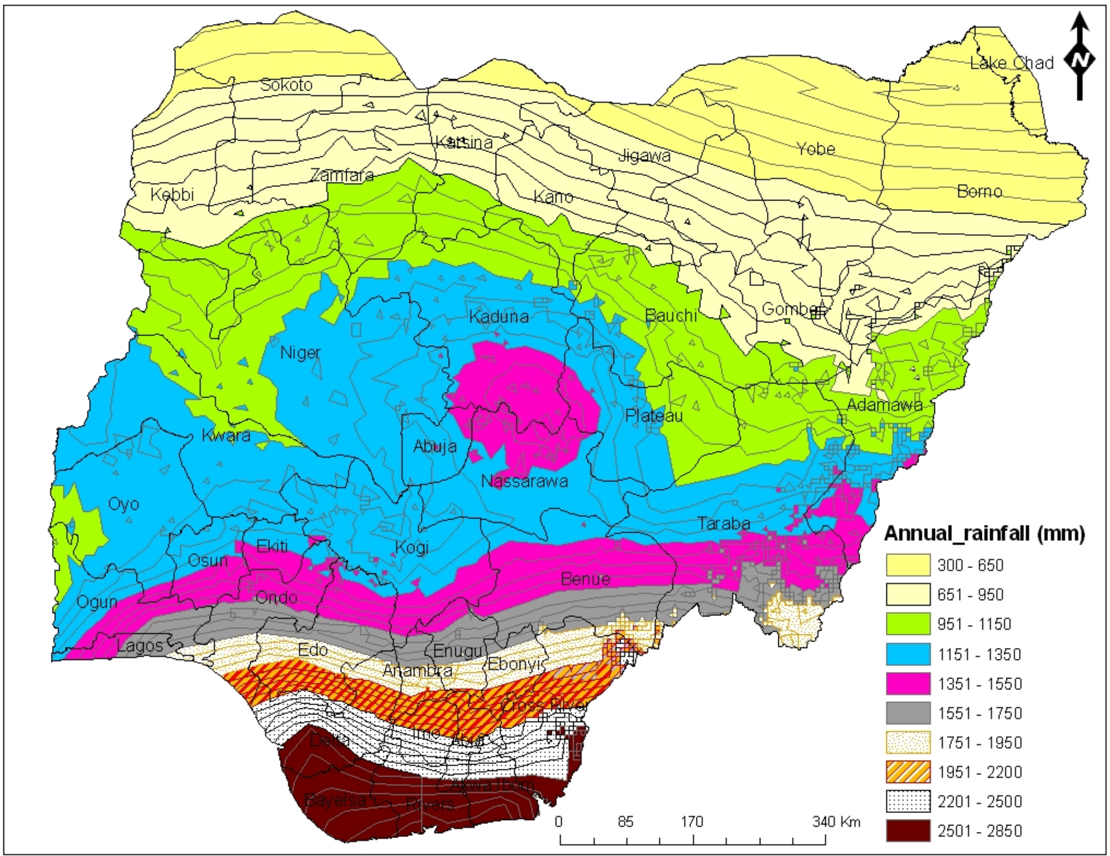
Maize is mainly grown as a sole crop and harvested green for the highly urbanized markets within Lagos State and green maize can be planted almost continuously from April through to July/August, with harvest from July to December (ICEED 2011). The World Bank team note that this long growing season with no defined start (sowing dates) and harvest season makes the design of a WII cover very difficult for maize in Lagos state.

The analysis of the NIMET daily rainfall and evapotranspiration data for Ikeja-Lagos meets most of the data consistency and plausibility checks with some outliers and this data is suitable for the analysis of a maize rainfall deficit WII prototype cover for Enugu Weather Station.

2.7. Correlations between Annual Rainfall Patterns for the 5 Weather Stations

This section briefly reviews the correlations between the annual total rainfall for the 5 NIMET Synoptic Weather Stations. A priori one would expect the correlations to be highest in Kano and Kaduna states given these are neighboring states and that the 2 airports are about 200 km apart, but this would be masked by the steep declining rainfall gradient between these two states and cities (See Rainfall Isohyets map in Figure A2.14). Higher correlations would also be expected between Cross River and Enugu States as these are again neighboring states located in the south east of Nigeria.

Figure A2.14. Rainfall Isohyets Map for Nigeria



The correlations in annual rainfall for the period 1981 to 2010 are, however, very low for all stations. In the case of the low correlations between Kano and Kaduna it is suspected this may be due to the identified rainfall data inconsistencies for Kano NIMET station. The highest correlation of 0.46 is between Cross River (Calabar) and Enugu, followed by Enugu and Ikeja-Lagos (Table A2.4.).

Table A2.4. Correlation between Annual Rainfall across stations

	Kano	Kaduna	Cross River (Calabar)	Enugu	Lagos (Ikeja)
Kano	1.00	0.31	0.26	0.27	0.28
Kaduna		1.00	-0.17	0.08	0.29
Cross River			1.00	0.46	0.24
Enugu				1.00	0.41
Ikeja					1.00

2.8. Analysis of Monthly Rainfall Distribution

The analysis of mean monthly rainfall over the past 30 years shows that year on year actual monthly rainfall is very variable as shown by the very high standard deviations and coefficients of variation typically of between 35% to 40% during the growing season months of June to October (Tables A2.5 to A2.7). In some states such as Lagos which have two rainy seasons, rainfall in August which is the dry season between the completion of harvest of the first crop and sowing of the second crop is extremely variable (COV 95%), suggesting that farmers who try planting their second-season crops in August are likely to face a very high rainfall deficit exposure at time of sowing. In other states such as Kaduna, October rainfall can be highly variable (COV 83%) suggesting farmers who plant late and are depending on final rains for grain swelling in October may not receive adequate rains.

Table A2.5. Mean Monthly Rainfall by Station 1981 to 2010 (mm)

Month	Kaduna	Cross River	Enugu	Ikeja
Jan	0.0	29.4	8.0	12.7
Feb	0.4	39.7	11.0	29.3
Mar	8.4	168.5	51.4	67.0
Apr	45.1	220.3	151.0	123.6
May	105.7	294.5	235.9	191.6
Jun	164.7	406.4	244.4	289.0
Jul	230.1	461.0	248.7	160.2
Aug	299.2	400.9	254.3	87.4
Sep	237.0	379.6	275.0	190.5
Oct	73.9	301.3	206.9	150.9
Nov	0.0	142.5	21.6	68.3
Dec	0.2	27.4	11.0	16.7
Annual	1,164.7	2,871.3	1,719.2	1,387.2

Source: Authors' analysis of NIMET data

Table A2.6. Standard Deviation in Mean Monthly Rainfall by Station 1981 to 2010 (mm)

Month	Kaduna	Cross River	Enugu	Ikeja
Jan	0.0	30.6	14.5	32.5
Feb	2.2	42.3	19.2	38.9
Mar	16.2	86.2	50.2	43.9
Apr	32.3	89.5	62.9	60.5
May	38.4	83.0	74.8	81.4
Jun	42.3	130.3	75.7	115.7
Jul	86.7	160.9	68.9	98.1
Aug	72.7	114.4	105.3	83.4
Sep	78.7	132.6	63.2	100.1
Oct	61.4	91.1	80.4	57.1
Nov	0.2	70.1	45.4	51.1
Dec	1.2	31.0	39.4	23.3
Annual	178.4	340.4	261.2	265.1

Source: Authors' analysis of NIMET data

Table A2.7. Coefficient of Variation in Crop Season Rainfall by Station 1981 to 2010 (mm)

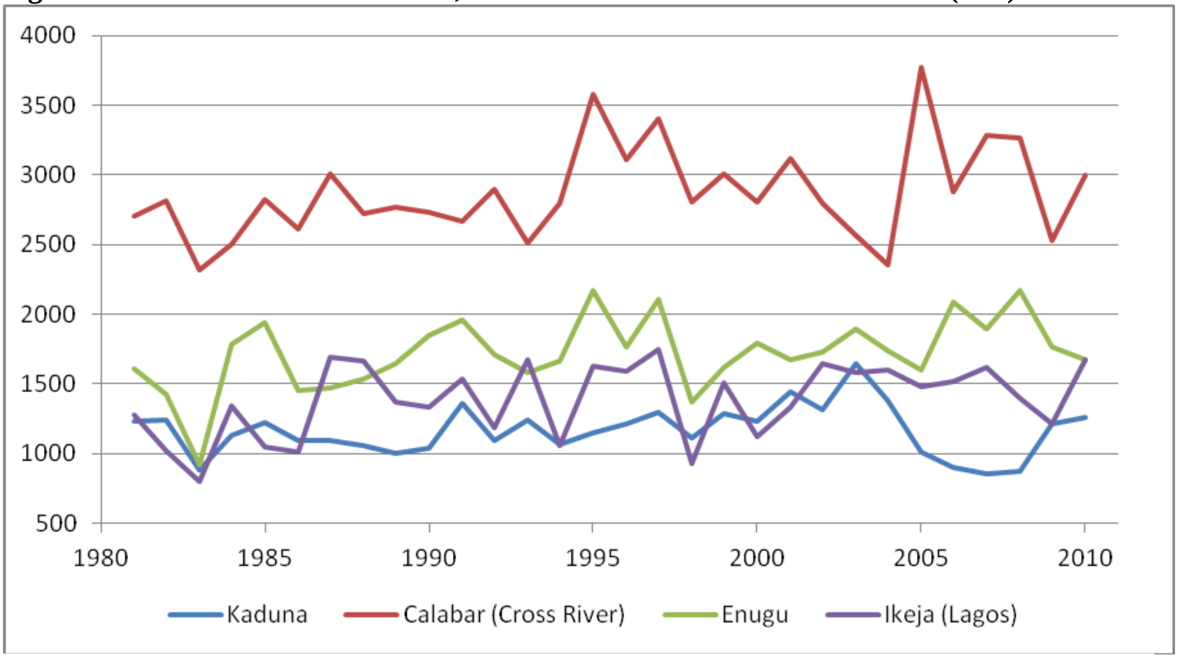
Month	**Kaduna**	**Cross River**	**Enugu**	**Ikeja**
May	36%	28%	32%	42%
Jun	26%	32%	31%	40%
Jul	38%	35%	28%	61%
Aug	24%	29%	41%	95%
Sep	33%	35%	23%	53%
Oct	83%	30%	39%	38%

Source: Authors' analysis of NIMET data

2.9. Rainfall Trends over Time

In the design and rating of a rainfall WII contract it is very important to check the rainfall data for trends and where major increasing or declining trends are identified to de-trend the data. Reference to Figure A2.15 and Tables A2.8 and A2.9, show that for the 4 stations with usable data (excluding Kano Airport) there is a small trend across all stations for higher rainfall over the past 15 years, but that these differences are not significant.

Figure A2.15. Annual Total Rainfall, Selected NIMET Stations 1981 – 2010 (mm)



Source: Authors' analysis of NIMET Data

Table A2.8 5-year running mean (Crop Season, mm)

WS	Kaduna	Cross River (Calabar)	Enugu	Lagos (Ikeja)
1981-1990	1024	2522.9	1535	1230.9
1986-1995	1034.4	2611.3	1646	1368.5
1991-2000	1071.6	2727.2	1759.7	1294.8
1996-2005	1128.4	2757	1752.7	1359
2001-2010	1038.6	2710.8	1778.2	1462.7

Source: Authors' analysis of NIMET Data

Table A2.9 5-year running mean (mm/year)

WS	Kaduna	Cross River (Calabar)	Enugu	Lagos (Ikeja)
1981-1990	1123.3	2714.2	1607.6	1320.8
1986-1995	1143.9	2839.5	1725.8	1491.3
1991-2000	1205.6	2977.3	1843	1420
1996-2005	1293.4	2995.5	1809.8	1496.7
2001-2010	1189.3	2982.3	1833.4	1574.5

Source: Authors' analysis of NIMET Data

2.10 Analysis of Dry Years for the Selected Stations

For the purposes of this analysis the following classification is used:

Table A2.9. Definition of Drought Years

Rainfall deviation below average	Drought Definition
-15% to -30%	Weak Drought
-30% to -45%	Moderate Drought
>-45%	Strong Drought

Source: Authors' definition

Using this classification, Figure A2.16 shows for the Main crop growing season defined as May to September, that over the past 30 years there have been:

- 6 weak droughts in Kaduna State in 1983, 1989, 1994, and then the three years 2006, 2007 and 2008 (frequency 20%; return period 1 in 5 years)

- 4 weak droughts in Cross River, in 1984 and 1986 and then again in 2003 and 2004 (frequency 13%, return period 1 in 7.5 years);

- 5 drought years in Enugu with a moderate/strong drought rainfall deficit year) in 1984, with weak droughts in 1983, 1987, 1989 and then 1998 (frequency 17%, 1 in 6 years)

- 7 droughts in Ikeja-Lagos, with weak droughts in 1982, 1985, 1994 and 2003, moderate droughts in 1983 and 1986 and one strong drought in 1998 with a rainfall deficit of -46%. (Frequency 23%, 1 in 4.3 years).

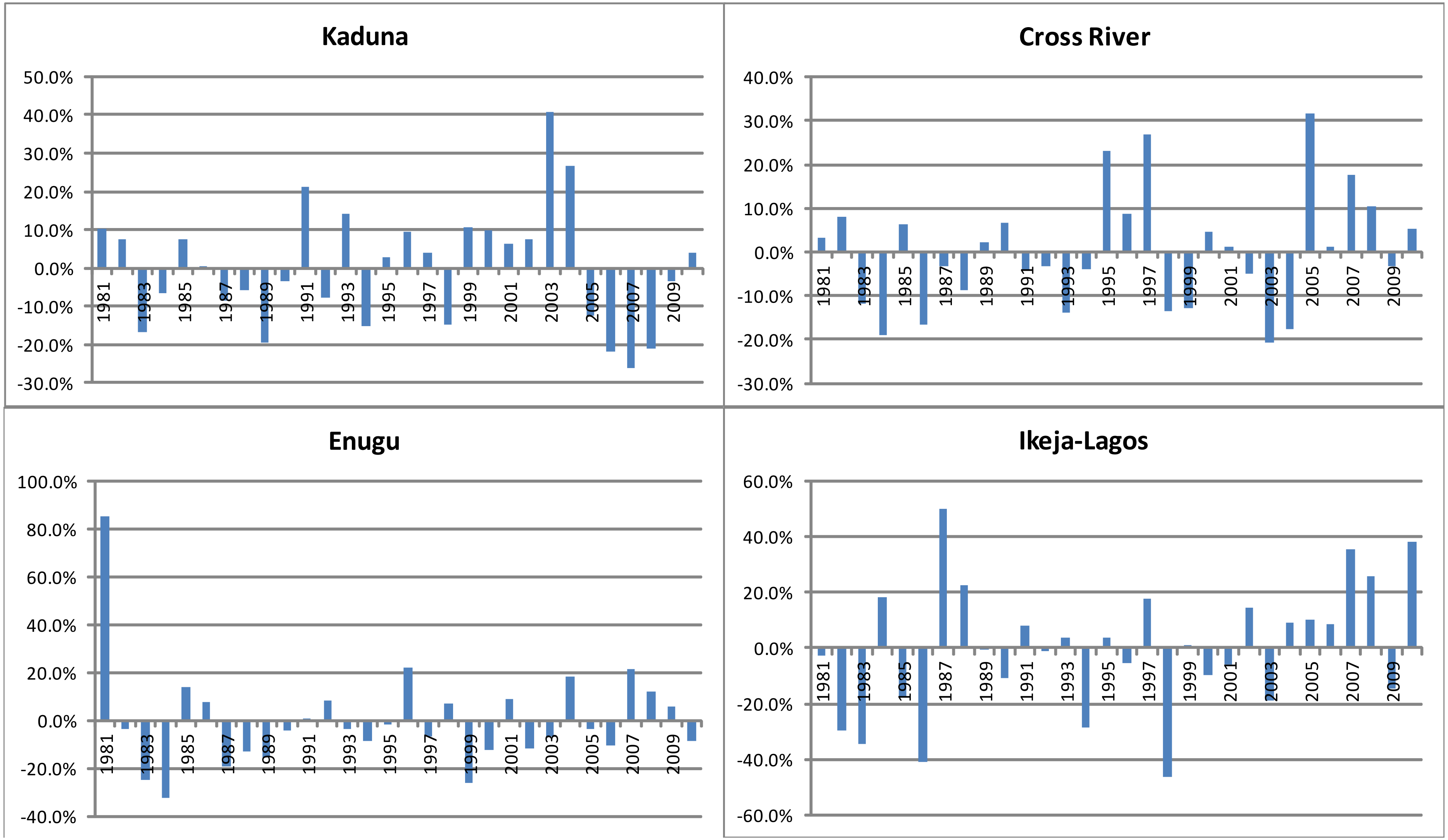
The conclusions to this analysis of rainfall deficit include:

Weak crop-season droughts are a fairly common feature of the selected stations with a one in every five to seven year return period in most states save, for Lagos which exhibits the most variable crop season rainfall and where seasonal droughts occur 1 in every 4 years. Cross River has the highest seasonal rainfall of any of the states and lowest exposure to the main crop growing season drought

Moderate to severe drought as measured by crop season total rainfall deficit compared to average are a relatively rare occurrence at the 4 weather stations in 4 different states of Nigeria. Over the 30 year period, only one severe drought year was recorded in 1998 at Enugu.

Finally, it is noted that in 1983 which was a very severe drought year in much of the Sahel Region, weak to moderate droughts were recorded at three of the four stations, the exception being Cross River. This analysis clearly shows the covariate nature of drought in severe rainfall deficit years, or in other words the potential under a rainfall deficit weather index crop insurance program for weather stations across wide geographic areas to be simultaneously affected and for payouts to result.

Figure A2.16. Analysis by State Weather Station of Cropping Season (May to September) Rainfall Deviation from Average (% of Average)



Source: World Bank Analysis of NIMET Rainfall Data

2.11. Analysis of Excess Rain Exposure in the selected states

For the purposes of this analysis excess rain exposure is measured in terms of the number of days during the cropping season when the daily rainfall exceeds 50 mm.

A review of the 30 year cropping season (May to September) daily rainfall data for the 4 weather stations of Kaduna, Cross River (Calabar), Enugu and Lagos (Ikeja) reveals a fairly high average number of excess rainfall days when precipitation exceeds 50 mm per day with a range from an average low of 2.1 days per crop season at Kaduna to an average high of 8.4 days at Calabar station, Cross River and with a maximum recorded single day's rainfall of 237 mm rainfall at Ikeja on 23 June 1997 (Table A2.10). Further information on the number of excess rainfall days per month and the intensity of excess rainfall days from >50 mm to over 250 mm per day is contained in Appendix 2.1 for each station.

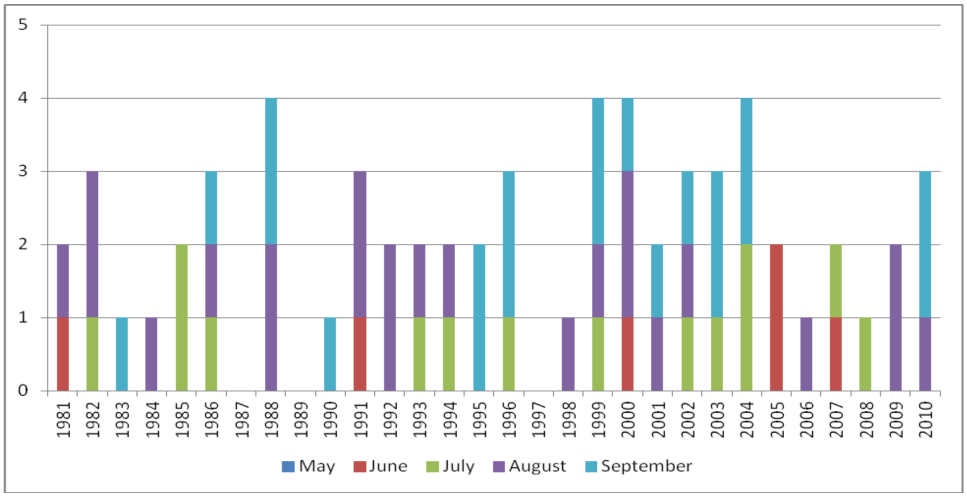
Table A2.10. Average Number Excess Rainfall Days (>50 mm) per Month during Cropping Season (May to September)

Month	Kaduna	Cross River (Calabar)	Enugu	Lagos (Ikeja)
May	0.0	1.2	0.9	0.6
June	0.2	2.0	0.9	1.4
July	0.5	2.1	0.7	0.6
August	0.8	1.6	0.9	0.2
September	0.7	1.5	0.8	0.6
Total	2.1	8.4	4.1	3.5

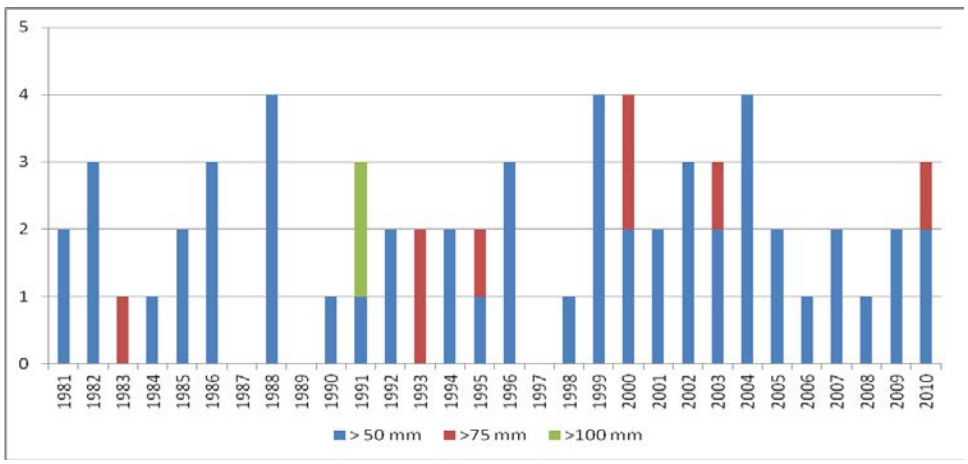
Source: Authors' analysis of NIMET Daily Rainfall data

Appendix 2.1. KADUNA Analysis of Crop Season Excess Rainfall

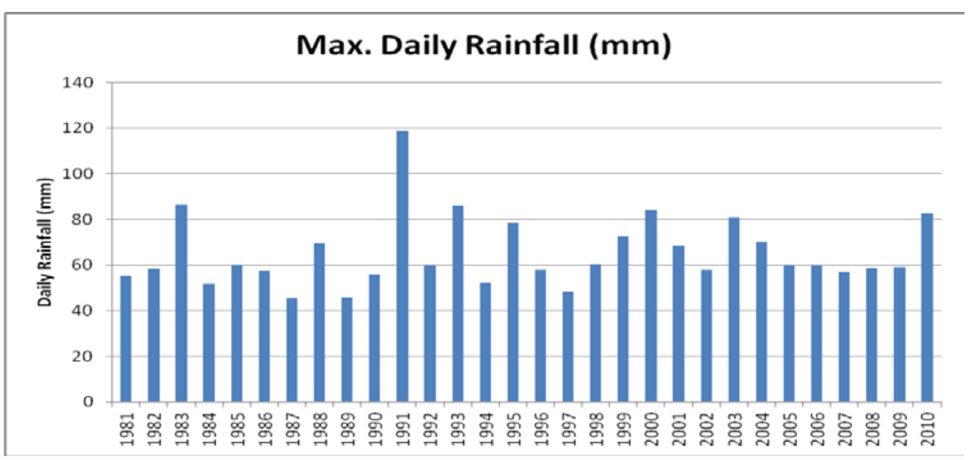
Kaduna: Number of Excess Rainfall Days (. 50 mm) by Month and Year



Kaduna: Excess Rainfall Intensity(mm) by Event per Year



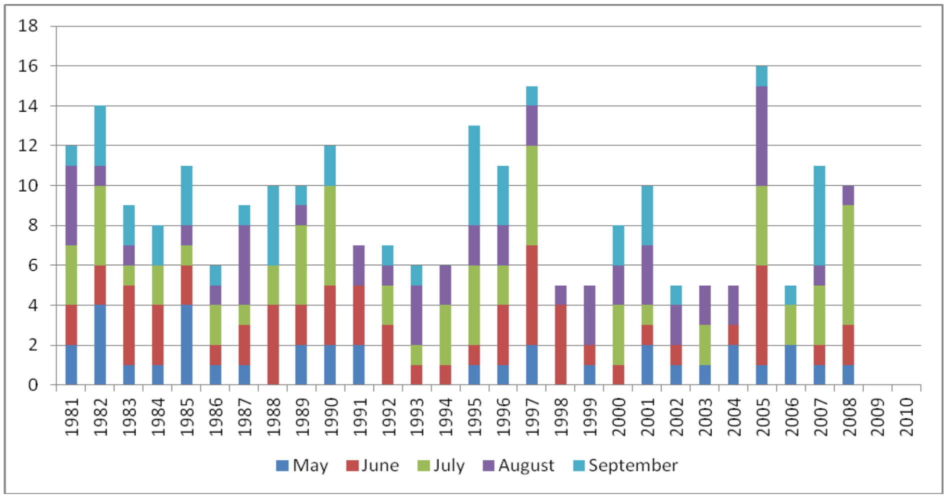
Kaduna: Maximum Recorded Crop Season Daily Rainfall (mm) per Year



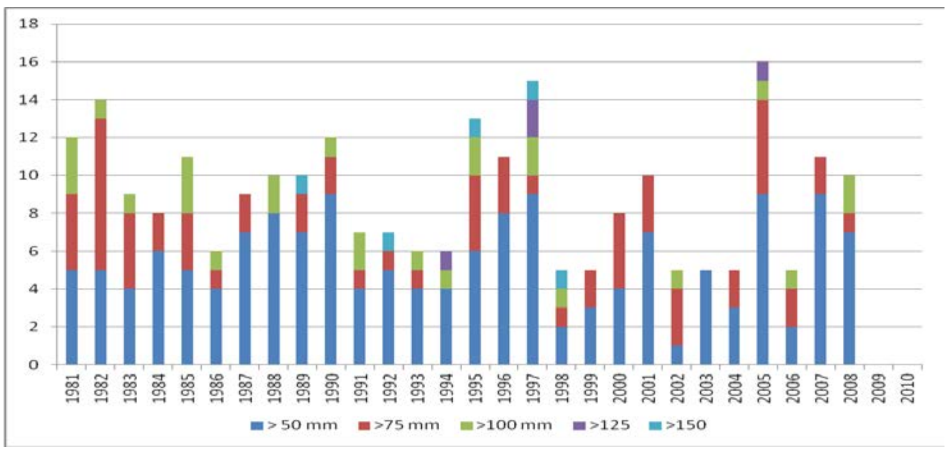
Source: Author's analysis of NIMET Rainfall data

Appendix 2.1 ***continued*** **CROSS RIVER Analysis of Crop Season Excess Rainfall**

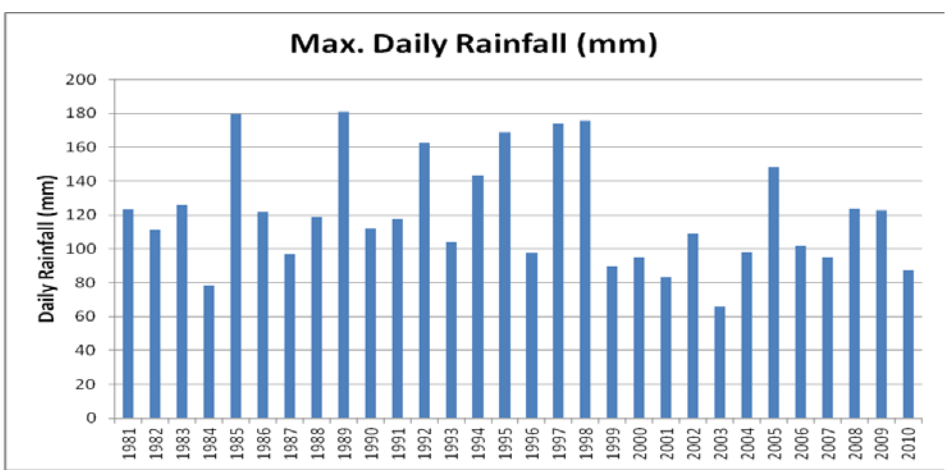
Cross River: Number of Excess Rainfall Days (. 50 mm) by Month and Year



Cross River: Excess Rainfall Intensity(mm) by Event per Year



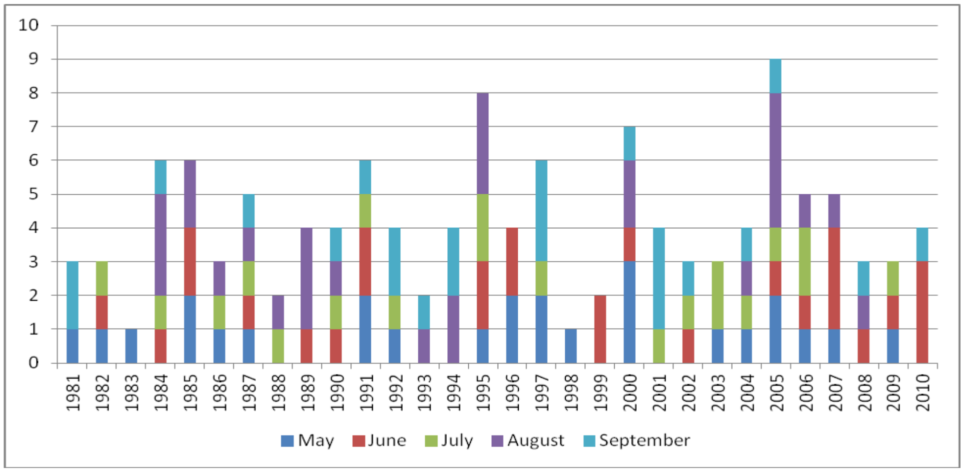
Cross River: Maximum Recorded Crop Season Daily Rainfall (mm) per Year



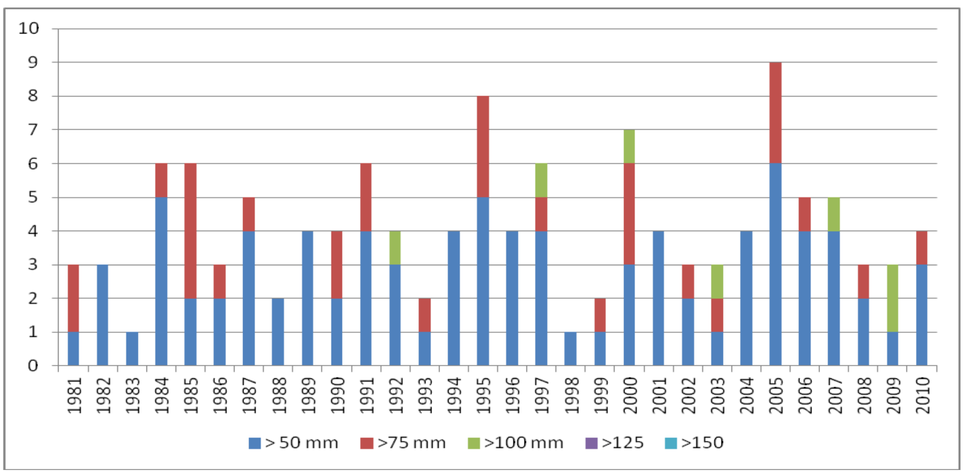
Source: Author's analysis of NIMET Rainfall data

Appendix 2.1. ***continued*** **ENUGU Analysis of Crop Season Excess Rainfall**

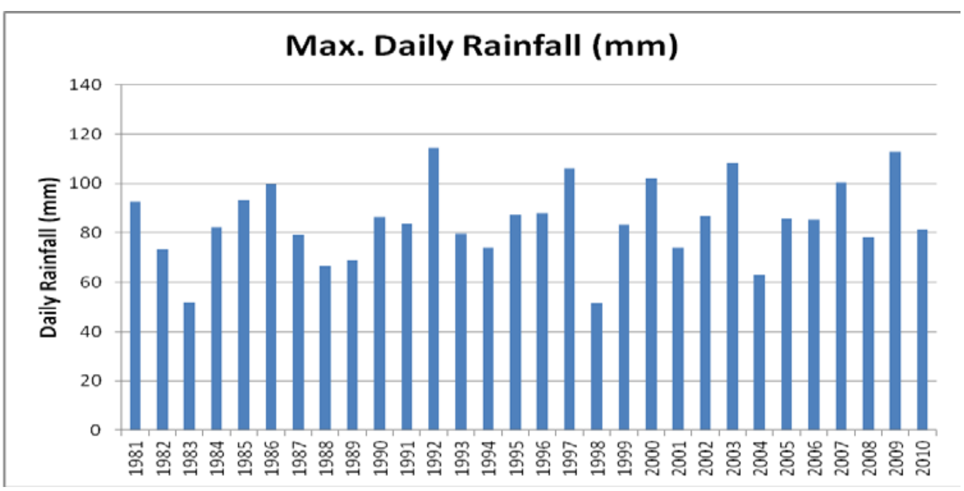
Enugu: Number of Excess Rainfall Days (. 50 mm) by Month and Year



Enugu: Excess Rainfall Intensity(mm) by Event per Year



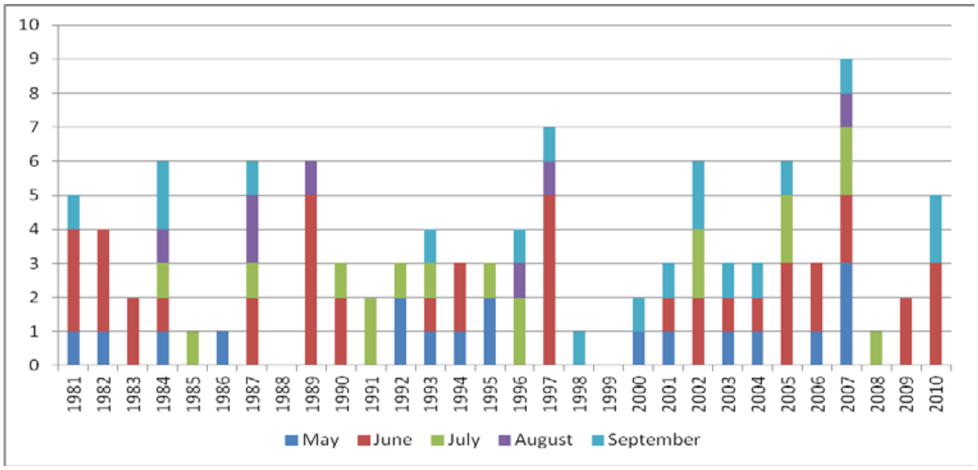
Enugu: Maximum Recorded Crop Season Daily Rainfall (mm) per Year



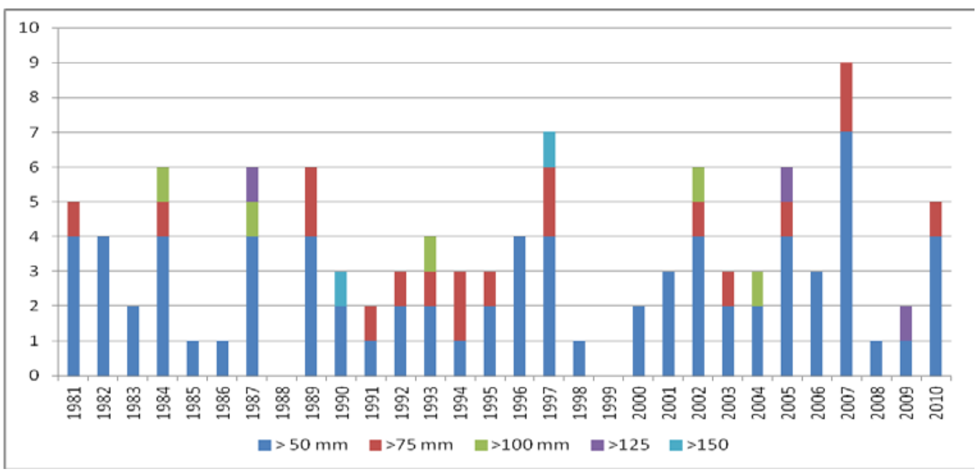
Source: Author's analysis of NIMET Rainfall data

Appendix 2.1. ***continued*** **LAGOS (IKEJA) Analysis of Crop Season Excess Rainfall**

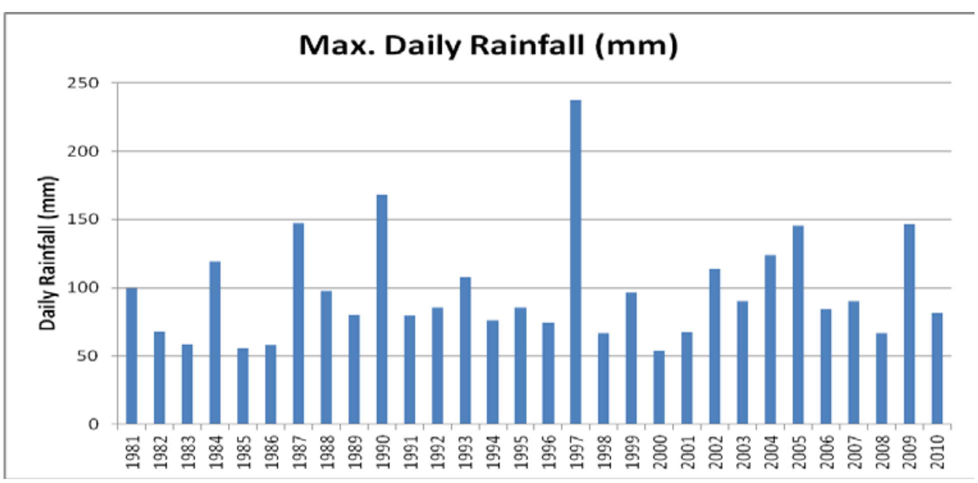
Ikeja: Number of Excess Rainfall Days (. 50 mm) by Month and Year



Ikeja: Excess Rainfall Intensity (mm) by Event per Year



Ikeja: Maximum Recorded Crop Season Daily Rainfall (mm) per Year



Source: Author's analysis of NIMET Rainfall data

3. Analysis of Maize and Rice Crop Production and Yield Data and Financial Gross Margins in Selected States

Nigerian agriculture is characterized by considerable regional and crop diversity. Analysis of this sector, particularly the food sub-sector, is fraught with serious data problems. However, the available statistics provide a broad overview of development in agriculture upon which we can make some broad generalizations about its role in economic development and structural change in Nigeria.

Under this Crop WII study 2 crops, rainfed maize and rainfed rice were selected along with five weather stations located in the states of Kano, Kaduna, Cross River, Enugu and Lagos. The aim of a rainfall contract is to reflect as closely as possible crop production and yields in the vicinity (20 km to 25 km radius) of the selected weather stations. In order to design and test a WII contract it is therefore essential to obtain time-series local crop production and yield data and to then correlate this production data with historical rainfall data and to check for causal relationships namely, the impact of too much rainfall (excess rainfall) or too little rainfall (drought) on maize and rice yields.

This annex therefore presents a review of maize and rice crop production and yield data availability in the selected states and presents some simple correlations between rainfall and yields. In the final section some financial information is presented on the per hectare gross margin costs of production and returns for rainfed maize and rice in the selected states: information which has been used to value the WII prototype contracts.

Data Sources on Crop Production and Yields

Two main sources of data and information were used for the selected crops of maize and rice. The first source of time-series crop production and yield data for maize and rice was provided by the local consultant appointed to the project, ICEED, which in turn. is mostly based on Food and Agricultural Organization (FAO), National Agriculture Extension Research and Liaison Service (NAERLS), and the National Program for Agriculture and Food Security (NPAFS) data. The second source for maize and rice yields was the National Bureau of Statistics (NBS), which is the official source of statistics in the country. The most important sources of survey-census-based official statistics on crops are the National Bureau of Statistics (NBS) and the Livestock Department of the Federal Ministry of Agriculture & Rural Development.

There are severe limitations in the usefulness for WII contract design and rating purposes of the time-series maize and rice crop production and yield information available in Nigeria. The main constraint is that the maize and rice area, production and yields obtained for the study are only available at a **state-level**. None of the agencies responsible for collecting agricultural data was able to provide maize and rice yields with a lower level of disaggregation, such as at the local government administration (LGA) level. The state level aggregated data is unfortunately at too large a scale to be able to establish any meaningful relationships between weather and crop yields at the individual weather station level. . Secondly there are only a maximum of 16 years (1994 to 2009) of historical time-series crop production and yield data are available for these two crops compared to 30 years of rainfall data. This again restricts the number of year's correlation analysis that can be conducted between these two variables to 16 years.

The information on rice and maize yields obtained was checked also checked for inconsistencies and outliers. The analysis of the maize and rice yield data shows that there are several inconsistencies on this information among the different sources of information. The World Bank team work on the maize and rice yield data in order to splice different series and to fill information that was missing in the original crop series. An example of the procedures followed for the detection of the inconsistencies and data filling is presented in the Table A3.1 below.

Table A3.1 Cross-River: Sources of Maize Crop Production and Yield Data (1994-2009).

Source	Year	SOWN AREA (000 HA)	PRODUCTION (000 MT)	AVERAGE YIELD (KG/HA)
NBS	1994	49	87	1,774
	1995	48	83	1,727
	1996	54	101	1,872
	1997	44	76	1,724
	1998	49	84	1,710
	1999	58	104	1,775
Other including ICEED	2000	59	98	1,671
	2001	56	95	1,704
	2002	60	99	1,652
	2003	57	94	1,645
	2004	63	109	1,730
	2005	69	113	1,639
	2006	72	124	1,718
	2007	76	123	1,617
	2008	112	220	1,970
	2009	143	321	2,239

Source: Authors from NBS and ICEED

Relationship between Crop Yields and Rainfall, Selected Weather Stations

The existence of correlations between productions a rainfall is a key for the development of weather index based products. Rice and Maize yields were tested against the cumulated rainfall along the growing season of these crops. The analysis shows that where correlations exist, these are usually very weak or even negative. The results of this analysis are presented for maize in Kaduna, Calabar-Cross River, Ikeja-Lagos, and Enugu in Table A3.2. and Figure A3.1. Similar results for rice production in Kaduna and Calabar-Cross River are presented in Table A3.3 and Figure A3.2.

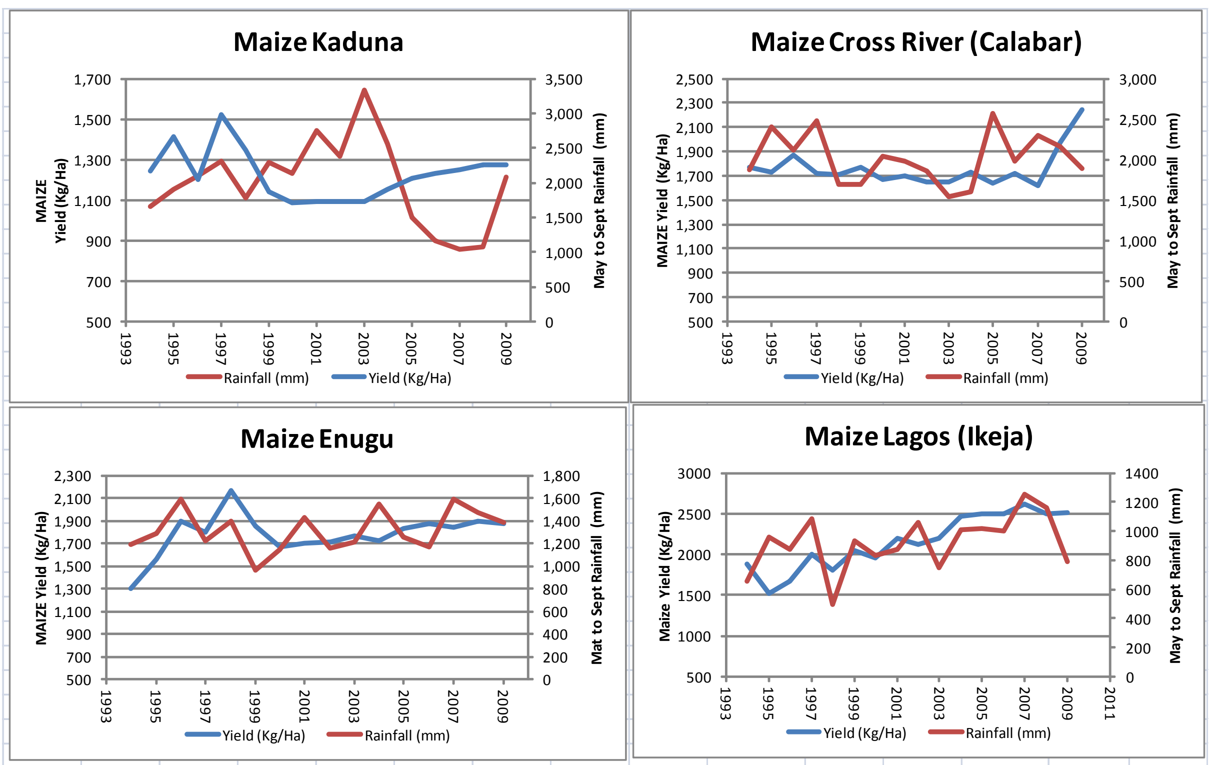
Table A3.2. Maize: Relation between yield and Cumulated rainfall during the crop season May to September for four selected weather stations

	KADUNA		CROSS RIVER		ENUGU		LAGOS	
Year	Rainfall May-Sept (mm)	Yield (Kg/Ha)	Rainfall May-Sept (mm)	Yield (Kg/Ha)	Rainfall May-Sept (mm)	Yield (Kg/Ha)	Rainfall May-Sept (mm)	Yield (Kg/Ha)
1994	1,067	2,171	1,876	1,774	1,194	1,303	659	1,880
1995	1,152	2,658	2,405	1,727	1,287	1,558	957	1,519
1996	1,217	2,050	2,121	1,872	1,593	1,895	873	1,679
1997	1,294	2,974	2,475	1,724	1,222	1,801	1,088	2,000

1998	1,109	2,463	1,690	1,710	1,401	2,162	498	1,806
1999	1,286	1,872	1,699	1,775	968	1,857	931	2,049
2000	1,233	1,716	2,044	1,671	1,143	1,672	836	1,955
2001	1,446	1,724	1,976	1,704	1,425	1,699	871	2,191
2002	1,315	1,729	1,855	1,652	1,154	1,713	1,056	2,121
2003	1,643	1,730	1,547	1,645	1,217	1,770	751	2,194
2004	1,379	1,898	1,610	1,730	1,546	1,720	1,008	2,470
2005	1,011	2,060	2,573	1,639	1,260	1,830	1,016	2,500
2006	899	2,138	1,979	1,718	1,173	1,870	1,004	2,500
2007	856	2,194	2,297	1,617	1,585	1,845	1,251	2,620
2008	869	2,251	2,158	1,970	1,466	1,894	1,160	2,501
2009	1,213	2,254	1,891	2,239	1,383	1,876	791	2,511
Correlation		**-0.376**		**0.223**		**0.270**		**0.494**

Source: Authors' analysis of NIMET Rainfall Data and various sources yield data

Figure A3.1 Relation between Maize Yields and Crop Season Rainfall (1994-2009)



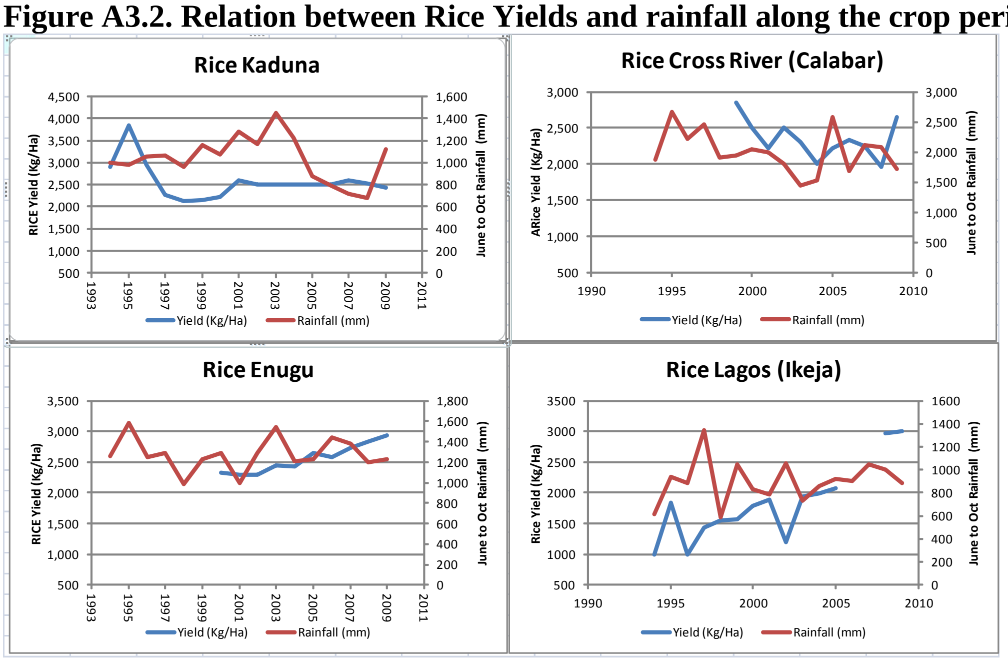
Source: Authors' analysis of NIMET Rainfall Data and various sources yield data

Table A3.3. Rice.: Relation between Rice Yields and June to October Crop Season Rainfall, for four selected weather stations

Year	KADUNA		CROSS RIVER		ENUGU		LAGOS	
	Rainfall June-Oct (mm)	Yield (Kg/Ha)	Rainfall June-Oct (mm)	Yield (Kg/Ha)	Rainfall June-Oct (mm)	Yield (Kg/Ha)	Rainfall June-Oct (mm)	Yield (Kg/Ha)
1994	1,002	2,900	1,883		1,258		613	1,000
1995	978	3,835	2,668		1,586		937	1,846
1996	1,053	2,948	2,221		1,248		881	1,000
1997	1,068	2,262	2,453		1,289		1,347	1,439
1998	957	2,120	1,917		990		586	1,554
1999	1,155	2,159	1,947	2,857	1,232		1,045	1,568
2000	1,075	2,225	2,051	2,500	1,287	2,321	831	1,788
2001	1,283	2,591	2,003	2,222	997	2,301	789	1,881
2002	1,172	2,500	1,812	2,500	1,285	2,301	1,052	1,193
2003	1,453	2,500	1,453	2,308	1,539	2,441	735	1,939
2004	1,219	2,509	1,535	2,000	1,212	2,431	857	1,992
2005	878	2,511	2,588	2,222	1,226	2,649	922	2,083
2006	790	2,504	1,687	2,340	1,444	2,580	901	
2007	716	2,609	2,108	2,254	1,382	2,734	1,047	
2008	678	2,536	2,089	1,967	1,198	2,833	1,003	2,972
2009	1,123	2,427	1,728	2,649	1,230	2,944	884	2,996
Correlation		**-0.117**		**-0.075**		**0.074**		**0.068**

Source: Authors

Figure A3.2. Relation between Rice Yields and rainfall along the crop period



Gross Margin Costs of Production for WII Contract Valuation Purposes

The production models and production cost were evaluated for rice and maize crops in Kaduna, Cross River, Kano, Lagos and Enugu. Total production cost for maize is slightly higher in the south Nigeria than in the northern parts of the country. In this regards, the ICEED reported per hectare costs of production of maize in Cross River and Enugu are very much higher than in Kaduna and Kano (Table A3.4). Caution should be exercised in interpreting these NAERLS figures because NAERLS is a research institution and the technology package and the costs of production are calculated on a research basis and maybe not related to the technological packages or production cost for the majority or the farmers in these areas. According to NAIC figures the average sum insured for all crops (investment made by a farmer) is around Naira 64,000/Ha.

Table A3.4 Production models and production for maize production in Nigeria.

	CROSS RIVER	ENUGU	KADUNA	KANO
Item	Naira	Naira	Naira	Naira
Costs of Production				
Inputs	57,000	57,000	57,000	57,000
Labour	114,000	213,000	46,500	46,500
Sub-Total Variable costs	171,000	270,000	103,500	103,500
Fixed costs	15,150	20,200	4,040	4,040
Total Costs Production	186,150	290,200	107,540	107,540
Average Yield	2,000	1,500	3,500	3,500
Price (Naira per Kg)	145	145	48	48
Gross Return	290,000	217,500	168,000	168,000
Net Return after Costs	103,850	-72,700	60,460	60,460
% return	36%	-33%	36%	36%

Source: ICEED

The gross margin costs of production and returns per hectare for maize and rice in individual states are listed in the tables below.

Table A3.5.: Cost Associated with Maize Production on one hectare of Land in Cross River State.

Item	**Unit**	**Quantity**	**Price(₦)**	**Value (₦)**
Output (Average grain yield/ha-Hybrid maize Variety)	kg	**2000**	145	**290,000**
Operating Inputs				
Maize seed	kg	20	150	3000
Fertilizer	kg	450	110	49500
Herbicide	litres	5	500	2500
Insecticide	litres	2	1000	2000
Labour				
Slashing and Land Preparation	Manday	15	1000	15000
Sowing	Manday	10	1000	10000
Fertilizer & Chemical application	Manday	9	1000	9000
Weeding	Manday	30	1500	45000
Harvesting	Manday	25	1000	25000
Shelling	Manday	5	1000	5000
Bagging	Manday	5	1000	5000
Total Labour				**114,000**
Sub-Total				**171,000**
Fixed Cost				
Land Charge	₦	1	15000	**15000**
Depreciation	₦	10%		**150**
	₦			
Total Cost	₦			**186,150**
Net Income	₦			103850
Output per Manday	hr	8		
Value of Output per Manday	₦	1000-1500		
Price of maize per kg.	₦	145*		

***** Price of maize in May 2011
Source: ICEED

Table A3.6. Cost of Rice Production on one hectare of Land in Cross River State.

Item	Unit	Rainfed Lowland		
		Quantity	**Price**	**Value (₦)**
Output (a**verage rice yield/ha)**	Kg	**3000**	155	**465,000**
Operating Inputs				
Rice seed	Kg	60	200	12000
Fertilizer	Kg	300	110	33000
Herbicide	litres	9	550	4950
Insecticide	litres	3	1100	3300
Labour				
Nursery Preparation	MD	5	1500	7500
Slashing and Land Preparation	MD	25	1000	25000
Transplanting/Sowing	MD	32	1500	48000
Fertilizer & Chemical application	MD	9	1000	9000
Weeding	MD	20	1500	30000
Bird scaring	MD	4	1000	4000
Harvesting	MD	10	1500	15000
Gathering	MD	5	1000	5000
Threshing	MD	5	1500	7500
Winnowing/Bagging	MD	4	1000	4000
Total Labour				**155,000**
Sub-Total	₦			**208,250**
Fixed Cost				
Land Charge	₦	1	25000	
Depreciation	₦	10%	250	
Total Cost	₦			**233,500**
Net Income	₦			**231,500**
Output per Manday	Hr	8		
Value of Output per Manday	₦	1000-1500		
Price of rice per kg.	₦	155		

Manday- MD

Labour Cost: 1 man-day of approximately 8 hours cost between ₦1000 and ₦1500 in Cross River State

Source: ICEED

Table A3.7: Cost associated with Rice (Upland) production on 1 hectare of Land in 2010.

S/N	Items	Cost (₦)
1	Seed (60 kg @ ₦250 per kg) –Transplanting	15000
2	Land preparation	
	Bunding (10 people @₦2000 per person)	20000
	Herbicide purchase (Gramoxone: 4 litres@ ₦ 1500)	6000
	(Touchdown: 2 litres@₦2500)	5000
	Spraying of herbicide (3 persons)	7000
	Ploughing and Harrowing (hiring plus fueling)	25000
3	Planting by direct seeding (15 persons for 2 days @ ₦ 2000)	60000
4	Manual weeding (5 persons @ ₦2000 for 2 days)	20000
5	Fertilizer NPK 15-15-15, 6 bags @ ₦4500 per bag	27000
6	Fertilizer application (First application)	3000
7	Second weeding-manual (10 persons @ ₦2000 for 2 days)	40000
8	Fertilizer application (Second application)	3000
9	Harvesting (30 persons @ ₦2000)	60000
10	Threshing and bagging (6 persons @ ₦1500 for 2 days)	18000
11	Purchase of bags (60 bags @ ₦100 per bag)	6000
	Total Expenses	**315000**
	Expected yield: 2500 kg/ha (conservative estimate)- 30 bags paddy **Gross income : Farm gate price ₦2700- ₦3000 per bag**	
	:Government Guaranteed Price ₦6000 per bag	**180000**
	***If paddy is kept for 2-3 months new price= ₦4000 per bag** **Home consumption (5 bags @ ₦6000 per bag)**	
		30000
	Net Loss and Final Income	**150000**
		-165000
	For processing, 60% recovery is expected. Therefore for the 25 bags, 15 bags are expected at 80 kg per bag to give 1200kg processed rice yield per hectare. **Milled rice cost ₦9000 per bag (24 bags)**	
	Cost of processing (1200 kg @ ₦20/kg)	
		216000
		24000
Source: ICEED	**Net Income**	**201,000**

Table A3.8.: Cost Associated with Maize Production on one hectare of Land in Enugu State (2010)

Item	Unit	Quantity	Price(₦)	Value (₦)
Output (Average grain yield/ha-Hybrid maize Variety)	Kg	**1500**	145	**217,500**
(Green Maize)		**4000**	100	**400,000**
Operating Inputs				
Maize seed	kg	20	150	3000
Fertilizer	kg	450	110	49500
Herbicide	litres	5	500	2500
Insecticide	litres	2	1000	2000
Labour				
Slashing and Land Preparation	Manday	15	2000	30000
Sowing	Manday	10	2000	20000
Fertilizer & Chemical application	Manday	9	2000	18000
Weeding				
Harvesting	Manday	30	2500	75000
Shelling	Manday	25	2000	50000
Bagging	Manday	5	2000	10000
Total Labour	Manday	5	2000	10000
				213,000
Sub-Total				
				270,000
Fixed Cost				
Land Charge				
Depreciation	₦			
	₦	1	20000	**20000**
	₦	10%		**200**
Total Cost	₦			**290,200**
Net Income (Net Loss- dry grain)	₦			72,700
(Profit-Green Maize)				**109,800**
Output per Manday	hr	8		

Value of Output per Manday	₦	2000-2500+ 1500-1800#		
Price of maize per kg. (dry grain)	₦	145*		
(fresh green cob)		100		

***** Price of maize grain in May 2011; Cost of Manday + (Man) and # (Woman)

Source: ICEED

4. Weather Index Insurance Prototypes for Maize and Rice in Nigeria

4.1. Introduction

This Annex presents one methodology for the design of a rainfall-deficit weather index insurance (WII) contract for rain fed maize grown in the selected states of Kano, Kaduna, Cross River, Enugu and Lagos and also for rainfed rice in Kaduna State. The contract design is based on the standardized deficit-rainfall insurance contracts that have been developed by the Agricultural Risk Management Team, ARMT (former Commodity Risk Management Group, CRMG), of the World Bank, in conjunction with IRI Earth Institute at Columbia University.

For a number of years, ARMT has been working closely with IRI to develop WII training materials to assist interested individuals and organisations to learn about WII and its applications to crop insurance in developing countries and there are a series of modular training materials that can be downloaded from the FARMD Forum for Agricultural Risk Management in Development website at:
http://www.agriskmanagementforum.org/farmd/content/implementing-weather-index-insurance-programs-training-presentations.

These training materials are summarised in modular format in 8 modules as described in Box A4.1.

Box A4.1. Weather Index Training Program Modules

1. **Weather Index Products**
2. **Market for Weather Risk**
3. **Selecting Weather Data**
4. **Indexing Weather Risk**
5. **Quantifying Weather Risk**
6. **Insurance Contract Design**
7. **Pricing the Insurance Product**
8. **Developing and Insurance Program**

Source: http://www.agriskmanagementforum.org/farmd

For technical specialists who are interested in more in-depth training in the design and rating of their own weather index insurance contracts, it is possible for them to register with FARMD and to use the IRI designed web-based multiphase WII rainfall deficit contract design tool which is based on a modified version of the FAO's Water Requirements Satisfaction Index (WRSI) and which is named "Weather Index Insurance Educational Tool (WIIET)[42]. .

The Nigeria study team has used the ARMT's modified FAO WRSI model to design the Prototype rainfall-deficit contracts for maize grown in 4 of the 5 Nigerian states and also to test this product for rice in one state. It is stressed, however, that the ARMT rainfall-deficit contract design and rating tool is not a commercial insurance pricing tool and under no circumstances can the outputs presented below relating to calculated pure loss cost rates and or indicative premium

[42] The WIIET Tool can be accessed from IRI at: http://iri.colombia.edu/wiiet

rates be considered to be final commercial insurance prices. Each Insurance company and their reinsurers will use their own procedures to price WII Contracts. A separate model is also described in this annex for testing "excess-rain" contracts for maize in Nigeria.

4.2. Data Requirements for Maize and Rice Rainfall Deficit Index Contracts and Data Quality Assessment for Nigeria

This section briefly describes the key data required to design the maize and rice rainfall deficit Contracts for the 5 selected states of Kano, Kaduna, Cross River, Enugu and Lagos in Nigeria based on a the FAO Water Requirements Satisfaction Index, WRSI, Model described below.

(1) **Rainfall data**. A minimum of 25 to 30 years uninterrupted daily rainfall data with a maximum of 2% to 3% missing data and data outliers is normally required to design and rate rainfall deficit contracts (World Bank 2005). Annex 2 showed that the Kano NIMET rainfall data exhibit major inconsistencies and could not be analysed further for WII contract design purposes. However, the NIMET daily rainfall data for the remaining 4 states/weather stations in Kaduna, Cross River (Calabar station), Engu and Lagos (Ikeja station) was found to meet the minimum data requirements for WII, and has therefore been used to design and rate prototype contracts for maize and rice. This rainfall data has been corrected by eliminating implausible outliers[43]. The rainfall analysis is carried out on a 10-day dekad[44] basis.

(2) **Evapotranspiration data** for the same period (25 to 30 years). 30-year daily evapotranspiration data were obtained from NIMET for the four stations and has been used in the modelling exercise by converting this to a 10-day (dekad) basis;

(3) **Maize and Rice Crop Production variables**. In order to design and rate WII rainfall-deficit contracts for maize and rice specific information is required on the main seed varieties grown, the length of the growing cycle of each major variety and length phenological growth stages, and start dates and closing dates for sowing of the crops and optimal sowing dates. In addition crop production and yield data is required in order to establish average yields and to correlate the WRSI outputs with actual time-series yields as well as crop gross margin costs of production and return data in order to value the WII contracts. ICEED, the local consultants prepared technical reports on maize and rice production in each state and collected the required agronomic, production and financial data for each crop. It was possible for the study team to collect useful data on crop production practices in each state, but none of the data is location specific in that it does not relate to maize and rice production in the vicinity of the selected weather stations and this applies specifically to the crop production and yield data which is only available at a state level and which is in most cases of very poor quality. These constraints over the

[43] The task of correcting for outliers and implausible data has been complicated in Nigeria by the lack of additional nearby weather stations (often termed "Buddy" stations) which can be used to check extreme rainfall events on the same day or periods of drought etc. Therefore under this study only very limited weather data cleaning has been possible as noted under Annex 2.

[44] There are 36 Dekads per year and each month is divided into three Dekads. The first Dekad is defined as the 1st to the 10th of each month inclusive; the second Dekad is defined as the 11th to the 20th of each month inclusive; the third Dekad is defined as the 21st to the end of the month inclusive, and can have from 8 to 11 days depending on the month.

lack of suitable location specific crop production and yield data have severely limited the ability to design and rate WII contracts for the 4(5) selected weather stations in the selected states.

(4) **Soil Water Holding Capacity and other Crop Water Use Parameters.** In order to run a WRSI model it is necessary to have an understanding of the soil type and water holding capacity. The study team was able to obtain general information on soil types and water holding capacity (WHC) for each state based on agricultural research data, but again the disadvantage was that this data is not site-specific and does not specifically relate to soils with the 25 km radius of each weather station. At best the information is applicable in generalised form at a state-level. WRSI requires information on maximum and effective root depth which in the absence of site specific data, for maize, were standardised at 1 meter and 0.7 meters respectively across the 4 states. Other WRSI specific crop water use parameters were defined using FAO standard coefficients for maize (See WRSI Appendix 1 for further details).

By way of summary to this section the lack of location specific crop production and soil data for each weather station is identified as a major constraint in the design and rating of prototype WII contracts for maize and rice in the 4(5) selected states.

4.3. The Three-Vegetative Phase Rainfall Deficit Contract Features

In Nigeria, under the current study, a **Three-phase rainfall deficit WII contract design** has been tested for maize in four states Kaduna, Cross River, Enugu and Lagos and for rice in one state Kaduna.

The three-phase weather insurance contract design described below 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 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. The contract design is most appropriate for the non-humid tropics, where meteorological drought is a potential risk and for rain-fed field crops that are susceptible.

The prototype contracts for maize in Nigeria have the following features:

1. **A dynamic start date**, that mimics the decision a farmer would take as to when to sow his crop of maize;
2. **Three subsequent physiological growth phases** depending on the length of growing period of maize, during which cumulative rainfall[45] is measured, with a trigger and exit levels in each phase. The trigger level in each phase 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

[45] Recorded cumulative rainfall is capped for every dekad in the contract at some level, e.g. for 60mm, Capped Cumulative Dekadal Rainfall = min(60, Cumulative Dekadal 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 in each phase 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 due to lack of rainfall.

3. **A tick 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 defined as Phase Limit/(Trigger – Exit).

The contracts are designed in an attempt to balance simplicity that farmers and stakeholders could understand, with the complex dynamics that characterize water stress impact on crop yields. The thinking on these contracts is still a work in progress and it is envisioned they and the methodologies used to design and calibrate them will be revised and refined many times moving forward. This methodology to design deficit-rainfall WII contracts has been used since 2004/05 by ARMT (formerly CRMG) in Asia and Africa including in Malawi, Tanzania and Kenya.

4.4. Contract Parameters

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[46] 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 which have distinct water stress response characteristics. In the case of maize these are: Phase 1 – Germination and establishment, Phase 2 – Vegetative Growth Stage and Phase 3 – Flowering and maturation of the grain.
- **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.

[46] A 10-day period, see Annex 6 for definition.

- **Maximum Payouts per Phase, $M_{1,2,3}$:** The maximum payout, in Nigerian Naira received per farmer per hectare insured if the cumulative rainfall total received in a phase is less and 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 Naira. 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:

$$\text{Tick per Phase} = \text{Maximum Payout per Phase} / (\text{Trigger Level per Phase} - \text{Exit Level per Phase})$$

- **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[47], that would not be used by the plant and would result in soil run-off, does not contribute or detract from the water-deficit compensation of the structure design, i.e.

$$\text{Capped Dekadal Rainfall} = \min(Y, \text{Dekadal Rainfall})$$

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[48], 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.

These parameters are discussed below for the Nigerian maize rainfall deficit prototype WII contracts and then following this for a rice-rainfall-deficit contract.

4.5 Maize Rainfall-Deficit Contract Parameters

1. ***<u>Sowing Window / Dynamic Start Date</u>***

In order to the capture events on the ground as well as possible an agricultural weather insurance contract should begin when the farmer sows his maize crop. As the key feature of such insurance

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

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. There are many possible definitions suggested in the literature (see discussion in Appendix 4.1, "Model Inputs and Assumptions" section).

In Nigeria, the optimum sowing dates for maize vary considerably across the 5 selected states as shown in Table A4.1. In the more southerly states of Enugu, Cross River and Lagos where there are two rainy seasons, maize farmers start planting their major rainy season maize crop in early April (Dekad 11) when there is enough moisture in the soil to plant their maize crop and secure good probability of seed germination. In the two more northerly states of Kano and Kaduna where there is only one rainy season with a later onset, the planting of maize starts in late May in Kano (Dekad 15) and even later in Kaduna from 1st June (Dekad 16). According to the local agro-meteorological experts in Nigeria, successful sowing of maize is usually associated with 25-30mm of rainfall in a dekad, which is line with the physical reasoning behind seed germination (see Appendix). Therefore in each state once 25mm or more of cumulative rainfall has been recorded it is assumed that farmers will decide to sow their maize and the policy would incept. However in addition to the earliest possible sowing date, the farmer has a limited sowing window within which he should plant his maize crop. A late planting can mean the cessation of rains early in the plant's growth cycle when it still needs water during its vegetative phase, therefore there is a latest possible planting date for the farmer to secure a successful crop. In the 4(5) selected states of Nigeria, the latest recommended sowing dates for maize and the corresponding dekad are shown in Table A4.1.and this varies from 10 May in the southern states through to 30 June in the more northerly Kaduna State.

Sowing windows and criteria must be set in a manner that makes sense for the crop, weather station and farming practices in question and incorporated into the weather insurance contract. For example, if the successful sowing condition is not satisfied during the sowing window, i.e. if none of the dekads in the sowing window record 25mm of rainfall or more, this could mean that either: a) the contract automatically starts on the last dekad of the sowing window or b) as it is expected that farmers would not have planted, or would have unsuccessfully planted their crop, they would receive a maximum payout from the weather insurance contract so that they could be compensated for their lost input costs.

Table A4.1. Start and Final Sowing Dates for Maize in Selected State, Nigeria

State	Kano*	Kaduna	Cross River	Enugu	Lagos
Start Date of Sowing	21st May	1st June	11th April	11th April	11th April
Start Dekad of Sowing	15	16	11	11	11
Last Date of Sowing	30th June	31st June	10th May	10th May	20th May
Last Dekad of Sowing	18	18	13	13	14
No Dekads Sowing Window	4	3	3	3	4

Source: ICEED State-level Technical Reports 2011

Note * In Kano the poor quality of the rainfall data meant that the maize rainfall deficit index could not be tested

2. ***The Phase Lengths***

To study the agro-metrology of a crop and the impact of water stress on yields to design the insurance contract, the World Bank uses the USGS/FEWS-NET Water Requirement Satisfaction

Index (WRSI) model, a modified version of the FAO WRSI, to index crop yield and therefore production to rainfall variability (a more detailed description of the model is given in Appendix 4.1). The advantage of using a model such as the WRSI is that as it uses rainfall as the only variable input parameter. Therefore when looking over several rainfall seasons, 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, technological changes and pest attacks. These other risks 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. By considering the variations in WRSI 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 design of weather insurance contracts and the interaction between the contract phases.

The first step is to choose the number of phases in the contract. The phases must correspond to the major phenelogical stages of the maize plant's growth, as determined by the FAO WRSI model[49] and the specifics of the crop and growing conditions. Generally three phases are chosen on no less than 2 to 3 dekads each to minimize basis risk, but more phases can be chosen if the growing period is sufficiently long.

In Nigeria, where much of the maize crop is relatively short 100 to 110-day varieties, the three phases selected for the maize contracts following sowing are:

- Phase 1 – Germination & **Establishment** (20 days, 2 dekads excluding the planting dekad);
- Phase 2 – **Vegetative Growth** (30 days, 3 dekads following Phase 1);
- Phase 3 – **Flowering and Yield Formation** (30 days, 3 dekads following Phase 2).

It is noted that the last 2 dekads (20 days) of the maize crop during which time the cobs are maturating and ripening does not require any rainfall and therefore this 2 dekad period is not included in the contract design for a rainfall deficit contract. Notwithstanding, however, the estimation of the WRSI includes all 10 dekads.

3. Setting the Three-Phase Rainfall Deficit Trigger and Exit Levels

Each of the three vegetative phases for the Maize rainfall-deficit contract is defined by its own specific rainfall (available soil moisture) requirements which are specified in conjunction with local experts and which are then calculated under the WRSI-based model. Each phase therefore has its own cumulate rainfall trigger which is set at a level when the crop starts to suffer from moisture stress leading to plant damage and potential yield loss, an exit level and an agreed payout per mm of deficit rainfall termed the tick, and which is usually a linear payout scale. These principles are illustrated in Figure A4.1 for Enugu weather station maize in Nigeria.

[49] See http://www.fao.org/ag/agl/aglw/cropwater/grount.stm for details and Appendix.

Figure A4.1. Three Phase Rainfall-Deficit Contract Model for Maize, Enugu Weather Station, Enugu State, Nigeria

Sowing	Germination	Vegetative stage	Flowering and Grain Formation	Ripening
	Dekads 1 & 2	Dekads 3 to 5	Dekads 6 to 8	Dekads 9-10

	Millimeters of Rainfall / Phase	
	Drought Triggered if Rainfall Less than	Exit (Maximum Payout if Rainfall less than
Phase 1	40	20
Phase 2	60	40
Phase 3	100	55
Sowing	failed if < 25 mm	

Source: adapted by the Authors from ARMT Training Materials

The **trigger and exit levels** set per phase depend on the objective of the weather insurance contract and the risk it is designed to protect. The trigger level should always be set at a level where damage will have started to occur to the maize crop through insufficient rainfall during that Phase. For maize the most critical physiological phase is the tasseling and flowering phase when inadequate total rainfall or a dry period of more than 15 days without rainfall is likely to lead to severe damage to the crop. Under this Nigeria maize contract design and rating exercise the trigger levels opening the policy to a claim were set at approximately 70% of the normal or optimal level of water demand calculated by WRSI for each phase. The exit level of rainfall in each Phase should be set to levels where the maize crop either suffers permanent damage or total failure due to deficit rainfall during the phase itself to trigger either a) the total sum insured of the contract or b) the limit of the phase. The exit levels are set through discussions with agro-meteorological experts knowledgeable of the crop being grown in the area in question, as well as through discussions with farmers and other stakeholders to elicit their preferences and opinions on how the contracts should be structured. In Nigeria, however, a combination of time constraints and security issues meant that it was not possible for the World Bank team to conduct field-level focus-group discussions with maize farmers in the 5 selected states to elicit their views on the rainfall trigger and exit levels. It is recognised that such an exercise will have to be conducted in future under any possible detailed design study for rainfall deficit WII in Nigeria.

For the Nigeria maize contracts a decadal rainfall cap of 60 mm of rainfall has been used. The purpose of a rainfall cap is to eliminate excess rainfall which occurs during each dekad and which will normally be lost as run-off and will not percolate into the soil and will not be effectively used by the crop roots to transpire.

Once the sowing definition, phase lengths, decadal rainfall caps and exit triggers are chosen, an optimisation can be run to calibrate the trigger levels per phase of the contract. There are various procedures that can be used which are detailed on the IRI FarmD website. For the purposes of this preliminary prototype rating exercise, every attempt has been made to manually adjust the contract parameters based on the available soil and moisture and crop production and yield data order to test the model for sensitivity and to calibrate the payouts. This process involves the matching of the payouts simulated by the WRSI model with the actual losses in the time-series crop yields: this task was, however, complicated because of the absence of location specific crop production and yield data for rice and maize relating to each weather station. The Prototype maize rainfall deficit rainfall trigger and exit levels in millimetres for each Phase of the Prototype contract are set out in Table A4.2.

4. Crop Valuation and Maximum Payouts per Phase.

For the purposes of valuing a WII contract for field crops such as maize and rice, the minimum level of protection should be based on the accumulated costs of production during the growing season, or alternatively if higher levels of sum insured protection are required, a revenue-based valuation may be used.

Under this study, it has been seen that between 2004 and 2010 the NAIC average sum insured all crops has been about Naira 66,000 per hectare. The local consultants also prepared gross margin cost of production and return per hectare budgets and this data is reviewed in Annex 3. However, given the very high production costs presented and which do not reflect farmer-level average typical costs of production a lower costs of production based valuation for maize of Naira 60,000 per hectare has been used for maize in all states. The figure of Naira 60,000/Ha also sets the basis of the sum insured per hectare, or in other words the maximum total payout which the policy will make in one cover period.

The maximum payouts for maize per phase have been calculated to represent as accurately as possible the lost costs of production that a typical farmer would incur at each phase under a severe rainfall deficit scenario. Under the sowing failure cover, it is estimated that the farmer will have incurred about 40% of his costs in terms of land preparation, seeds, basal fertiliser dose and sowing costs, which gives a sowing failure payout of Naira 24,000/Ha. For Phase 1 Germination failure the farmer would lose the costs invested to date in land preparation and sowing, but at this stage he will not have incurred major additional costs to maintain the crop and therefore the maximum payout in this two dekad period is also fixed at Naira 24,000 (40% of total production costs). In Phase 2 Vegetative Stage the farmer will incur additional costs for weeding and fertiliser application (top dressing) and also in plant protection measures and the maximum payout for Phase 2 is set at Naira 30,000 50% of the total costs of production/ maximum total annual payout. Finally during Phase 3 flowering and grain formation the maximum payout is set at Naira 40,000 or 67% of the total production costs / total sum insured: at this stage the typical maize farmer will have incurred between two thirds and three quarters of his production costs save for harvest labour costs and post-harvest transport, storage and threshing. In Phase 3, tasseling / flowering in maize rainfall deficit will result in major loss of grain formation and yield. These policy payouts are summarised in table A4.2 below.

It should be noted that the Policy Maximum Total Payout is Naira 60,000 per hectare or in other words the policy does not pay out the sum total of the maximum payouts for each vegetative phase. This is because the policy allows for a total loss scenario in each phase, but in reality once the crop had been lost say following sowing failure, there would not be any more crop production to lose. The recognition that a farmer may incur losses or damage to his crop at different stages of the growth cycle means that the policy is designed to make at least 2 full payouts in Phases 1 and 2, or partial payouts in either of these phases and still make payouts in Phase 3 if drought conditions continue to dominate. Under such a WII cover, once the maximum payout of US$ 60,000 / Ha has been reached, cover will cease and no further payouts will be due from Insurers in that cover period (insurance year).

The payout rates or the Tick in Naira per millimetre of rainfall deficit are also shown for the illustrative Prototype maize rainfall deficit contracts in Table A.4.2.

Table A.4.2 Nigeria Maize Deficit Rainfall Insurance Contract Parameters

State / Weather Station	Kaduna	Cross River (Calabar)	Enugu	Lagos (Ikeja)
Insured Crop: (**Main Season or first crop Maize**)	Maize	Maize	Maize	Maize
Contract Parameter				
Failed Sowing Trigger (mm)	25	25	25	25
Phase 1 Trigger (mm)	40	40	40	40
Phase 2 Trigger (mm)	75	70	65	65
Phase 3 Trigger (mm)	100	100	100	80
Phase 1 Exit (mm)	30	25	20	20
Phase 2 Exit (mm)	35	40	40	35
Phase 3 Exit (mm)	55	50	55	45
Maximum rainfall cap per dekad	60mm	60mm	60mm	60mm
Failed Sowing Payout (Naira)	24,000	24,000	24,000	24,000
Phase 1 Max Payout (Naira)	24,000	24,000	24,000	24,000
Phase 2 Max Payout (Naira)	30,000	30,000	30,000	30,000
Phase 3 Max Payout (Naira)	40,000	40,000	40,000	40,000
Phase 1 Payout Rate (Naira/mm)	2,400	1,600	1,200	1,200
Phase 2 Payout Rate (Naira/mm)	750	1,000	1,200	1,000
Phase 3 Payout Rate (Naira/mm)	889	800	889	1,143
Contract Maximum Payout (Naira)	60,000	60,000	60,000	60,000

Source: World Bank

4.6. Maize Rainfall-Deficit Contract Modelled Outputs and Payouts

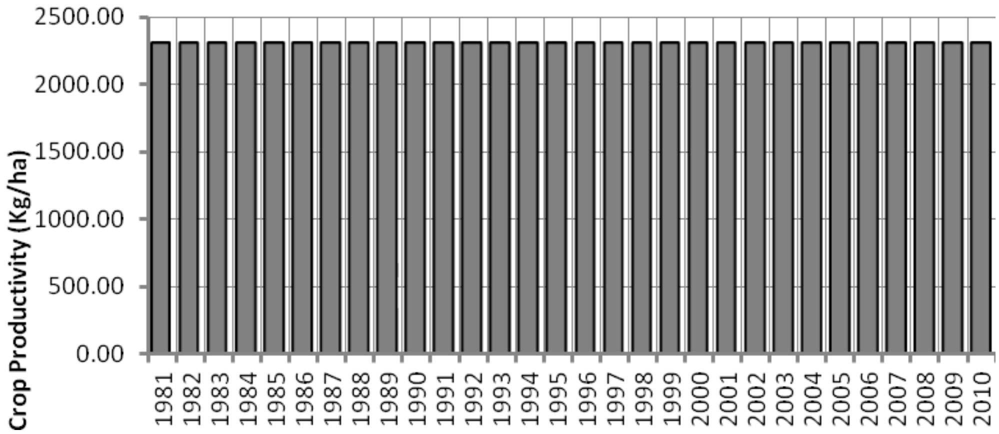
To date a simple manual analysis has been conducted to model the payouts that would have been made under the rainfall deficit models for maize for the 4 selected stations and states. The outputs of this analysis are summarised below.

Kaduna:

In Kaduna based on the NIMET rainfall data and the WRSI modelled water balance, there was adequate rainfall in each phase of the 30 year period to fully meet the crop water requirements for maize to achieve a potential yield of 2,300 Kg/Ha, which would imply that rainfall deficiency (drought) is not the primary cause of yield variability or loss in the vicinity of the Kaduna airport weather station (Figure A4.2).

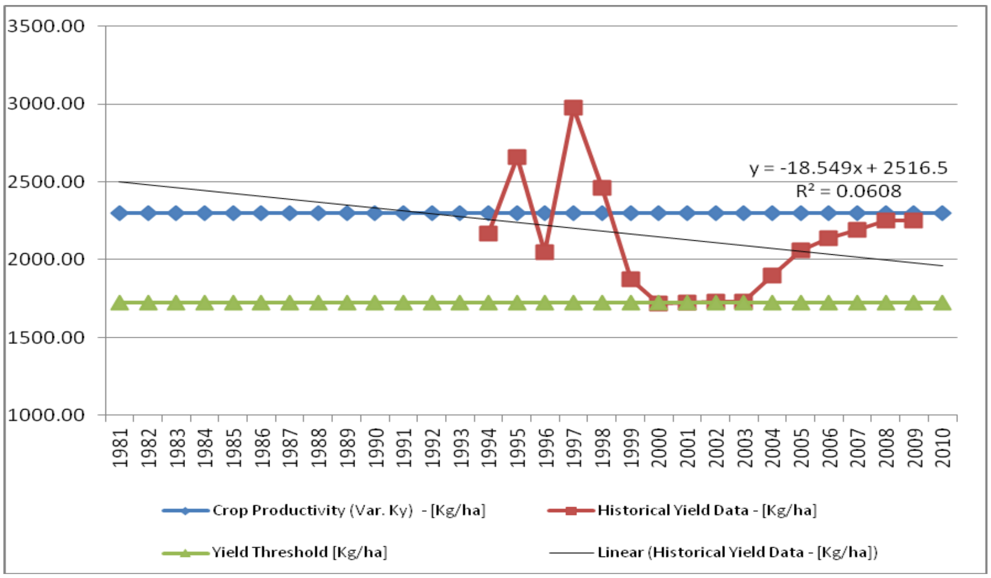
There was no significant correlation between the rainfall and WRSI analysis and the Kaduna State-level yields for the 16 year period 1994 to 2009. This is probably explained by the fact that the state-level aggregated maize area, production and yield data fail to reflect the local variations in maize yields in the vicinity of the Kaduna NIMET weather station (See comparison in Figure A4.3 of WRSI calculated yield productivity for maize and actual average state-level yields of maize from 1994 to 2009).

Figure A4.2. Kaduna: WRSI Calculated Maize Yield Potential 1981 to 2010 (Kg/Ha)



Source: Authors

Figure A4.3. Kaduna: Comparison of WRSI Calculated Maize Yields with Actual average state-level Maize Yields



Source: Authors

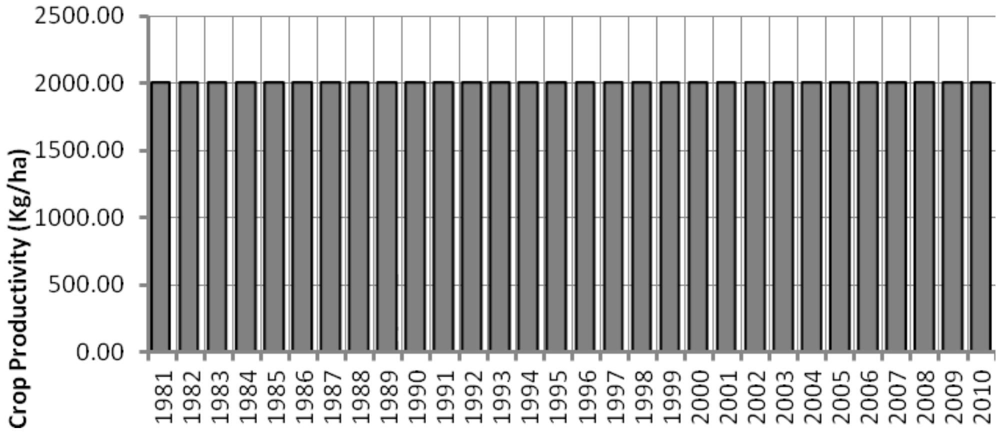
Cross River State

In Cross River (Calabar) average rainfall is extremely high throughout the year. Based on the NIMET rainfall data and the WRSI modelled water balance, there was adequate rainfall in each phase of the 30 year period to fully meet the water satisfaction requirements for maize to achieve a potential yield of 2,000 Kg/Ha, or in other words rainfall deficit is not the primary cause of yield variability in the vicinity of the Calabar Weather Station, Cross River State (Figure A4.4).

There was no significant correlation between the rainfall and WRSI analysis and the Cross River state-level average yields of maize for the 16 year period 1994 to 2009. This is probably explained by the fact that the state-level aggregated data fail to reflect the local variations in maize crop production and yields in the vicinity of the Calabar weather station. (See Figure A4.5

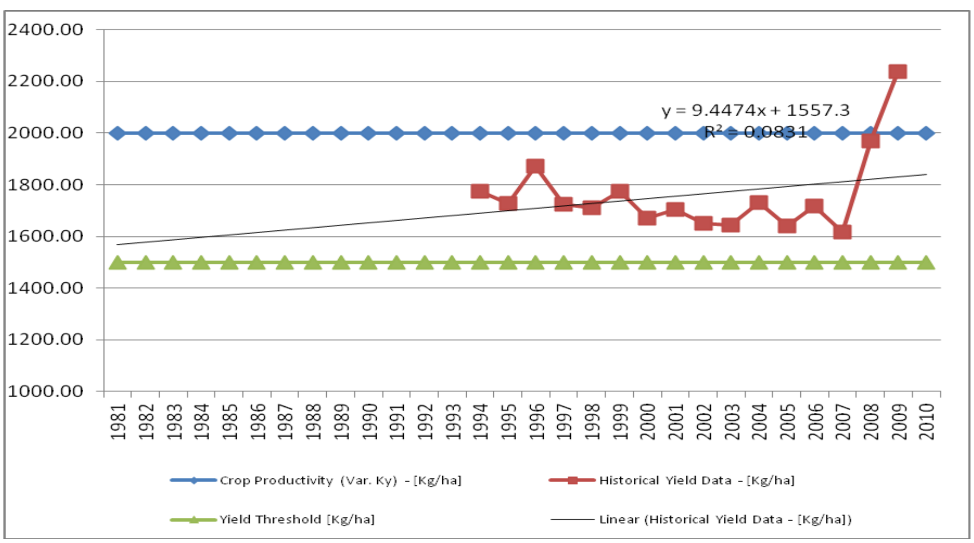
for comparison of WSRI calculated potential maize yields for Calabar weather station and actual historical state-level maize yields 1994 to 2009 in Cross River state).

Figure A4.4. Cross River (Calabar) WRSI Calculated Maize Yield Potential 1981 to 2010 (Kg/Ha)



Source: Authors

Figure A4.5. Cross River (Calabar): Comparison of WRSI Calculated Maize Yields with Actual average state-level Maize Yields



Source: Authors

Enugu State

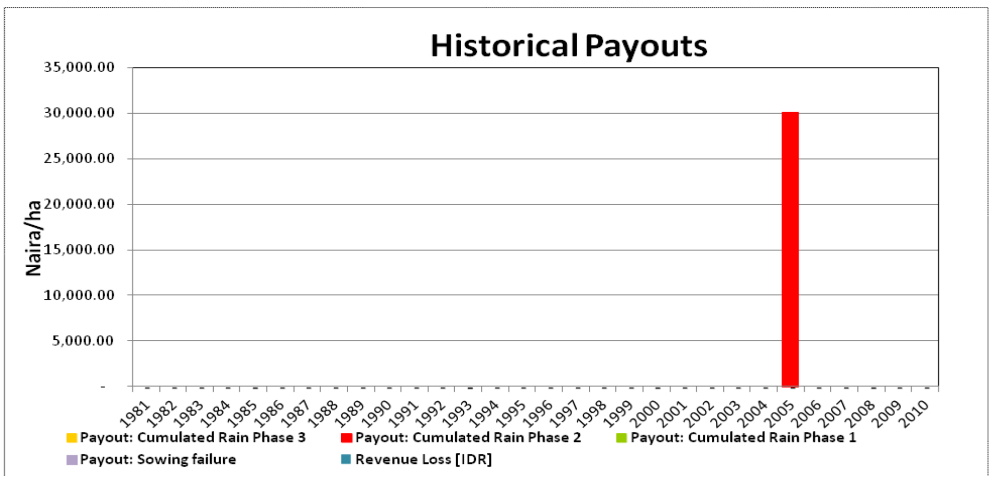
In Enugu, the WRSI model produces one triggered rainfall deficit event, in Phase 2 Vegetative stage in 2005 when a maximum Phase 2 payout of Naira 30,000/Ha would have been made equivalent over the 30 years to an average pure loss cost of 1.7%. (Figures A4.6, A4.7, A4.8, and A4.9). However, this WRSI calculated water-deficit payout is not matched up by any corresponding loss of crop yield and crop revenue loss.

According to the state-level data the actual average yield for Enugu in 2005 was 1,830 Kg/Ha, compared to a 16-year average yield of 1,779 Kg/Ha, or in other words there was no reduction or loss to state-level maize production and yields in that year. However, it is possible that maize production and yields on farms located close to the Enugu weather station did, in fact, suffer from drought loss in Phase 2 in 2005, but that these localised losses are not reflected in the state-level aggregate data..

Sensitivity analysis involving changing the phases and trigger and use of a single cumulative index did not improve the contract payouts and there was no correlation between the WRSI index and corresponding yield and revenue losses.

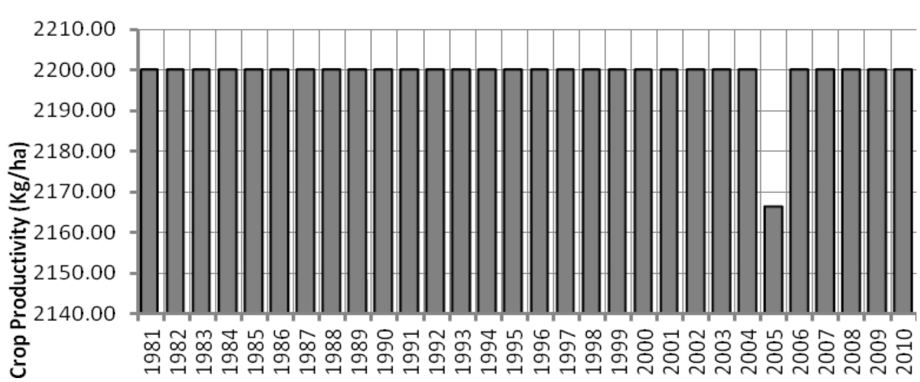
In conclusion, the 3-Phase Rainfall Deficit Model does not perform well for Enugu and in sprite of registering one Phase 2 vegetative stage maximum payout in thirty years, this does not mean that there is a clear argument for trying to develop further and to implement a WII product for rain-fed maize in the vicinity of Enugu station.

Figure A4.6. Enugu Station calculated Rainfall Deficit Index Payouts



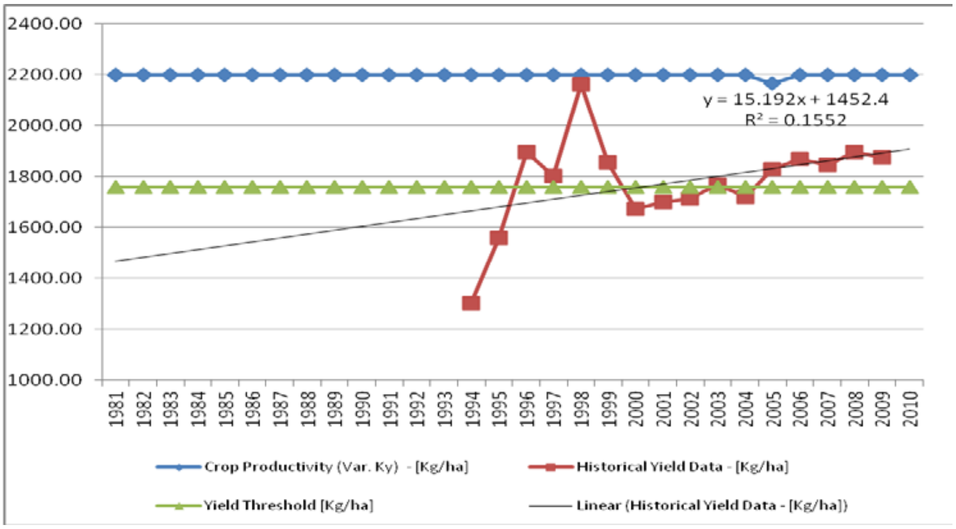
Source: Authors

<u>Figure A4.7. Enugu: WRSI Calculated Yield Potential 1981 to 2010 (Kg/Ha)</u>



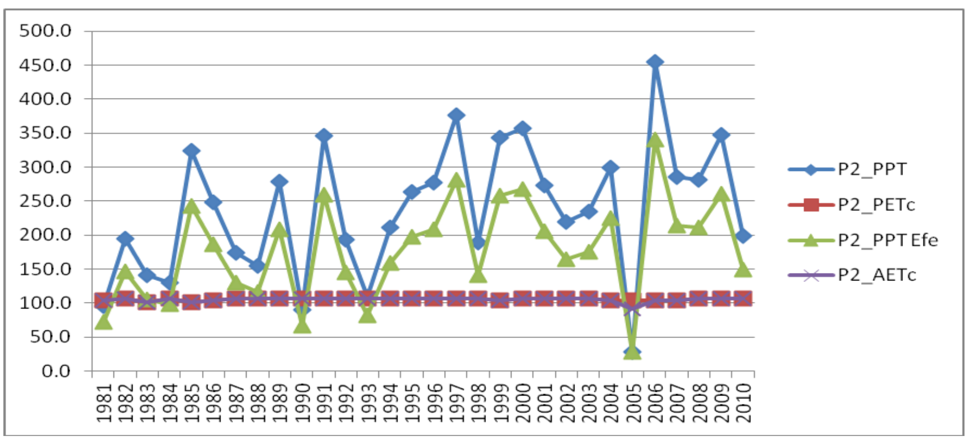
Source: Authors

Figure A4.8. Enugu: Comparison of WRSI Calculated Maize Yields with Actual average state-level Maize Yields



Source: Authors

Figure A4.9. Enugu: Phase 2 Maize Contract: comparison of Actual Precipitation (PPT) Effective Precipitation (PPTEfe)[50], Potential Evapotranspiration (PETc) and Actual Potential Evapotranspiration (AETc)



Source: Authors

Lagos State – Ikeja Weather Station

In Lagos-Ikeja, the WRSI model produces two triggered rainfall deficit events, the first in 1985, a very small phase 3 Flowering and Grain Formation/Maturation stage loss and then a much bigger Phase 2 Vegetative growth stage loss in 1997 when a maximum payout of Naira 30,000 would have been made. The estimated average pure loss cost is 1.9% for these two events over 30 years.

[50] For the estimation of the effective precipitation (PPT Efe) the following conditioning formula, proposed by J.D. Vega was used:

$$PPTEfe : si\left(PPT > 0.9ETP^{0.75}, \quad 0.75 * PPT, \quad PPT\right)$$

(Figure A4.10). However, these WRSI calculated water-deficit payouts are not matched up by any corresponding loss of crop yield and crop revenue loss and there is no correlation with the actual state-level maize yields[51] over the period 1994 to 2009 (Figure A4.12).

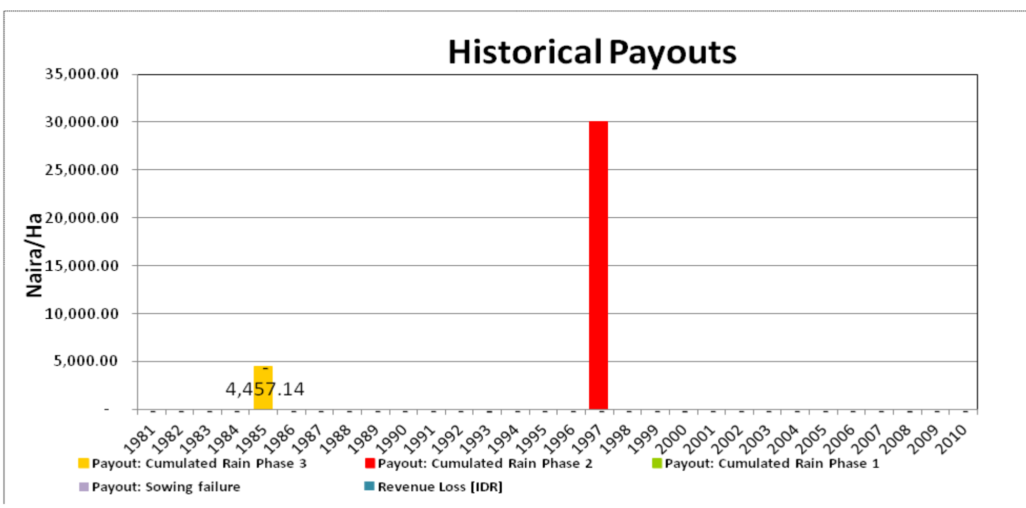
We do not have state-level maize yield data prior to 1994 and cannot therefore comment whether actual maize yields were lower than average. In 1997 the reported state-level average yield for maize was 2,000 Kg/Ha or 103% of the 10-year average yield 1994 to 2003, or 93% of the 16-yerars average yield 1994 to 2009. On either count no significant maize yield reduction or loss was recorded in 1997 (Figure A4.12).

Reference to the NIMET rainfall data for Lagos (Ikeja) shows that zero rainfall was recorded for all 31 days in May 1997 (dekads 13 to 15) and that this month's rainfall pattern is completely different to all other 29 years of data when an average of 188 mm of rainfall and a minimum of seven rainy days in the month (Figure A4.14). May 1997 appears even stranger because the rainfall patterns both in April and then in June appear completely normal and the most plausible explanation is that the May rainfall recordings have subsequently been lost.

Sensitivity analysis involving changing the phases and trigger and use of a single cumulative index did not improve the contract payouts and there was no correlation between the WRSI index and corresponding yield and revenue losses.

In conclusion, the 3-Phase Rainfall Deficit Model does not perform well for Lagos-Ikeja and the totally inconsistent rainfall pattern in May 1997 with zero rainfall recorded in this month and which accounts for the Phase 2 full payout in 1997 cannot be regarded as a reliable result. The analysis does not provide any firm indicators of the potential application of a rainfall-deficit index to maize grown in Lagos State.

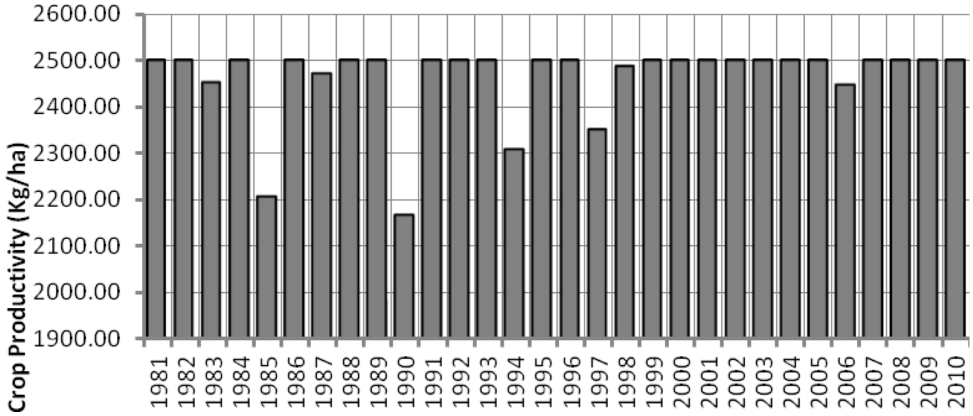
Figure A4.10. Lagos (Ikeja) Station calculated Rainfall Deficit Index Payouts



Source: Authors

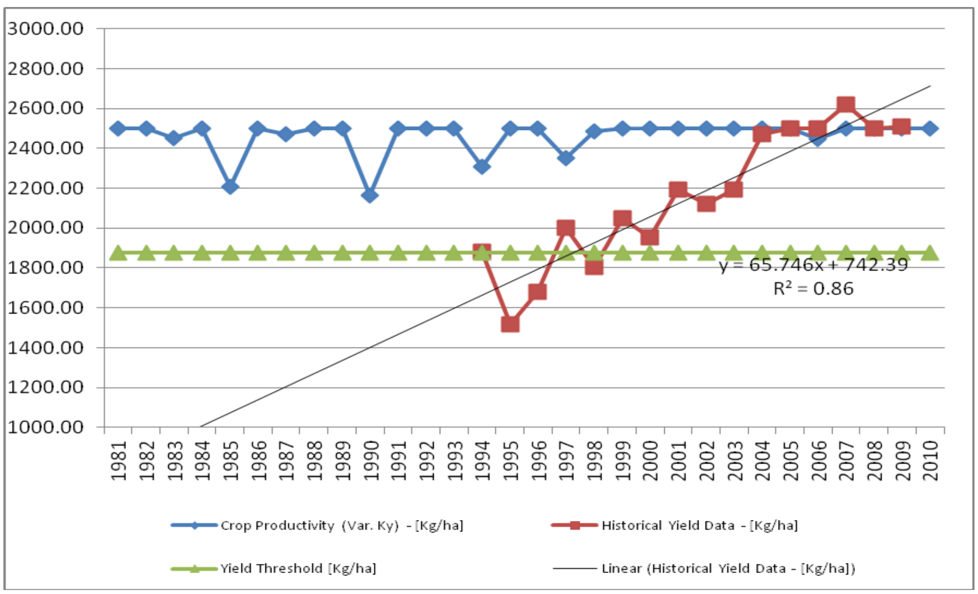
[51] It is recognised that Maize yields in Lagos show a distinct increasing yield trend in the 1990s and that these yields should be de-trended under any future analysis.

Figure A4.11. Lagos(Ikeja): WRSI Calculated Yield Potential 1981 to 2010 (Kg/Ha)



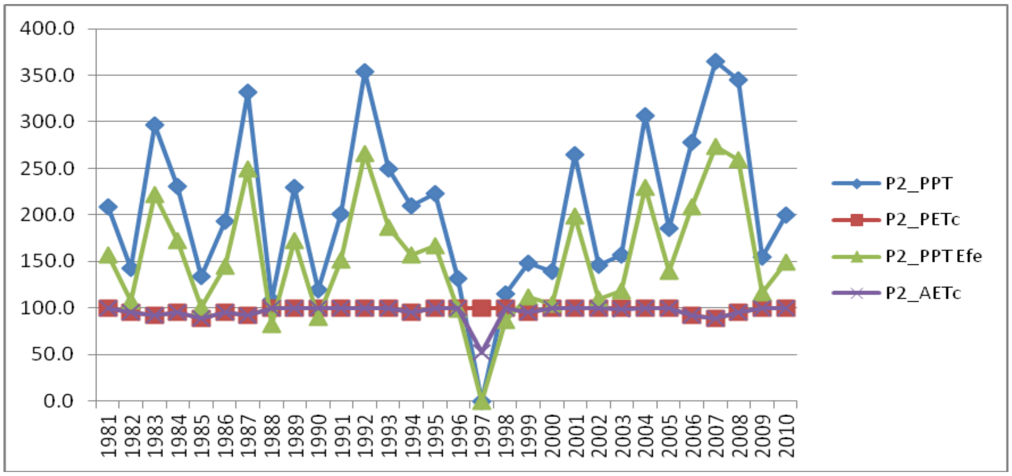
Source: Authors

Figure A4.12. Lagos (Ikeja): Comparison of WRSI Calculated Maize Yield Potential with Actual average state-level Maize Yields



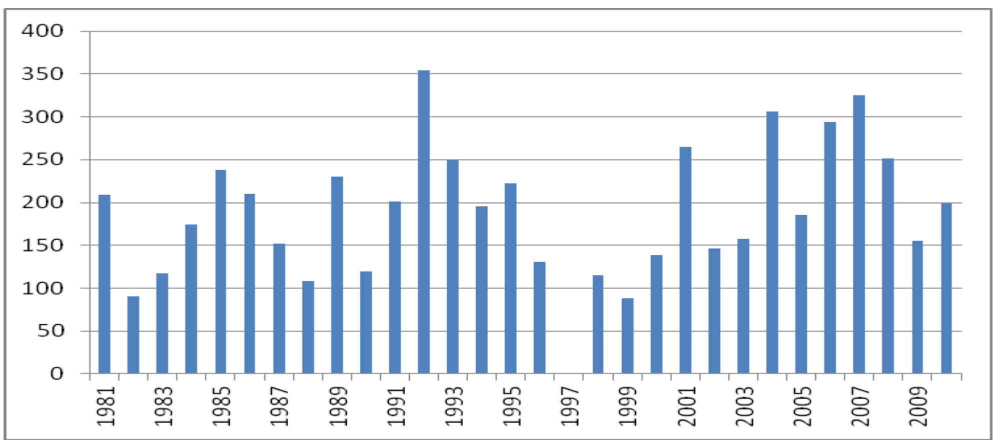
Source: Authors

Figure A4.13. Lagos (Ikeja): Phase 2 Maize Contract: comparison of Actual Precipitation (PPT) with Effective Precipitation (PPT Efe), Potential Evapotranspiration (PETc) and Actual Potential Evapotranspiration (AETc)



Source: Authors

Figure A4.14. Lagos – Ikeja Total May Rainfall 1981 to 2010



Source: NIMET Lagos-Ikeja Rainfall Data

4.7. Rainfall-Deficit Cover for Rice grown in Kaduna State

Rice production systems in Kaduna State

Rice is produced in all the LGAs in Kaduna State as upland rice and lowland rice in valley bottom soils (Fadama). Rice production in Kaduna State is mainly under rainfed conditions as upland and lowland rice cultivation. The lowland rice is grown on lowlands and river valleys that are liable to flooding later during the rainy season. The lowland areas are capable of retaining water after the rains have stopped to extend the period of water available for rice growth and development, hence their extensive use for rice cultivation. The Lere zone also produce rice but less in quantity compared with other zones because of its location in the north which is less humid compared to the central and southern zones of Kaduna state. The improvement in rice production is attributed to increase in cultivated lands, especially for lowland rice production and provision of improved rice varieties, agricultural inputs and extension services.

For Upland rice, the soil must be properly tilled and harrowed to create a uniform terrain before the main rainy season starts. Rice is sown on flat lands after the establishment of rains.
In Lowland rice cultivation, the fields are ploughed manually or mechanically after the first rain and then harrowed and puddled to kill weeds. The use of systemic herbicide (e.g. Glyphosate) can be used to achieve this aim, if done before land preparation. Lowland rice farmers build bunds around the field to retain water and create easy access to the field. The bunds also allows for efficient water management of the rice field.

Issues of Designing Rainfall Deficit Insurance Covers for Rice

A rainfall deficit insurance cover only works with crops which are rainfed and where the plant moisture received by the crop is only supplied by rainfall which can be measured at the nearby weather station. In Kaduna state Nigeria this applies to upland rice cultivation. Much of the rice crop in Kaduna (and other rice growing states) is, however, produced in valley bottoms (Fadama) and where rainfall is supplemented by run-off water or by irrigation and the rice crop is grown under puddled conditions with a lamina of water covering the soil and the rice roots. **WRSI cannot be used effectively to design a rainfall deficit contract for lowland rice**.

In spite of these reservations, an attempt has been made to model a three-phase rainfall deficit WII cover for upland rice grown in Kaduna state. The contract parameters are summarised in Table A4.3 using the World Bank teams' experience with rice Rainfall indexes in other parts of the World. The production costs parameters are again based on the World Bank's estimates because the gross margin production cost estimates provided by ICEED appear to be far to be high to be rice produced under farmer's conditions.

Table A4.3. Kaduna: Rice Rainfall Deficit Index Insurance Contract Parameters

State / Weather Station	**Kaduna**
Insured Crop: (Upland Rice)	Rice
Contract Parameter	
Failed Sowing Trigger (mm)	25
Phase 1 Trigger (mm)	70
Phase 2 Trigger (mm)	140
Phase 3 Trigger (mm)	135
Phase 1 Exit (mm)	45
Phase 2 Exit (mm)	80
Phase 3 Exit (mm)	70
Failed Sowing Payout (Naira)	40,000
Phase 1 Max Payout (Naira)	40,000
Phase 2 Max Payout (Naira)	50,000
Phase 3 Max Payout (Naira)	67,000
Phase 1 Payout Rate (Naira/mm)	1,600
Phase 2 Payout Rate (Naira/mm)	833
Phase 3 Payout Rate (Naira/mm)	1031
Contract Maximum Payout (Naira)	100,000

Source: World Bank

The modelled results for the 30 years of data for the Kaduna Rice-Rainfall deficit contract shows three small phase 1 germination payouts in 1982, 1992 and again in 2006 and then another small Phase 2 vegetative state and flowering in rice payout in 1994. The payouts in all 4 years are tiny and the estimated pure loss cost rate if only 0.6% over the 30 years period. (Figure A4.15). Also there is no corresponding income loss which reduced the validity of these payout results.

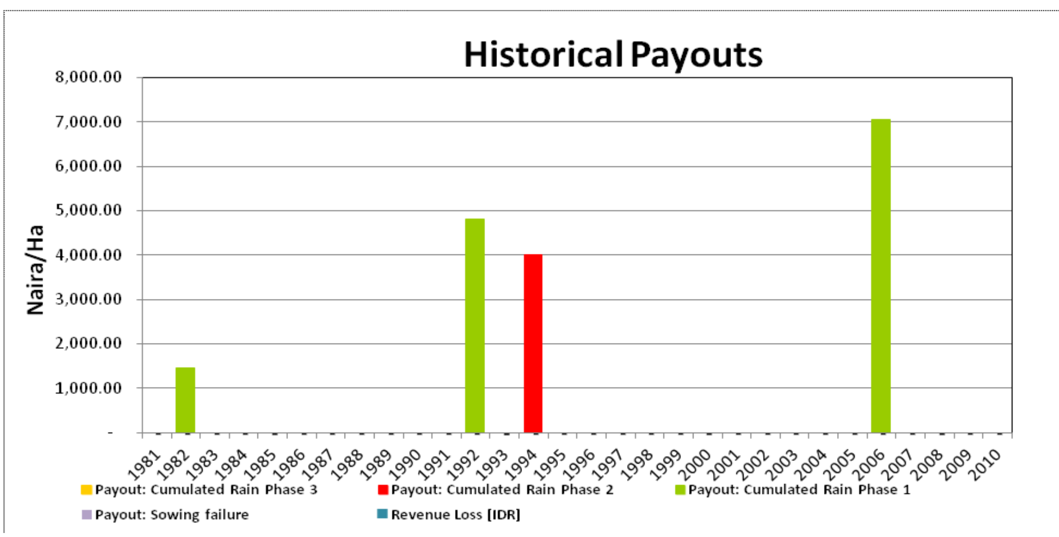
The instability of the Kaduna rice model is, however, demonstrated by the fact that if the Phase 1 contract trigger is slightly reduced from 70 mm rainfall to 65 mm rainfall and the Phase 2 contract trigger reduced from 140 mm rainfall to 135 mm rainfall, then all four payouts disappear altogether

The seasonal rainfall and rice yields from 1994 to 2010 do not shown any correlation, save for small negative correlations implying too much rainfall leads to reductions in rice yields. This is a similar finding to other parts of West African including Ghana (GIZ 2010). The lack of correlation of rice yields is not unexpected given the fact that Kaduna is a very large state with nearly 150,000 Ha of upland and lowland rice and the state yields may be totally un-representative of yields in the vicinity of Kaduna NIMET synoptic weather station.

Reference to Figure 4.16 shows the difficulties of trying to relate the WRSI modelled maize yields at Kaduna airport station to the actual reported state-level maize yields from 1994 to 2009. The reported average rice yields for the period 1994 to 1996 of more than 3,000 Kg/Ha appear unrealistically high: the reasons for the slump in average yields to slightly above 2,000 Kg/Ha from 1997 to 2001 is not known, since when average state-level yields have been very consistent at about 2,500 Kg/Ha up to 2009.

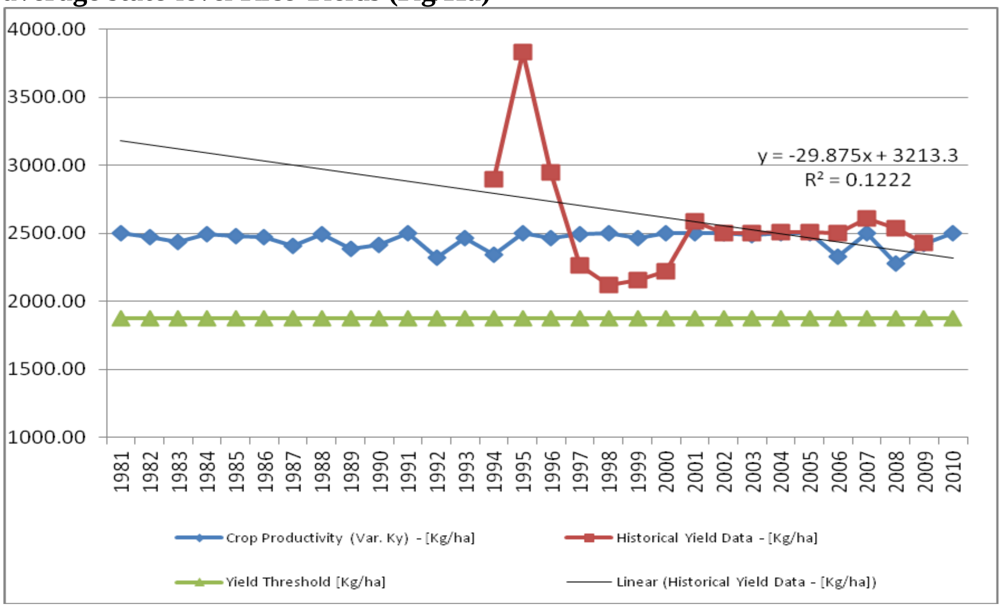
The conclusions to this preliminary analysis are that the ARMT modified WRSI model is not very well suited to rainfall deficit in rice and that in the absence of location specific rice production and yield data it is not possible to properly test and calibrate a rainfall deficit contract for this station.

Figure A4.15. Kaduna Rice Rainfall Deficit Model, Estimated Payouts



Source: Authors

Figure A4.16. Kaduna: Comparison of WRSI Calculated Rice Yield Potential with Actual average state-level Rice Yields (Kg/Ha)



Source: Authors

4.8 Excess Rainfall Index Cover in Maize in Nigeria

International experience with excess rainfall indexes for crop insurance

Since the earliest introduction in India of the 3-phase rainfall deficit WII product in 2003 in India there has been a proliferation of similar rainfall deficit WII programs for individual farmers in other parts of Asia, Africa and Central America (See IFAD & WFP 2010 for a good up to date review of these programs). It is noticeable, however, that most of these WII crop insurance programs are restricted to rainfall deficit (drought) in crops and few programs have yet to develop similar products to protect against excess rain.

Countries that are currently offering excess rain cover include most notably India where both the public sector insurer AIC and ICICI Lombard offer excess humidity and excess rain on some of their composite rainfall deficit plus additional peril crop WII policies: in India some policies use a **daily rainfall excess rainfall threshold of 50 mm rainfall** or more to trigger excess rainfall payouts while also AIC offers a **cumulative excess rainfall** and cumulative deficit rainfall cover for the kharif season crops from July to September . In Thailand Sompo Japan Insurance Company has since 2009 been piloting a combined rainfall deficit (drought) and too much rain (excess rain) WII policy for rice farmers. The underlying basis of the excess rain trigger is understood to be based on the cumulative amount of rainfall in a defined time period rather than a single event trigger of xx mm in a 24 hour period. In Central America (Nicaragua) there is pilot rice WII insurance scheme which has been implemented since 2006 and which offers a combination of rainfall deficit and excess rainfall cover. **In Nicaragua the excess rainfall triggers are based on the cumulative amount of rainfall in each vegetative growth stage / contract phase of the crop** and the basis of this model is examined below for Nigeria. In Africa, the authors are aware of only one pilot initiative for small maize farmers in northern Ghana which uses a "**number of days continuous rainfall index** " (where a rainy day is defined as a day on which more than 1.5 mm of rainfall), to trigger excess rainfall claims[52]. In Ghana the maize rainfall deficit and excess rain contract was offered by Innovations for Poverty Action (IPA) between 2009 and 2010 and in August 2010 paid out excess rainfall leading to flood claims to maize farmers. The authors are not aware of any other micro-level individual farmer excess rainfall contracts which are being commercially implemented in Africa.

Key Issues for Insuring Excess Rain in Crops

Drought or plant moisture deficit is a continuous peril and which in many crops has a close linear correlation with yield reduction. A carefully designed three phase rainfall deficit program for a crop such as maize can usually demonstrate a high degree of correlation between reduced rainfall and reduced yield.

Conversely the impact of excess rainfall in field row crops (cereals, oilseeds, fibres such as cotton etc) is much more difficult to quantify and measure. **Damage due to excess rain** can take several forms starting with:

v) **direct mechanical or physical damage** to young plants which may be broken or washed away, or if this occurs at the time of harvest, physical damage to the grain and or cotton bolls etc and or

vi) **secondary or consequential losses** including prevention of access to combine harvesters and delayed harvest during which time overripe crops will shed their grain and or lodge and start rotting in the wet soils through to

vii) **prolonged continuous rainfall** over a period of a dekad or more which exceeds the soil water holding capacity will results in soil waterlogging and standing water and if these anaerobic soil conditions persist from more than 2 to 3 days the plants will start to die due their inability to transpire /photosynthesise.

viii) **intense torrential rainfall** events whereby 50mm to 100mm or more of rainfall in 24 hours will lead to direct physical damage to crops according to their growth stage and cause further damage by sheet flow and erosion and by water stagnation and flooding.

The timing of the excess rainfall event in relation to the physiological growth stage of the crop will have major bearing on the amount of damage caused to the crop: for example in cotton a torrential Excess Rainfall event when the crop is in the vegetative stage will cause much less damage than if this occurs at the time of harvest of the cotton when the cotton bolls have burst and the cotton lint is very susceptible to rainfall physical and qualitative damage. In Maize excess rain at the time of sowing may lead to soil erosion and soil capping and germination failure: however, the same excess rain event at vegetative stage when the plants have established a strong root system and are a metre and a half high will have no effect on the crop. Excess rain will have little impact on established wheat and rice crops in the vegetative stage, but excess rain at harvest can be extremely damaging resulting in grain shedding and lodging of the crop and prevention of harvest resulting in the crop rotting.

It is therefore extremely difficult to design an excess rainfall index and to set trigger level which will capture all of the above types of excess rain and the damage that will occur to the crop at different stages of its growth cycle. As such the early generation of excess rainfall

[52] Microensure the international microfinance and microinsurance specialist has been actively providing WII training in the design of simple “number of rainy days” and “number of dry days” rainfall contracts for maize and other crops in various African countries including Ruanda, Uganda, Zimbabwe, South Africa and Ghana.

index products have proved to be very subject to basis risk under which the outcomes as determined by the index at the weather station have little relation to the actual damage incurred in the crops in the neighbouring area.

Excess Rainfall Exposure in selected States of Nigeria

In order to test the relationship between the impact of excess rain on maize and rice production and yields, the available state-level yields (for maize 16 years 1994 to 2009; for rice from 1999 or 2000 to 2009) were correlated with the total number of crop season excess rainfall days per year. The results of this correlation analysis are summarised below in Table A4.4. The number of days excess rainfall correlations for maize are generally higher than for cumulative crop season rainfall and with the exception of Lagos (Ikeja) show a negative correlation between excess rain and maize yields implying that heavy excess rain >50 mm per day is one factor which accounts for yield reduction or loss in maize. In the case of Kaduna the effect of excess rain days on state-level maize yields appears to be very high with a correlation coefficient of -0.75, but when the number of rainfall days and state-level maize yields are graphed this relation is not as clear as indicated by the correlation coefficient (see Figure A4.17). In the case of rice, state-level annual average yields are inversely correlated with the number of excess rain at all four weather stations, but the relationships are very weak for Kaduna and Enugu.

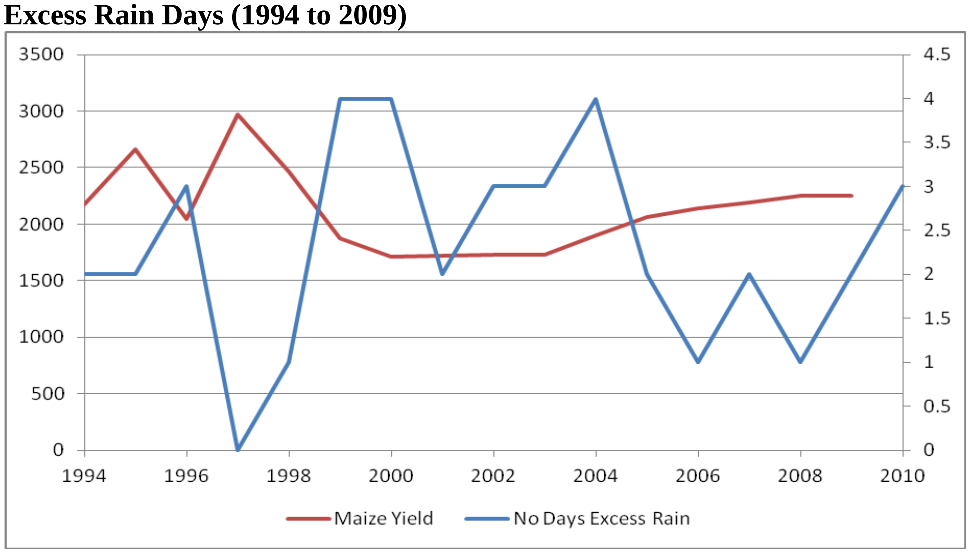
Overall, this analysis suggests that excess rain may be a more important factor affecting maize and rice yields in the selected states that lack of rainfall (drought).

Table A4.4. Correlation between No Days Excess Rainfall (>50 Mm) and State-level Crop Yields

Crop	**Kaduna**	**Cross River**	**Enugu**	**Lagos (Ikeja)**
Maize	-0.75	-0.40	-0.37	0.23
Rice	-0.03	-0.48	-0.08	-0.34

Source: Authors' analysis of NIMET Daily Rainfall data 1981 to 2010

Figure A4.17. Kaduna: Relationship between State-level Maize Yields and Number of Excess Rain Days (1994 to 2009)



Source: Authors

Excess Rainfall Index tested for Maize in Nigeria

The above sections have shown that a **Rainfall Deficit Contract for Maize** performs very badly for the 4 selected weather stations in Nigeria: this is partly due to the relatively stable and high cropping season precipitation in three of the locations and the extremely high precipitation at one station (Calabar, Cross River State), but also due to the lack of location specific information on crop production and yields to enable meaningful causal relationships between timing and amount of rainfall and maize and rice yields to be tested in depth. Conversely the simple correlation analyses between the amount of seasonal rainfall and number of excess rainfall days and maize and rice yields tends to show an inverse relationship between rainfall and yield, suggesting that excess rain leading to standing water and flooding may in fact be a more severe problem in maize and rice production than drought.

It is outside the scope of this study to conduct any flood analyses, but some preliminary research has been conducted into **Excess Rainfall** Contracts for Maize for the 4 selected weather stations - Kaduna, Cross River (Calabar), Enugu and Lagos (Ikeja). On the basis of the knowledge of the World Bank's technical team, however, one of the main limitations is that unlike the FAO-WRSI rainfall-deficit-drought model which is widely applied in different parts of the world, there is no physiological (agronomic) model that adequately captures the effects of excess rainfall on crop production and yields.

In the absence of a specific Excess Rain-yield model, a simple approach has been adopted based on the **amount of cumulative rainfall in each crop physiological growth stage in maize**. As such, The excess rainfall index tested under this study is a 3-phase cumulative excess rainfall index for maize which replicates as closely as possible the rainfall deficit model outlined above for maize.

The contract carries a failed sowing cover either due to deficit rainfall (drought) or due to excess rainfall. For Enugu the sowing window is the 3 dekads between 11 April and 10 May. It is assumed that sowing failure due to drought occurs if the rainfall is less than 25 mm. Sowing failure due to excess rain is defined as more than 135 mm rainfall in a dekad during the sowing window. The payout for failed sowing is Naira 24,000/Ha. (Table A4.6). It is assumed that following a sowing failure event the policy is cancelled. If sowing is successful the cover incepts and this forms the first dekad of Phase 1, germination and establishment phase.

For the operation of the three phase excess rain contract for maize the full 10 dekad growing season including ripening and harvest is included and the Phase lengths have therefore been adjusted to Phase 1, Dekads 1 to 2; Phase 2, Dekads 3 to 6, Phase 3, dekads 7 to 10.

The excess rainfall triggers and exists are defined in terms of the accumulated rainfall in each phase. Given the complexities surrounding excess rainfall damage in crops, the threshold trigger for excess rainfall has been estimated at 90% percentile of the rainfall distribution for each phase and the exit at the 97.5% percentile of the rainfall distribution for each phase. It is recognised that this is a somewhat arbitrary criterion to use to define the trigger point where excess rain damage starts to be serious and the exit point at which it is assumed that the crop will be totally damaged and the maximum payout made. In addition the excess rain triggers and exits have been adjusted based on transferred experience from the Nicaraguan excess rainfall WII schemes. It is stressed that future research and development will be required under Nigerian rainfall, soil type and crop growing conditions to refine these excess rainfall contract triggers and exit points in each phase for maize and rice. The adopted procedure produces admittedly high excess rainfall thresholds for maize grown in Enugu of 325 mm (Phase 1), 530 mm (Phase 2 and 425 mm (Phase 3) against the WRSI calculated water requirements for Enugu maize of 29 mm, 160mm and 151 mm respectively per Phase. (Table A4.6).

The maximum excess rainfall payouts in each phase are the same as those set for the maize-rainfall deficit contracts and the overall contract payout in any one insurance period is also the same at Naira 60,000. In each phase a liner payout rate (tick) has been applied per mm of rainfall (Table A4.5.).

Table A4.5. ENUGU: Excess Rainfall Contract for Maize: Contract Parameters

State / Weather Station	**Enugu**
Insured Crop: (Upland Rice)	Maize
Contract Parameter	
Failed Sowing Trigger Drought (mm)	25
Failed Sowing Trigger Excess Rain (mm)	130
Phase 1 Trigger (mm)	315
Phase 2 Trigger (mm)	530
Phase 3 Trigger (mm)	425
Phase 1 Exit (mm)	340
Phase 2 Exit (mm)	565
Phase 3 Exit (mm)	445
Failed Sowing Payout (Naira)	40,000
Phase 1 Max Payout (Naira)	40,000
Phase 2 Max Payout (Naira)	50,000
Phase 3 Max Payout (Naira)	67,000
Phase 1 Payout Rate (Naira/mm)	960
Phase 2 Payout Rate (Naira/mm)	857
Phase 3 Payout Rate (Naira/mm)	2000
Contract Maximum Payout (Naira)	60,000

Source: Authors

Excess Rainfall Contract Payout Results for Enugu Maize

The modelled results for Enugu are shown in Figure A4.18. Over the 30-year period 1981 to 2010 there would have been a total of 5 modelled contract payouts relating to excess rain or a frequency of 1 payout in every 6 years. To begin with there would have been a **sowing failure** payout in 2001 due to the very high rainfall in the first dekad of 171 mm or considerably above the 135 trigger threshold resulting in an indemnity of Naira 24,000. This is followed by one full Phase 1 **Germination failure** payout of Naira 24,000 in 1997, one Phase 2, **Vegetative stage** maximum payout of Naira 30,000 and finally two Phase 3 **flowering and yield formation** excess rain payouts in payouts in 1984 and again in 1995 when a maximum payout would have been made. The average pure loss cost or burning rate is 8.6% for this example.

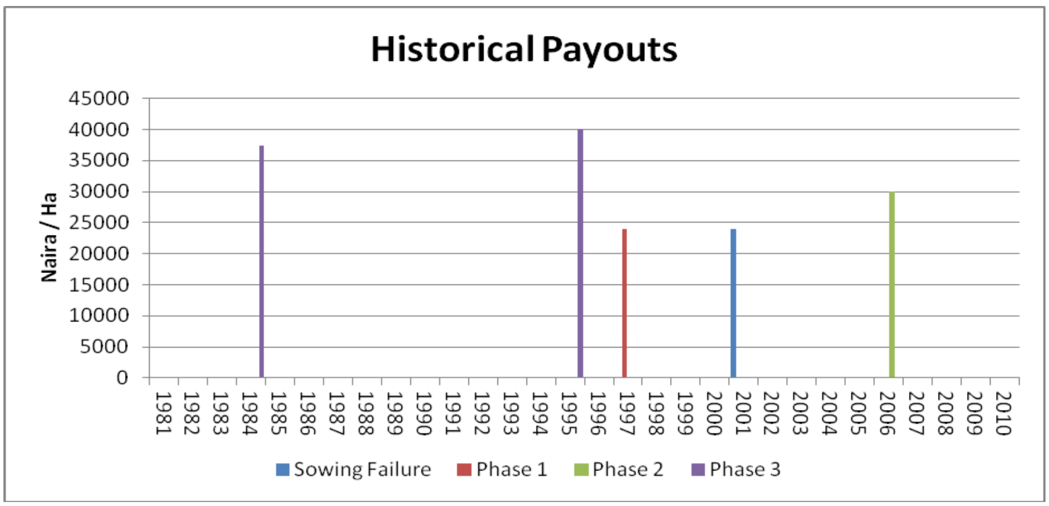
Similar modelled results are obtained for the excess rain contracts for maize in Kaduna, Cross River (Calabar) Lagos (Ikeja) namely a high number of modelled excess rainfall claims based on the accumulated per phase rainfall data.

The major drawback of this excess rainfall analysis for Enugu maize is that there is (1) no correlation at all between the cumulative excess rainfall payouts and the WRSI calculated optimal yields over the 30 year period and (2) there is no correlation between excess rain payouts and the actual state-level time-series yields for maize grown in Enugu from 1994 to 2010. In other words, if one were to offer a three-phase cumulative excess rainfall cover in Enugu, it is possible that the payouts triggered by the rainfall index may have no correlation whatsoever, with maize crop yield and revenue losses on the ground. (Figure 4.19).

Similar modelled results are obtained for the excess rain contracts for maize in Kaduna, Cross River (Calabar) Lagos (Ikeja) namely, a high number of modelled excess rainfall claims in each of the phases based on the accumulated per phase rainfall data. However, the modelled results are not deemed safe to recommend the design of maize excess rainfall contracts on this basis.

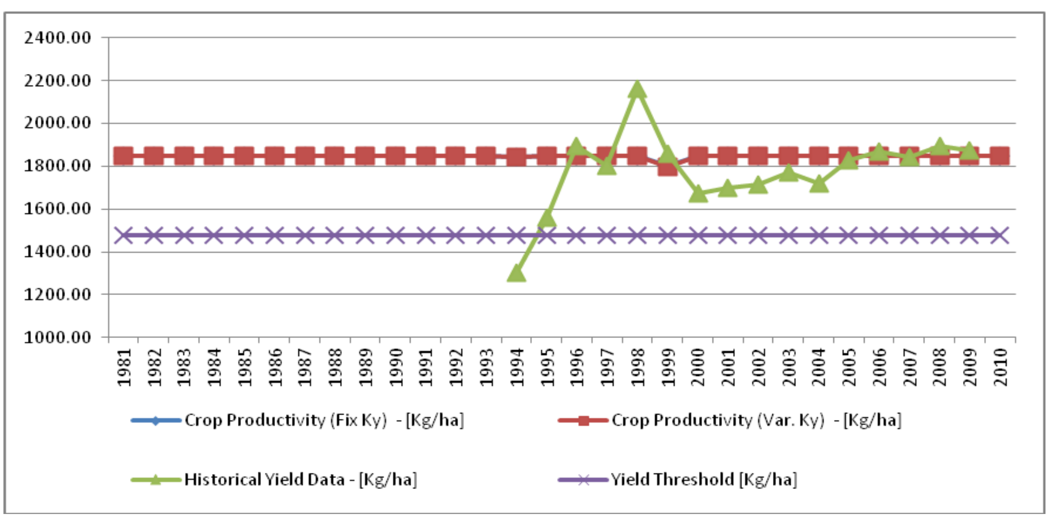
The finding that excess rain events as measured by rainfall exceeding 50 mm in a 24 hour period are very frequent during the growing season suggests that future research should be conducted using this definition of excess rain either in conjunction with a cumulative rainfall contract or by itself.

Figure A4.18. Enugu Maize: Cumulative per Phase Excess Rainfall Contract Payouts



Source: Authors

Figure A4.19. Enugu Maize: relationship between WRSI calculated yield potential for maize and actual state-level annual yields maize.



Source: Authors

4.9. Pricing of Weather Index Insurance Contracts

In general the premium charged for a weather index contract can be broken down as follows:

Original Gross Premium = Expected Loss + Risk Margin + Administrative Costs

A detailed description of the issues and methods for pricing weather index insurance contracts is included as Module 7 of the ARMT-IRI WII Training modules and can be downloaded from the FARMD website as noted in the introduction to this annex. The World Bank's pricing methodology is termed the "Return on Risk" (ROR) approach to WII pricing.

The expected loss is calculated as the pure loss cost rate and which may be based on historical burning cost data only, for example for the 30 years of rainfall data which has been modelled for Nigeria. Alternatively monte-carlo simulation may also be employed to extend the analysis of the average loss cost to any number of specified iterations – for example 10,000 iterations (years).

According to the level of confidence the contract designer has in the underlying weather data, including factors such as the number of years and percentage missing data, standard procedures are outlined in the World Bank training materials to adjust the expected loss by fitting confidence limits to the estimated parameter (the average loss cost) and correcting the number of year's data for missing values. The output is termed the Adjusted Expected Loss (AEL).

For the purposes of adding a security margin to cover both infrequent, but potentially catastrophe weather event years a standard procedure is to calculate the 1 in 100 year expected probable maximum loss (again using monte carlo simulation) and according to the risk carrier's (underwriter's) perception of risk and his required rate of return to accept this risk, a percentage of the PML value is then taken as a security load. It is also fairly common for underwriters to accept the security load as a contribution to their expected profit margin

The technical rate is defined by: Technical Rate = AEL + Security Load

As a guideline, the final technical rate after addition of the security load may often be double the average pure loss cost rate.

In order to derive the final commercial premium rate (or Original Gross Premium rate), underwriters will gross-up the Technical Rate by their A&O (acquisition and own operating costs) which include brokerage and the companies fixed and variable expenses for administering the WII business. A&0 expenses will commonly add between 25% and 35% percentage points to the Technical Premium rates. If local taxes such as insurance stamp duty and VAT (Value Added Tax) are levied on crop insurance, then the A&O loadings will be correspondingly higher.

Given the very poor fit of the maize and rice rainfall deficit contracts modelled for the selected stations in Nigeria, it is not appropriate to calculate illustrative commercial premium rates applying to these rainfall deficit prototype contracts. Local interest groups should, however, be very aware that rainfall deficit WII contracts commonly cost at least 7.5% to 10% and premium rates of 15% and more my apply in high drought risk situations.

Appendix 4.1: Note on WRSI Model

The FAO Water Requirement Satisfaction Index (WRSI) establishes how production of a crop grown in a microclimate can be indexed to rainfall amount and distribution. A description follows of the WRSI model and its inputs and assumptions.

Model Description

The pilot project uses the USGS/FEWS-NET WRSI[53] model, a modified version of the FAO WRSI[54] to index maize crop yield and therefore production to rainfall variability in each state in Nigeria. A well-timed water supply is necessary for optimum maize production. WRSI is an indicator of crop performance based on water availability during the growing season, calculated using a crop water balance model. Studies by FAO have shown that WRSI can be related to crop production using a linear yield-reduction function specific to the crop in question[55]. WRSI is defined as the ratio of seasonal actual evapotranspiration experienced by a crop to the crop's seasonal water requirement; hence it monitors water deficits throughout the growing season, taking into account the phenological stages of a crop's evolution and the periods when water is most critical to growth. The WRSI model was initially developed for use with weather station data to monitor the supply and demand of water for a rain-fed crop during the growing season. The model currently is used by FEWS-NET as one of the operational remote-sensing products to monitor agricultural areas around the world for signs of drought on a near-real-time, spatial and continuous basis using a combination of satellite-derivative rainfall estimates and rain-gauge data from the GTS to compute WRSI values.[56] There are many more robust and data-intensive physically-based crop models available, but FEWS-NET adapted the FAO WRSI model for geospatial implementation in 2002[57] because of its limited data requirements and simplicity in operational use and made it an operational model, with some modifications in the algorithm.[58] This project therefore also chose the WRSI model, which has been successfully tested against ground crop production data for Africa, including Ethiopia, to monitor crop performance.[59]

Model Inputs and Assumptions

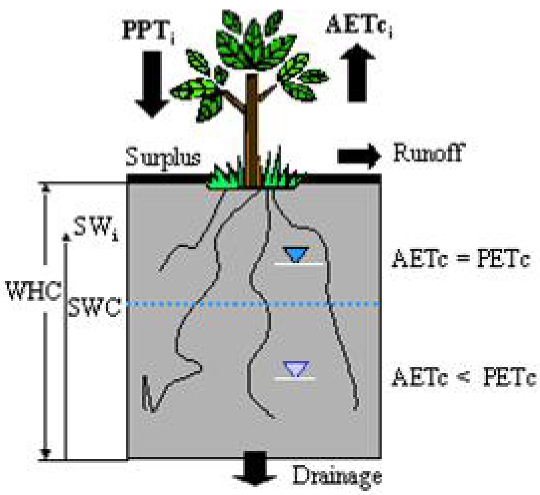
The inputs and data sources required to calibrate the WRSI model for a weather station and for maize in Nigeria during a growing season are illustrated in Figure A4.12. and include:

- Cumulative dekadal rainfall (PPT in mm) for a weather station for as many years as are available (Source: data available from NIMET Accra);
- Average dekadal potential evapo-transpiration (PET) (mm) for the station (Source: NIMET Accra);

[53] Senay and Verdin 2003.
[54] Frere and Popov, 1986.
[55] FAO. 1986.
[56] Senay and Verdin, 2003.
[57] Verdin and Klaver, 2002.
[58] Senay and Verdin, 2003.
[59] Ibid. This paper gives an exhaustive description of the WRSI model and the inputs required to run the water-balance calculation.

- The water-holding capacity (WHC) (mm) of the soil in the cultivated area surrounding the station that falls within the same micro-climate as the station (Source: local consultants, ICEED);
- Crop coefficients (Kc) for maize; Kc values define the water-use pattern and are defined for each of the critical phenological points of a crop's evolution; they are linearly interpolated between these points during each phonological stage during the growing season (Source: FAO[60],);
- Maximum crop root depth (m) and the allowable depletion fraction (Source: FAO[61]); and
- Seasonal yield-response factors (Ky) for each crop to convert WRSI values to yield estimates (Source: FAO[62],).

Figure A4.12. Factors affecting Water Demand and Supply for Plant Growth and which are included in the WRSI Model



The WRSI calculation requires start-of-season (SOS) and end-of-season (EOS) times and hence the length of growing period (LGP) for each crop considered and a potential sowing window for a crop. The LPG for maize grown in Nigeria varies according to the different varieties used in each state, but as commonly grown maize varieties are 100 day LPG varieties, or 10 dekads, this figure has been used for maize in the four states (Kaduna, Cross River Enugu and Lagos). . The SOS dekad must be based on an objective and consistent criterion for identifying the sowing dekad – the time during the potential sowing window when farmers choose to sow. There are several rainfall-accounting methods for identifying the SOS;[63] the method chosen for this model was the first dekad in the sowing window where the ratio of cumulative rainfall recorded in PET is greater than 50 percent; once this ratio exceeds 50 percent, the soil favours germination.[64]

This method usually corresponds to the first dekad in which cumulative rainfall exceeds 25 mm, a trigger often used in other rainfall accounting methods; however the criterion is less restrictive because it does not require a second criterion[65] and is therefore simpler to implement. The sowing windows for maize in Nigeria were confirmed for each state by the local consultants and are

[60] FAO. 1998.
[61] Ibid.
[62] FAO. 1986.
[63] Senay and Verdin. 2003; Hunde *et al.*, 2000.
[64] Senay, G. Personal communication. 1 June 2005.
[65] See for example Senay and Verdin, 2003.

shown in Table Ax.1. If no SOS condition is met during the potential sowing window, it is expected that farmers would not have planted, or would have unsuccessfully planted maize.

Model Outputs

WRSI can be related to crop production or yield estimate by using the following linear yield-reduction function:[66]

$$\text{Actual Yield} = 1 - (1 - \text{WRSI}) * \text{Seasonal Ky} * \text{Maximum Potential Yield} \quad (4)$$

It is often assumed that if WRSI < 50 percent at the end of the growing season, a crop has failed,[67] giving a non-linear relationship between WRSI and yield estimates.

The beauty of using a model such as the WRSI is that as it only uses rainfall as a variable input parameter – it is the only non-constant parameter in the system. Therefore when looking over several rainfall seasons, by using historical rainfall data from the 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, technological changes and pest attacks. These other risks 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. By considering the variations in WRSI 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 design of weather insurance contracts.

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[66] FAO. 1986.
[67] Senay and Verdin, 2003.

Map of Nigeria showing the 36 States + Federal Capital Territory