Chaco Province, Argentina

Feasibility Study for the Design and Implementation of Cotton Index Insurance

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The report was prepared by the World Bank in collaboration with the Agricultural Risk Office – Ministry of Agriculture, Livestock, and Fisheries, Argentina (ORA-MAGyP) and was authored by a team led by Diego Arias (Senior Agricultural Economist, LCSAR, The World Bank, Task Team leader), Peter Wrede (Senior Insurance Specialist, FCMNB The World Bank), Pablo Valdivia (Agricultural Insurance Specialist, LCSAR, The World Bank), Charles Stutley (Agricultural Insurance Specialist, Consultant), and Darío Bacchini (Actuarial and Rating Specialist, Consultant). The ORA-MAGyP team was comprised of Sandra Ochiuzzi (Coordinator, ORA-MAGyP) and Daniel Míguez (Insurance Expert, ORA-MAGyP).

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ABBREVIATIONS AND ACRONYMS

APA	Provincial Water Administration, Chaco Province (*Administración Provincial del Agua, Provincia del Chaco)*
AYII	Area Yield Index Insurance
CONES	Economic and Social Council of the Province of Chaco
CREA	Regional Consortiums for Agricultural Crop and Livestock Experimentation (*Consorcios Regionales de Experimentación Agropecuaria*)
DdA/MPCh	Cotton Department – Ministry of Production and the Environment of the Province of Chaco
ENSO	El Niño Southern Oscillation
GNPI	Gross Net Premium Income
GoA	Government of Argentina
GoC	Government of Chaco Province
IBGE	Brazilian Institute of Geography and Economy
IDB	Inter-American Development Bank
IFAD	International Fund for Agricultural Development
INTA	National Institute of Agricultural Technology (*Instituto Nacional de Tecnología Agropecuaria*)
MAGyP	Ministry of Agriculture, Livestock and Fisheries
MPCh	Ministry of Production and the Environment of the Province of Chaco
MPCI	Multiple Peril Crop Insurance
NOAA	National Oceanic and. Atmospheric Administration
ORA	Agricultural Risk Office (*Oficina de Riesgo Agropecuario*)
PAC	Chaco Agricultural Producers (*Productores Agrícolas Chaqueños)*
PML	Probable Maximum Loss
PRODAF	Program for Agriculture and Rural and Family Development (*Programa de Apoyo al Desarollo Rural y Familiar*)
PTTS	Seed Exchange Program (*Programa Troca Troca de Sementes)*
SSN	Superintendent of Insurance of the Nation (*Superintendencia de Seguros de la Nación*)
TSI	Total Sum Insured
WFP	World Food Programme
WII	Weather Index Insurance

Executive Summary

1. ***This report presents the findings and recommendations of the feasibility study for a macro-level index insurance program for the Provincial Government of Chaco (GoC) as part of its natural-disaster risk management strategies for cotton growers located throughout the 25 Departments of the Province.*** Two index options were reviewed under this study starting with a macro-level rainfall deficit and excess rainfall cover based on individual rainfall weather stations in Chaco Province, but as the rainfall index prototypes modeled produced very poor correlations with departmental average yields of cotton, this option was deemed inappropriate as a risk transfer instrument for Government of Chaco (GoC). The second index product analyzed was a macro-level Area Yield Index Insurance (AYII) cover which uses, as the basis of insurance and indemnity, the Departmental average yield of raw cotton and which was designed to protect the GoC's and/or lending institutions' financial exposure to severe climate related cotton production and yield shortfall. This product appears to show potential for implementation for cotton grown in Chaco province, but further technical and operational design work will be required in 2013 before this AYII product could be launched.

Background and Objectives of the World Bank Index Insurance Study for Cotton in Chaco Province

2. ***In 2011, the Government of Argentina through the Ministry of Agriculture, Livestock and Fisheries (MAGyP), requested the World Bank to conduct a feasibility study for the development of a suitable index-based agricultural insurance product to protect cotton producers located in Chaco Province against severe drought and excess rainfall (leading to flooding) losses in their cotton crops.*** The main objectives of this study were to assist the Agricultural Risk Office (ORA-MAGyP) in the design and rating and implementation planning of an appropriate rainfall index-based insurance product and program for small and medium cotton producers (classified as those farmers with between 10 Ha and 100 Ha of cotton); to advise on the organizational, operational and financial requirements of the cotton insurance program and where appropriate to provide capacity building and support on index insurance to the Superintendent of Insurance of the Nation (SSN) and interested insurance companies.

3. ***During the final May 2013 Mission the Ministry of Production of the Province of Chaco (MPCh) presented firm proposals for a cotton technical assistance and credit project, the "Program of Assistance for Rural Agricultural and Family Development", PRODAF, and made a specific request for the World Bank to assist GoC-MPCh to place its cotton insurance requirements.*** PRODAF is a four year (2013/14 to 2016/17) cotton project targeted at small and marginal farmers with between 60 and 150 Ha of cotton which aims to increase cotton production and yields and farmers' incomes through a combination of technical and financial assistance. The project is expected to reach a maximum of 67,500 Ha at full scale implementation and is funded by the Inter-American Development Bank (IDB) with total funding of US$ 11 million.

4. ***GoC-MPCh have specifically requested the World Bank to assist them to obtain suitable crop insurance protection to cover the credit exposure under the PRODAF program through the Area-Yield Index Insurance (AYII)*** product that has been designed by the World Bank-ORA team over the past year. Currently in the 2012/13 cropping season no public or private insurer in Argentina has been willing to offer individual farmer Multiple-Peril Crop Insurance (MPCI) for cotton grown in Chaco because they regard this crop as being too exposed to drought

and or excess rain and flood losses. The AYII product is therefore the only option currently open for consideration. The AYII proposals were presented by ORA-World Bank at final meetings with the leading insurance companies on 31 May 2013 and the reactions so far have been very positive. There is, however, much work that has to be carried out before this AYII product could be launched as an insurance program linked to the PRODAF project for small and medium cotton producers in Chaco Province.

Climatic Risk Exposures to Cotton Production in Chaco Province and Risk Transfer Experience

5. ***Chaco Province is the most important cotton producing area in Argentina.*** Over the past 5 years (2006/07 to 2010/11), the total annual average sown area of cotton in Argentina has been 424,667 Ha of which Chaco Province has accounted for an average of 279,038 Ha or 66% of total sown cotton area, 53% of average raw cotton production and 52% of the total value of cotton fiber production (CONES 2012).

6. ***Cotton is grown throughout the province and is an important cash crop for small and medium farmers***. According to 2002 National Agricultural Census data, at the time there were approximately 18,000 cotton producers in Chaco Province of which the very smallest group of Minifundists cultivating less than 10 Ha, accounted for 60% of all cotton producers, but only 9% of the total cultivated area of cotton in the province. This was followed by small and medium semi-commercial farmers cultivating between 10 Ha and 100 Ha of cotton who comprised about 34% of all cotton producers and who cultivated about 41% of the cultivated area of cotton and finally large farmers cultivating more than 100 Ha of cotton who accounted for 6% only of farmers, but for 50% of all cotton production in the province. Up to date statistics suggest that the total number of cotton producers in Chaco Province is much lower today: according to MPCh 2012 data there are about 1,046 small and medium cotton producers with between 10 Ha and 100 Ha of cotton, cultivating an average of about 77 Ha of cotton.

7. ***Cotton production in Chaco Province is very exposed to climatic and biological perils***. Chaco Province experiences extremes of weather which are usually related to the El Nino Southern Oscillation (ENSO) phenomenon which brings acute drought or excess rain and flooding. In the past thirty years there have been several major flood and extreme drought losses (Chapter 2 provides a list of those major natural events that have impacted the cotton sector). In addition the Argentinean cotton crop has been severely affected by cotton boll weevil since it spread from Brazil and Paraguay in the early 1990s.

8. ***The Federal government cotton production statistics for Chaco Province suggest that over the past 41 years an annual average area of 20,174 Ha of cotton or 6.5% of the total sown cotton area has been lost each year due to climatic and other perils with an estimated value of losses at 2012 cotton prices in the order of AR$ 50 million (US$ 10 million)***[1] ***per year.*** In major loss years such as 1997/98 when an estimated 205,000 Ha of the cotton crop was lost due to excess rain and flooding, the value of losses at current prices would be a huge AR$ 513 million (US$ 103 million). These losses suggest there is an important need to design appropriate risk transfer / crop insurance products to manage the flood and or drought risk exposure.

9. ***Argentina has a lengthy history of private sector crop insurance, but to date no company has successfully underwritten cotton grown in Chaco Province***. Argentina has a

[1] This simple calculation assumes an average gross revenue or sale value for cotton of AR$ 2,500/Ha or US$ 500/Ha

lengthy tradition of private sector crop hail insurance: however, the hail exposure is very limited in Chaco Province and rather there is a major exposure to drought and excess rain and flood losses and which calls for a loss of yield-based multiple peril crop insurance program. On various occasions in the past the private commercial insurers have attempted to introduce an individual grower Multiple Peril Crop Insurance (MPCI) which provides loss of yield all risk cover, to medium and large cotton producers in Chaco Province. None of these voluntary individual farmer cotton insurance initiatives have been successful and most of the companies have withdrawn their products after one or two years on account of high underwriting losses: typically the companies have faced severe adverse selection and moral hazard and lack of insurance demand and uptake to generate an adequate volume of premium and spread of risk to be sustainable.

10. ***The Government of Chaco (GoC) has in recent years actively supported the introduction of cotton insurance in Chaco Province, but again with limited success.*** Since 2008/09 GoC has provided premium subsidy support to an individual grower MCPI crop insurance program linked to a cotton-credit (Fideicomiso Chaco Produce Algodón) program which is implemented by the Coordination and Evaluation Financing Unit (UCEF). This program operated up to 2011/12 with very poor underwriting results, following which no Argentinean public or private crop insurers has agreed to renew the individual grower cotton MPCI program in 2012/13. In addition, in 2009/10 GoC-MPCh contracted an excess rainfall and drought index insurance cover for cotton which operated for one year and which was claims free.

11. ***In view of these difficulties, in 2011 ORA-MAGyP approached the World Bank with a request for technical assistance to conduct a review and assessment of possible alternative risk transfer / insurance options for cotton grown in Chaco Province***. From the outset, it was agreed that the World Bank would not try to replicate the individual grower MPCI products that the local Argentinean insurers have unsuccessfully tried to introduce for cotton in recent years. Rather, it was agreed that the World Bank would conduct a Feasibility Study into the design of a macro-level rainfall index cover that would be offered to GoC to protect its financial loans for the purchase of seed/fertilizers and pesticides.

Main Findings of the Rainfall Index Insurance Feasibility Study

12. ***For the purposes of the macro-level excess rainfall and rainfall deficit (drought) index insurance covers for cotton that were analyzed under this study time series rainfall data were obtained for 25 Provincial weather stations located in the 25 cotton producing Departments of Chaco Province.*** The ORA-World Bank team tested two types of rainfall index cover for cotton***:*** (i) a cumulative rainfall index (covering either excess rainfall, or rainfall deficit-drought) in millimeters during four different cotton vegetative growth stages; and (ii) a number of consecutive days drought[2] cover during each of the four crop growth stages. In both cases, the total length of the cotton crop cycle (or Cover Period) was assumed to be 120 days (in accordance with the widely sown short-duration GM varieties in Chaco province) divided into four stages: stage 1 comprises 20 days or 2 dekads; stage 2 comprises 30 days or 3 dekads; stage 3 comprises 30 days or 3 dekads; and finally, stage 4 comprises 40 days of 4 dekads. The Sum Insured was set at a revenue based valuation of AR$2,200 per hectare. For the purposes of this analysis, the maximum liability was related to the cumulative production cost at the end of each crop growth stage.

[2] Due to the characteristic high spatial rainfall variability in Chaco Province, the World Bank considered that defining an excess rainfall cover based on the count of consecutive rainy days in which each day the rainfall amount exceeds a predefined threshold would not add any value. Therefore, such type of cover was not included as part of the analysis.

13. ***For both rainfall index covers modeled (i) cumulative excess rainfall and rainfall deficit and (ii) number of consecutive days rainfall deficit (dry days), the analysis showed a very poor correlation between Departmental yield data and modeled annual loss values and index payouts.*** In the case of the 4-vegetative growth stage Cumulative Rainfall Deficit (drought) index there was an extremely poor correlation for all weather stations between the cumulative rainfall deficit index and the departmental annual average yields of raw cotton over the 31 year reference period (1979/80 to 2009/10). The correlation coefficients ranged from +12.6% at La Clotilde Weather Station (WS) through to -31.7% Corzuela WS, General Belgrano Department. The inverse relationship at many stations implies that as rainfall decreases, raw yields of cotton actually increase. The 4-stage Cumulative Excess Rainfall Index showed more consistent correlations with raw cotton yields than the cumulative drought index. In nearly all weather stations the correlation between cumulative excess rain and yields was inverse which is to be expected namely, excess rainfall particularly at boll burst and ripening of the cotton crop can be very damaging and lead to significant yield reduction. The correlation coefficients were, however, still far too low (range -15% to -30%) across weather stations to be able to recommend offering a cumulative excess rainfall index contract for cotton grown in each department. Finally the number of Dry Days Rainfall Contract proved to be a very poor predictor of annual average departmental level raw cotton yields.

14. ***The very low correlation found in both rainfall index cover suggest that rainfall is only one of many factors affecting cotton production and yields in the Chaco***; therefore, none of the evaluated rainfall index contracts are a suitable proxy to cover extreme negative yield deviations.

15. ***In conclusion the WII Feasibility Study has shown that the correlation between rainfall (excess rainfall and rainfall deficit) and cotton yields is so low that it is not possible to capture this peril through a Weather Index Insurance (WII) policy.*** The World Bank-ORA-MAGyP team cannot on this basis recommend the use of a rainfall index cover to insure losses in cotton grown in Chaco Province.

Area-Yield Index Insurance (AYII) as an alternative macro-level risk transfer product for GoC to protect its financing of small and medium cotton development projects

16. ***In 2012 when it became evident to the World Bank-ORA team that a macro-level excess rainfall and rainfall deficit WII cover would not work for cotton grown in Chaco Province, it was agreed to consider alternative products namely the possibility of developing AYII cover for the cotton sector***. Due to the budgetary and time restrictions for the Chaco crop index insurance component of this technical assistance project, the additional work on AYII insurance for cotton has been limited to a prefeasibility analysis and the presentation of outline proposals and recommendations. It is stressed that further design work will be required in any pilot implementation phase and this will fall outside the current World Bank feasibility study which is due to be completed by 30 June 2013.

Technical Features of AYII Insurance

17. ***Area-Yield Index Insurance (AYII) represents an alternative approach which aims to overcome many of the drawbacks of traditional MPCI crop insurance***, and which may have

application to the cotton sector in Chaco Province. The key feature of this product is that it does not indemnify crop yield losses at the individual field or grower level. Rather, an Area-Yield-Index product makes compensation payments to growers according to yield loss or shortfall against an average area yield (the index) in a defined geographical area (e.g., county or department). In practice AYII programs typically offer Insured Yield Coverage levels of between a minimum of 50% and a maximum of 90% of the area average yield. Where actual yield falls short of the selected Insured Yield coverage level that has been selected, this physical yield shortfall forms the basis of the payout to all insured farmers in that Department times their individual insured area times the agreed unit sum insured and indemnity value. AYII is a multiple peril insurance cover and therefore protects against a far wider range of perils than a WII cover which typically insures against one (e.g. rainfall deficit - drought) or two perils (e.g. rainfall deficit - drought and temperature) only.

18. ***The main drawback of an AYII policy is "Basis Risk" or the potential difference between the insured area-yield outcome and the actual yields achieved by individual insured farmers within the insured area***. Basis risk arises where an individual grower may incur severe crop yield losses due to a localized peril e.g. hail, or flooding by a nearby river, but because these localized losses do not impact on the department-level average yield, the farmer who has incurred severe crop damage does not receive an indemnity. In addition, basis risk may arise where individual farmer crop production and yields are highly heterogeneous (different) within the same department, which will invalidate using an Area-based approach. Under the proposed AYII program for Chaco Province the ORA-World Bank team have specifically recommended that this product is not marketed as an individual grower (or micro-level) insurance cover because of our concerns over basis risk. Rather the design team has recommended a macro-level AYII cover which would be offered to GoC-MPCh to protect its financial exposures in the PRODAF small and medium cotton producer program: GoC is able to accept a much higher level of basis risk than individual cotton producers.

19. ***In Chaco Province, cotton planted (sown) area, harvested area, cotton production and yield data is collected both by the Federal Government and by the Ministry of Production (MPCh) at a Departmental-level each year, and this forms the Insured Unit for the purposes of the operation of the proposed AYII Policy for cotton.*** Lower levels of disaggregation of cotton area, production and yield statistics, for example, at the sub-departmental-level or municipality-level are not, however, available in Chaco Province. This means that the smallest size of Insured Unit that could be adopted for a cotton AYII program in Chaco Province would be the Department and this may or may not represent a homogeneous cotton growing area (i.e. with similar varieties, planting dates, technology levels and individual farm-level cotton yields).

20. ***For the purposes of the AYII Contract design and rating study a decision was made to use the Federal government Departmental-level cotton production and yield data-base rather than the Provincial level data***. There are considerable differences in the reported yields under the two data sets which must be resolved. The Federal data were selected for this pre-feasibility study because there is a much longer 41 year time series of data and the level of missing and or anomalous yield data is lower than the provincial data.

21. ***This report presents full details of the cotton AYII cover design features and rating methodology used to derive the average yields and 50% to 90% Insured Yield coverage levels in each of the 25 departments along with the calculated pure loss cost and technical premium rates and illustrative commercial premium rates for each coverage level***. In Chaco Province cotton production varies widely across departments: for the purposes of this prototype AYII cover, departments with an average of less than 2,000 hectares of sown cotton in the past three years were excluded from the cover. The Insured Yields in each department were calculated as a

percentage of the most recent 5-year actual average departmental yield. The rating methodology adopted conforms to international standard practices for rating AYII policies (full details are presented in Chapter 4 and Annex 4). With departmental average yields ranging from about 1.1 to 1.4 MT/Ha across departments, the maximum recommended 80% Insured Yield Coverage levels are in the order of 0.9 to 1.2 MT/Ha. The unit sum insured used in this study of AR$ 2.0 per insured kilogram of raw cotton yield was based on the average costs of production of cotton for small and medium farmers which are in the order of AR$ 2,000 /Ha. An Excel based AYII contract design rating model has been designed under this study and this product has been made available to ORA-MAGyP and interested insurers and the SSN.

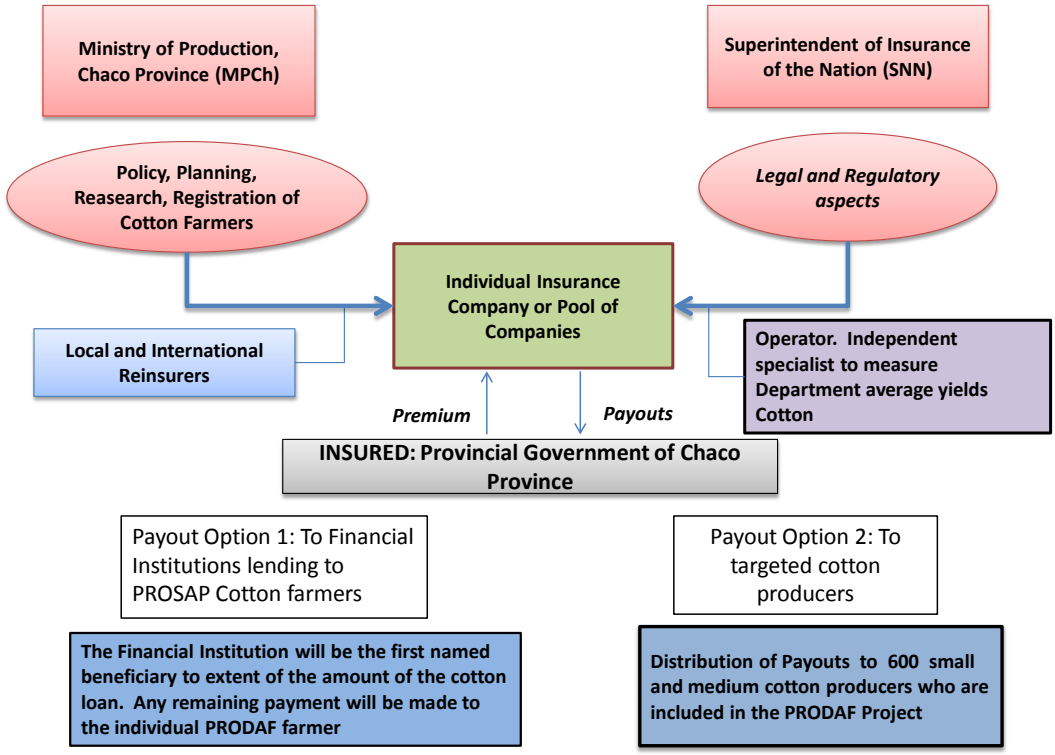
22. ***For an 80% coverage level and under the assumption that 100% of the eligible cotton area in Chaco province is insured*** (amounting to 221,301 Ha based on the most recent 3-years average sown area), ***the TSI would amount to AR$ 461 million with a total illustrative commercial premium of AR$ 32.3 million equivalent to an average premium rate of 7.00%.*** Across individual cotton growing department the 80% coverage level commercial premium rates vary from a low of 4.96% in 9 de Julio Department to a high of 11.98% in Fray Justo Department. The rating model shows that if the coverage level is reduced to 70% of the average raw cotton yield in each Department, the TSI would be reduced to AR$ 403.7 million, but the cover would become much cheaper with a total illustrative commercial premium of AR$ 15.6 million (average commercial premium rate of 3.86%). It is stressed that final rating decisions will be made by insurers and their reinsurers.

23. ***The Probable Maximum Loss (PML) on the Chaco Cotton AYII program has also been calculated for each insured yield coverage levels under the assumption of 100% of the eligible area is insured***. The PML is a useful indicator of the worst losses that could be experienced under this cover and enables underwriters and their reinsurers to layer a structured risk program. For an 80% insured yield coverage level the calculated 1 in 100 year PML is 30.2% of TSI or a loss (payout) of AR$ 139 million.

Institutional and Operational Framework for Chaco Cotton AYII program

24. ***Under the proposed Macro-level AYII Program for the PRODAF cotton project, the Government of Chaco (GoC) would be the Insured and would be responsible for paying premium***. The key organizations that would be involved in the AYII program are shown in Figure 1. The SSN would be responsible for legal and regulatory issues and for approving this new index insurance product in the Argentinean insurance market. The Ministry of Production of Chaco Province (MPCh) would be responsible for overall policy and planning and research and development for the AYII cover for the PRODAF cotton project and the 600 participating cotton producers. The Argentinean specialist agricultural insurance companies that have supported this AYII initiative over the past two years will need to decide whether they wish to form a coinsurance pool to underwrite the program, or whether a single company will be appointed to underwrite the program. The role of local and international reinsurers in providing reinsurance capacity will be critical to the implementation of this cover. It is recommended that an Argentinean specialist agricultural loss adjusting company is appointed to estimate the actual average yield of raw cotton in each insured department for the purpose of verifying whether payouts are due in each department. There appear to be two main options for distributing the payouts on this scheme. Under Option 1 where PRODAF farmers are also beneficiaries of cotton production credit it is recommended that lending institution is named as the primary beneficiary and would receive the payouts up to a maximum of the loan amount per cotton farmer. If there is no credit program, GoC as the Insured will need to determine the payout rules for distributing the payouts to each PRODAF cotton producer (Figure 1).

Figure 1. Outline Institutional Framework for Chaco Province Macro-level Government AYII crop insurance program for PRODAF Cotton Farmers



Source: Authors

Key Outstanding Issues and Challenges for Introducing AYII Cover for Cotton in Chaco

25. ***It is currently not possible to provide portfolio estimates (Insured Area, TSI and Premium) for the 600 small and medium cotton farmers with between 60 Ha and 150 Ha who will be targeted by the PRODAF project between 2013/14 and 2016/17.*** It is important that MPCh provides these estimates (number of farmers and planned cultivated cotton area per farmer and per department) to ORA-MGAP and the insurance companies as soon as possible to enable the insurers to start reviewing their required rates and capacity requirements and therefore reinsurance requirements on the PRODAF scheme.

26. ***It will be necessary for MPCh to register all the PRODAF participating cotton producers for insurance purposes and to provide these details to interested AYII insurers***. In this context it is noted that the GoC has recently passed legislation under the Provincial Law No. 7154 of 12 December 2012, that obliges all farmers in Chaco Province to register their planned and actual cultivated area for each crop with Chaco Agricultural Producers (*Productores Agrícolas Chaqueños*- PAC) data base.

27. ***For the purposes of the AYII prefeasibility study a decision was made to use the Federal Government Departmental-level cotton production and yield data to design and rate the area-yield index insurance***. This decision was based on the longer 41 years Federal time-

series cotton production and yield data which has a lower level of missing and or implausible (outliers) data. This decision needs to be approved by the key stakeholders including GoC and MPCh and the insurance company or companies that are interested in underwriting this AYII program.

28. ***The Federal Government cotton statistics are only updated to the 2009/10 season***, and it will be necessary in due course to update the yield estimation and rating exercise for the past three seasons 2010/11 and 2011/12 and 2012/13. It is likely that the stakeholders will need to contract an actuary to assist them in this exercise.

29. ***For the operation of this AYII Cotton insurance policy it is unlikely that the Insurers and their Reinsurers will accept MPCh's estimates of the actual average yields without some form of independent monitoring and measurement and validation of these departmental level cotton yields.*** The simplest option would be to appoint an independent and reputable local agricultural services organization with expertise in cotton yield estimation (through in-field sample measurement and weighing of the cotton bolls using standard procedures to estimate the actual average yield in each insured department) and on which basis to determine if a payout is due on the AYII Policy. This report lists the names of several leading local crop loss assessment companies and it is recommended that the key stakeholders in this cotton AYII program start discussions with these companies about the their proposed methodology for cotton yield estimation and the associated costs.

30. ***The optimum procedures for distributing the payouts on the AYII program for PRODAF cotton producers will need to be discussed and agreed between GoC-MPCh and interested local insurers***. The system for disbursing AYII insurance Payouts in a timely and cost-effective manner either to (i) the financial institutions if cotton credit is provided or (ii) directly to individual farmers where no credit is involved, must also be discussed and agreed between the Insured (GoC) and Insurers. Ideally where payouts are made to cotton farmers, it would be most efficient to make these payments directly to each farmers' bank account, but on the assumption that many farmers do not have bank accounts, a system of redeemable bank-drafts may need to be considered.

Conclusions on AYII for Cotton in Chaco Province

31. ***Area-yield Index insurance for cotton, operating at a Departmental Inured Unit level, appears to be technically and operationally feasible in Chaco Province*** if an independent system of verifying actual average Departmental cotton yields can be introduced in order to confirm the cotton industry's existing procedure for recording planted cotton area, harvested cotton area, raw seed cotton production and yields in each department. It is recommended that an independent Argentinean firm of crop loss adjusters is appointed to do field-level sampling of cotton yields and on which basis to estimate the actual average yield of raw cotton in each department.

32. ***The preliminary analysis of AYII Insured Yield coverage levels and technical premium rates suggests that the maximum coverage levels that should be offered in any start-up phase should be 80% of Expected Yield any one department*** and in high risk departments where cotton yields are very variable that maximum coverage levels may need to be reduced to 70%. This recommendation is made to avoid potential situations in departments with high yield variability that the policy ends up making payouts to small-medium farmers even if they have not incurred major yield loss.

33. ***It is recommended that the macro-level AYII option is adopted under which the GoC would identify its target audience of cotton farmers and would then assume the role of the Insured and be responsible for the payment of premium***. The PRODAF project with 600 cotton farmers has been identified as the target audience for the AYII program. Two options for the distribution of premiums have been identified (1) where cotton farmers are receiving seasonal crop loans, the payouts would be settled directly to the lending institution and any balance over and above the loan amount will then be paid to the individual farmer, or (2) where no credit is involved, payouts would be made directly to the cotton growers registered with PRODAF.

34. ***The key deliverables resulting from the Chaco Cotton Pre-feasibility study include this final report and recommendations, an Excel-based AYII contract design and rating tool which meets international standards and a manual of instructions.*** These final deliverables will now be presented to ORA-MAGyP for distribution to: (i) SSN for it to review and approval; (ii) interested insurers and reinsurers; and (iii) GoC-MPCh.

1. Introduction and Background to Feasibility Study

Small Holder Cotton Production and Climatic Risk Exposures in Chaco Province

1.1. ***Chaco Province is the most important cotton producing area in Argentina.*** Over the past 5 years (2006/07 to 2010/11), the total annual average sown area of cotton in Argentina has been 424,667 Ha of which Chaco Province has accounted for an average of 279,038 Ha or 66% of total sown cotton area, 53% of average production and 52% of the total value of cotton fiber production (CONES 2012). Chaco Province is the third poorest of Argentina's 23 provinces.

1.2. ***Cotton is grown throughout the province and is an important cash crop for small and medium farmers***. According to 2002 National Agricultural Census data there are approximately 18,000 cotton producers in Chaco Province of which the very smallest group or 60% of all cotton farmers cultivated less than 10 Ha of cotton on an annual basis. About 34% of cotton farmers are classified as semi commercial small and medium cotton producers with between 10 Ha and 100 Ha of cotton and finally there is a very small number (6% of total) of large mechanized producers who cultivate 50% of the total cotton area in the province. Cotton production and technology levels vary considerably between these different size groups of farmers: the smallest farmers use very low levels of purchased inputs and achieve low average yields of less than 1 MT raw cotton per hectare; at the other end of the spectrum, the largest producers are fully mechanized and use high levels of technology and achieve average yields of raw cotton in the order to 2.5 to 3.0 MT/Ha. Poor land use management for many years has led to severe soil degradation and erosion in Chaco Province.

1.3. ***Cotton production in Chaco Province is very exposed to climatic and biological perils***. Chaco Province experiences extremes of weather which are usually related to the El Nino Southern Oscillation (ENSO) phenomenon which brings acute drought or excess rain and flooding. In the past thirty years there have been several major flood and extreme drought losses (Chapter 2 provides a list of those major natural events that have impacted the cotton sector). In addition the Argentinean cotton crop has been severely affected by cotton boll weevil since it spread from Brazil and Paraguay in the early 1990s.

1.4. ***Cotton Production in Chaco Province and throughout Argentina has experienced a major decline since the late 1990s due mainly to lowered world market prices, but in recent years has seen a modest recovery.*** The cotton sector has experienced severe economic decline over the past 15 years. At its peak, the sown area of cotton peaked at 712,000 Ha in 1997/98, but then declined significantly over the next five years to reach a low of only 85,000 Ha in 2002/03 before recovering in recent years to about 381,120 Ha in 2010-11 (DdA/MPCh 2012). Average yields of cotton in Chaco are well below international average and have stagnated over time: with the falling prices for cotton in the early 2000s many farmers experienced major losses and bankruptcy and severe problems of lack of access to bank credit to finance their cotton operations.

1.5. ***Both Federal and Provincial Governments in Argentina place a high priority on financial support for the cotton sector.*** In 2005 Congress approved under Law No 26.060 (dated 20 October 2005), the creation of the Plan for the Sustainable Development and Promotion of Cotton Production (*Plan de Desarollo Sustentable y Fomento de la Produccion Algodonera*) with responsibility for implementation of the plan under MAGyP. The law authorizes Federal and provincial governments to contract agricultural insurance services and or to provide financial assistance to cotton producers to contract crop insurance protection against catastrophe losses to

their cotton caused by climatic, natural and biological perils. Cotton producers who elect on a voluntary basis to contract insurance with the financial assistance from this program would no longer be eligible for compensation under the National Agricultural Crop and Livestock Emergency Law (*Ley de Emergencia Agropecuaria* 22.913). The law 26.060 also authorizes the creation of an Income Compensation Fund for Cotton Production (*Fondo de Compensación de Ingresos para la Producción Algodonera*, FCIPA) with an initial capital of AR$ 50 million funded from the national treasury and which is designed to stabilize cotton prices. It is understood that the FCIPA may be used to finance premium subsidies for cotton farmers.

1.6. ***Argentina has a lengthy history of private sector crop insurance, but to date no company has successfully underwritten cotton grown in Chaco Province***. Argentina has more than a century of experience with crop hail insurance mainly for summer and winter cereals grown in the Humid Pampa (Pampa Humeda) and for fruit and tobacco. In Chaco Province the hail risk exposure in cotton is relatively low: however the crop is very exposed to seasonal excess rain and flood damage and/or to droughts. On various occasions in the past the private commercial insurers have attempted to introduce an individual grower Multiple Peril Crop Insurance (MPCI) which provides loss of yield all risk cover, to medium and large cotton producers in Chaco Province. None of these voluntary individual farmer cotton insurance initiatives have been successful and most of the companies have withdrawn their products after one or two years on account of high underwriting losses: typically the companies have faced severe adverse selection and moral hazard and lack of insurance demand and uptake to generate an adequate volume of premium and spread of risk to be sustainable.

1.7. ***The Government of Chaco (GoC) has in recent years actively supported the introduction of cotton insurance in Chaco Province.*** Since 2008/09 GoC has provided premium subsidy support to an individual grower MCPI crop insurance program linked to a cotton-credit (Fideicomiso Chaco Produce Algodón) program which is implemented by the Coordination and Evaluation Financing Unit (UCEF). In 2008/09 this program was insured by a coinsurance pool of several Argentinean insurers led by SANCOR; in 2009/10 only SANCOR was willing to renew the program and in 2011/12 the program has been insured by the Nation Insurance Company (*Nación Seguros*). In 2010/11 Government of Chaco (GoC) contracted a macro-level cotton weather index insurance (WII) policy which used ground-based weather stations to insure against drought in the growing stages of the cotton crop and excess rain at boll formation and harvest. Finally since 2012 the Argentinean Congress has been investigating the feasibility of introducing a national (voluntary or possibly obligatory) multiple-peril agricultural insurance scheme for all farmers.

1.8. ***In view of the failure to develop a suitable and sustainable cotton insurance program especially for small and medium cotton producers, the Government of Argentina, has sought technical assistance from the World Bank.***

Government Request to the World Bank and Scope of the Cotton Insurance Feasibility Study

1.9. ***In 2011, the Government of Argentina through the Ministry of Agriculture, Livestock and Fisheries (MAGyP), requested the World Bank to conduct a feasibility study for the development of a suitable index-based agricultural insurance product to protect cotton producers located in Chaco Province against severe drought and excess rainfall (leading to flooding) losses in their cotton crop.*** The specific components of this study included to:

- Assist the Agricultural Risk Office (ORA-MAGyP) in the design and rating and implementation planning of an appropriate rainfall index-based insurance product and program for small and medium cotton producers (classified as those farmers with between 10 Ha and 100 Ha of cotton). GoC is committed to assisting this group of small and medium farmers to increase their cotton production and yields and this incomes through an integrated package of subsidized seasonal production credit to purchase improved cotton seeds, fertilizers and pesticides, and to provide education and training in improved cultural practices. GoC sees crop insurance as playing a critical role in protecting the seasonal loans it is providing through the banks and other financial providers. During the final Mission to Chaco in late May 2013, GoC presented a specific proposal for a 4-year project starting in 2013 called the Program for Agriculture and Rural and Family Development (*Programa de Apoyo al Desarollo Rural y Familiar* (PRODAF) which is targeted at cotton farmers with a slightly larger planted cotton area of between 60 Ha and 150 Ha of cotton. This project will provide technical and financial assistance to yup 600 cotton farmers included in the Provincial Cotton Register and at full implementation is planned to cover 67,500 Ha of cotton. GoC has requested that the AYII cotton insurance proposals presented in this report be tailored to protect the financial loans being provided to cotton farmers under PRODAF. Further information on PRODAF is presented in Box 1.1.

- Design a macro-level weather index insurance (WII) cover for cotton. At the outset of the feasibility study it was agreed by all parties that this study would not seek to replicate the individual grower MPCI products that have been provided (largely unsuccessfully) by the local agricultural insurance companies and their reinsurers, but rather that the study would focus on innovative index insurance solutions in this case an excess rainfall/rainfall deficit cover using ground-based weather stations. It was therefore agreed that the excess rainfall/rainfall deficit WII cover would be based on macro-level policy designed to protect GoC's financial (seasonal cotton credit) exposure rather than an individual grower cover. During the conduct of the study, the TORs have, however, been modified to include an analysis of the feasibility of introducing a cotton Area-Yield Index Insurance (AYII) insurance policy because of the inability of any modeled WII rainfall index cover adequately to capture production and yield losses in cotton grown in Chaco Province.

- Develop a policy framework based on public-private partnerships, for the implementation of index based agricultural insurance for cotton grown in Chaco Province, and

- Provide MAGyP, the Insurance Regulator and the private commercial insurance sector with capacity building on index-based agricultural insurance.

1.10. ***The Chaco Cotton index insurance feasibility index insurance study was implemented under the World Bank's Non-Lending Technical Assistance to MAGyP.*** This World Bank technical cooperation with ORA-MAGyP for the development of index based crop insurance policy and regulatory capacity for the cotton sector in Chaco Province, Argentina, has been a 30 month project (April 2011 to June 2013) which has been financed by the Japanese Government and administered through the Regulatory and Policy Capacity Building Window of the Global Index Insurance Facility (GIIF), managed by the International Financial Corporation (IFC). This activity supports the MAGyP's Agricultural Provincial Services Program (PROSAP) which is co-financed by the World Bank.

Report Outline

1.11. ***This report presents the findings and recommendations of the feasibility study for the introduction of a macro-level index program which would be purchased by the Provincial Government of Chaco Province as part of its natural-disaster risk management strategy for small to medium cotton producers located in the province.*** The report consists of five chapters starting with this introduction. Chapter 2 includes a review of cotton production systems in Chaco Province along with an assessment of the main natural, climatic and biological risk exposures associated with cotton production in this province and a review of the recent crop insurance initiatives for cotton that GoC has been promoting.. Chapter 3 deals with the results of feasibility study for a macro-level Weather Index Insurance (WII) cover designed to protect against excess rainfall and rainfall deficit (drought) in cotton and the issues, challenges and conclusions on the appropriateness of cotton WII in this province. Chapter 4 deals with the technical, organizational operational and financial issues and options for developing alternative Area Yield Index Insurance (AYII) cover for cotton grown in Chaco Province. Chapter 5 presents the conclusions and recommendations arising out of the cotton feasibility study and possible next steps. The report contains 4 technical annexes which are provided for reference purposes.

Box 1.1. PRODAF Program for Small to Medium Cotton Growers 2013 to 2016

Program Implementation Period: 4 years starting with the cotton campaign 2013/14 up to 2016/17

Target Beneficiaries: Cotton producers in Chaco Province cultivating between 60 Ha and 150 Ha of cotton.

PRODAF Objectives: The objective of the program is to achieve through the introduction of improved practices and technology a major increase in cotton production and yields over the duration of the 4-year project. Free technical assistance will be provided to the targeted cotton growers to ensure they comply with the technical recommendations. It is planned to increase the average cotton fiber yields from 350-400 Kg per hectare to a yield of 700-800 kg per hectare between the crop campaigns of 2013/14 and 2016/17.

Implementing Agencies: Ministry of Production Chaco Province (MPCh) and the National Institute for Agricultural Technology (INTA).

PRODAF Assistance Package: The program will provide a combination of technical and financial assistance to up to 600 cotton producers registered in the Provincial Cotton Register with the objective of covering up to 60,00 ha by the 4th year. Farmers will be organized into small groups of about 15 farmers for the purposes of receiving extension advice on improved cotton production techniques. Credit will be provided both for inputs and for capital equipment.

PRODAF Build-up over time: In 2013/14, the area under technical assistance will be 15,000 to 20,000 Ha, for 2014/15, 30,000 Ha, for 2015/16, 50,000 Ha and finally in 2016/17, 67,500 Ha.

PRODAF Funding: The program will receive full funding from the Inter-American Development Bank, (IADB), with a contribution of US$ 11 million.

Source: MPCh May 2013

2. Cotton Risk Assessment for Chaco Province

2.1. ***This Chapter presents an overview of cotton production in Chaco Province***, followed by an analysis of historical production and yields and the impacts of climate especially rainfall and other factors on production and yields. At the end of the Chapter there is a review of the various public and private risk management instruments available to cotton producers in Chaco Province.

Cotton Production in Chaco Province

2.2. ***Chaco Province is located in northern Argentina bordering Paraguay***. It has an area of 99,633 Km^2, and a population of 1.1 million in 2010 making it the 9^{th} most populated of the 23 Argentinean Provinces. The capital is Resistencia. Chaco Provinces is one of the poorest provinces in Argentina.

2.3. ***The Chaco is principally a sub-tropical zone***, with winter frosts occurring less frequently in the northeast and with higher frequency going towards the southwest. Because of its continental climate there are large variations in temperatures between summer and winter, as maxima of 40° C can be reached when the sun is high, whereas in winter some frost does occur. Annual mean temperatures range from 24° C to 25.5° C. The main rainfall, as a result of isolated storms, is from October to March; the driest months are July and August. The average rainfall varies from 450 to 850 mm. During the rainy season, 400 to 600 mm fall. The water balance has negative values for up to 10 to 12 months of the year.

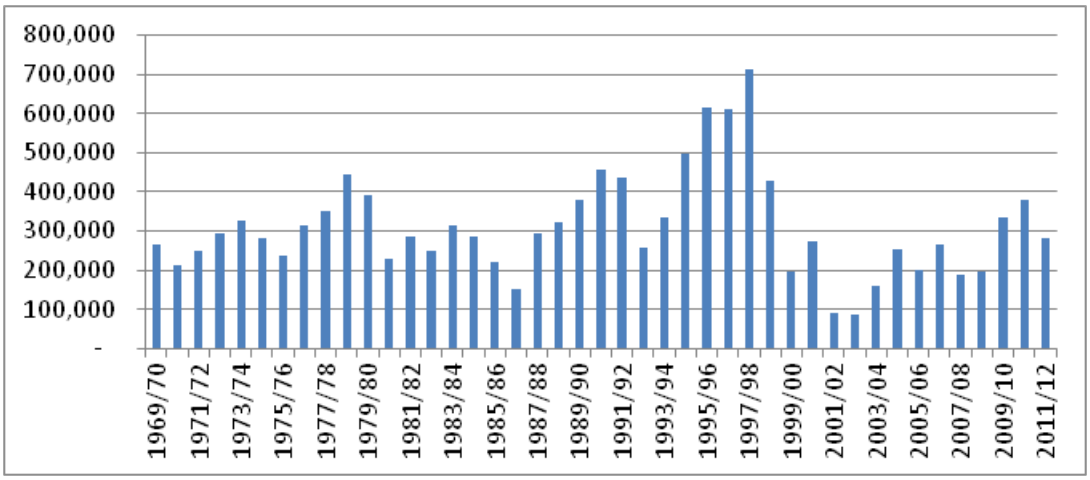
2.4. ***Agriculture (crops, livestock, hunting and forestry) is very important in Chaco Province*** and in 2010 accounted for 32.4% of the Gross Domestic Product of the Province. Agriculture in Chaco was traditionally centered on cotton production, but in the past decade there has been a major expansion in the cultivation of soya, sorghum and maize in the province. Sugar cane is also cultivated in the South, as well as rice and tobacco in lesser proportion.

2.5. ***Chaco Province is the most important cotton producing area in Argentina.*** Over the past 5 years, 2006/07 to 2010/11, the total annual average sown area of cotton in Argentina has been 424,667 Ha of which Chaco Province has accounted for an average of 279,038 Ha or 66% of total sown cotton area, followed by Santiago del Estero with an average of 75,805 Ha (18% of total average), Santa Fe (9% of total average), Formosa (5% of total average), Salta (2% of total average) and all other provinces have accounted for less than 1% of sown area (DdA-MoP, 2012). Over this same period the total annual production of raw cotton has been 667,367 metric tons of which Chaco Province has accounted for 53% of average production, followed by Santiago del Estero and Santa Fe with 27% and 11% of average production, respectively (see Annex 1 for full details). Over the same five years, Chaco has contributed an average of 52% of the total value of cotton fiber production in Argentina, followed by Santiago del Estero (29%) and Santa Fe 12% (CONES 2012).

2.6. ***Cotton production in Chaco Province increased significantly during the 1980s and 1990s on the back of high international prices for cotton, but production then declined sharply in the early 2000s following the collapse of cotton prices and is only just starting to recover again in the past five years.*** At its peak, the sown area of cotton peaked at 712,000 Ha in 1997/98, but then declined significantly over the next five years to reach a low of only 85,000 Ha in 2002/03 before recovering in recent years to 336,330 Ha (2009-10) and then 381,120 Ha in

2010-11 (DdA/MPCh 2012).(See Figure 2.1). In 2012/13, however, the cultivated area of cotton in Chaco Province has been halved to about 150,000 Ha only. According to MPCh the contributing factors to this major decline include very early rains in August 2012 which led many farmers to plant sunflower which being a short-term 90 day crop would enable them to sow soya beans afterwards in the summer season and the fact that with very restricted access to credit many farmers opted to grow cereals and oil seeds because the costs of production are much lower to finance than cotton.[3]

Figure 2.1. Chaco Province, Cotton Sown Area to 2011-12.



Source: Cotton Department – Ministry of Production and the Environment of the Province of Chaco, (DdA/MPCh).
Note: 2011/12 sown cotton area is provisional up to end November 2012.

2.7. ***Reasons for the decline of cotton production in Chaco Province in the 2000s center on stagnating production and yields and reduced internal and world market prices for cotton plus the switch by farmers to more profitable crops such as soya, sunflower and maize on the back of the global cereal commodity price boom.*** Over the past 30 years the overall provincial-level average yield of cotton grown in Chaco has remained virtually unchanged at about 1.2 MT of raw cotton per harvested hectare producing an average of about 400 to 450 Kg/Ha of cotton lint (again on a harvested area basis), which is at least 40% lower than the world market average yield of cotton (CONES 2008). The cotton industry experienced low profitability on account of lowered world market prices for cotton, farmers faced major problems of financing inputs and other yield enhancing technology due to lack of access to credit and the sector was also severely affected by cotton boll weevil. In the late 90's when cotton production in the Chaco peaked at slightly greater than 700,000 Ha, the sown area of soya and sunflower was less than 200,000 Ha: however, by 2002/03 when the cotton area had bottomed at only 85,000 Ha, the area of soya and sunflower had grown more than fivefold to nearly 1.1 million hectares on account of the very high prices for cereal and oil seed exports mainly to China (CONES 2008).

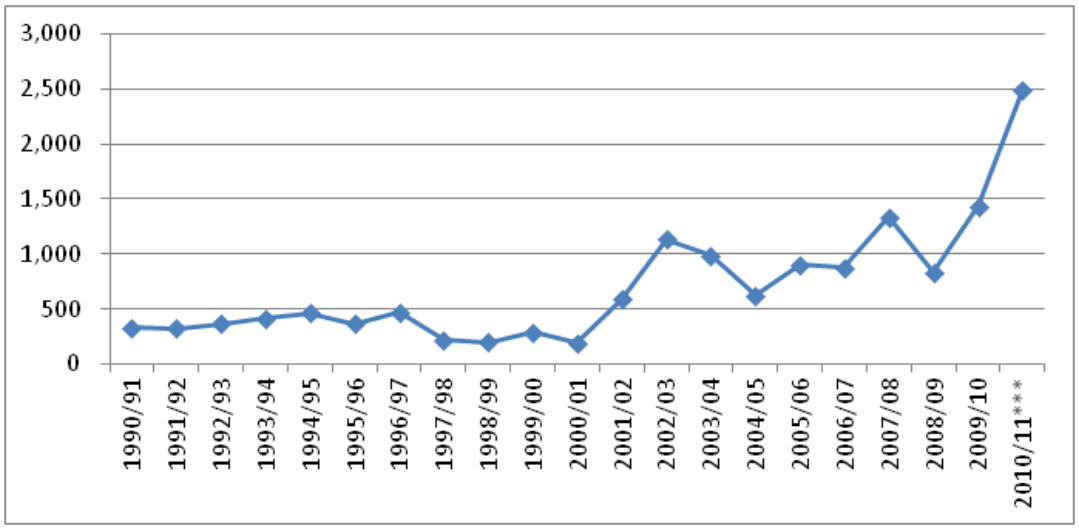
2.8. ***The total cotton production area has decreased dramatically since the mid-1990s.*** After the 1997/1998 crop season, the cotton sector started experiencing a major reduction in the planted area due to a drastic decline in the international prices of cotton. The decrease in the planted areas as well as the impact of a devastating flood event during the 1997/98 crop season reduced the availability of raw cotton for the Argentinean textile industry to keep their installed industrial

[3] Verbal communication MPCh 30 May 2013.

capacity working. As a consequence of this situation and due to subsequent losses experienced by farmers due to adverse climatic events (i.e. 2011/2012 drought event), the availability of financial resources became even harder for farmers and framers' cooperatives to obtain than in previous years.

2.9. ***In the past few years the cotton industry in Chaco Province has experienced a modest recovery*** due to increases in internal and world market prices for cotton and special projects implemented by Government of Chaco to improve cotton farmers' access to credit linked to crop insurance. The sown area of cotton has increased to 381,000 Ha in 2010/11 and production to 530,000 MT raw cotton (CONES 2008) and coupled to this the average prices for Chaco cotton have more than doubled over the past three years[4] (Figure 2.2.).

Figure 2.2. Chaco average prices for raw cotton paid by individual stockpilers 1990/91 to 20101/11 (Prices in AR$ / Metric Ton)



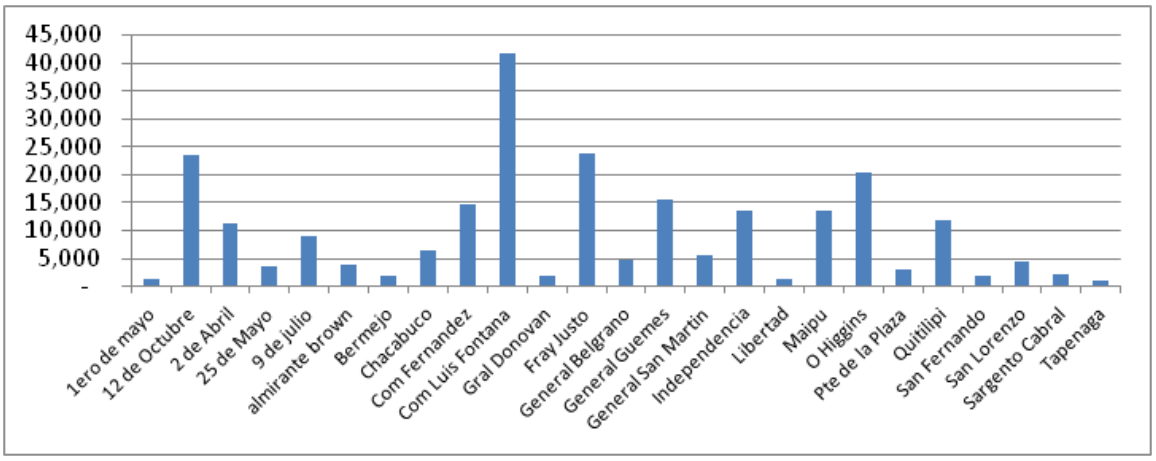
Source: CONAF based on data from DdA-MdP.

Distribution of Cotton Production by Department

2.10. ***Cotton is produced in 25 Departments in Chaco Province, but is only an important commercial crop in five departments, including the largest, Coronel Luis Fontana*** with an average of 41,790 Ha of sown cotton (17.3% of total area) over the most recent three years (2007/08 to 2009/10), followed by Fray Justo (average 23,700 Ha, 9.8% of total), 12 de Octubre (23,433 Ha, 9.7% of total), O Higgins (20,280 Ha; 8.4% of total) and General Guemes (15,640 Ha; 6.5% of total). In 13 or 52% of the departments the sown area of cotton has averaged less than 5,000 Ha over the past three years (Figure 2.3 and Annex 1).

[4] Note that these figures do not include correction for inflation.

Figure 2.3. Chaco Province: 3-Year (2007/08 to 2009/10) average sown area of cotton by Department (Ha)



Source: ORA-MAGyP and MPCh

Farm Size Distribution and Cotton Production

2.11. ***According to the 2002 Agricultural Census (which is the most recent data available for the cotton sector), there were about 18,000 cotton producers in Chaco Province*** in 2002 . The same census estimated that about 60% of cotton producers in Chaco Province were very small scale (Minifundistas) cultivating less than 10 Ha of the crop and who only accounted for 9% of the total sown area of cotton in the province. This was followed by small and medium semi-commercial farmers cultivating between 10 Ha and 100 Ha of cotton who comprised about 34% of all cotton producers and who cultivated about 41% of the cultivated area of cotton and finally there were a small number (6% of total) of large farmers with > 100 Ha of cotton (some of whom cultivated several thousand hectares), but whom controlled 50% of all cotton production in the province (Table 2.1).

Table 2.1. Chaco Province: Distribution of Cotton Farmers by Size (2002 data)

Size Classification	Cultivated Cotton Area (Ha)	Number of Cotton of Farmers [1]	Percentage of Cotton Farmers	Percentage of Total Sown area of Cotton Area (%)
Minifundista	0.1 to 10	10,800	60%	9%
Small-medium	10 to 100	6,120	34%	41%
Large	> 100	1,080	6%	50%
Total		**18,000**	**100%**	**100%**

Source: National Institute of Statistics and Census (INDEC); National Agricultural Census 2002.
Note: [1] Figures estimated by the authors based on a total of 18,000 cotton producers in 2002

2.12. ***The number of active cotton producers is estimated to have declined considerably since 2002*** and according to MPCh's 2012 estimates there are currently about 1,450 small to medium cotton producers in Chaco Province cultivating about 81,000 hectares of cotton (Table 2.2). The

bulk of these small to medium cotton producers are located in the three departments of Fray Justo, Comandante Luis Fontano and O'Higgins, accounting for 46% of all small and medium farmers and 63% of the cotton area cultivated by this group of farmers.

Table 2.2. Estimated Number of Small and Medium Cotton Producers and their cultivated area by Department (2011/12 statistics)[1]

Department	No. of Small and Medium Cotton Producers	% of Producers by Department	Cultivated Area of Cotton (Ha)	% of Cultivated area by Department	Average Area Cotton per Farmer (Ha)
12 de Octubre	35	3%	2,500	3%	71
2 de Abril	32	3%	3,074	4%	96
25 de Mayo	30	3%	754	1%	25
9 de Julio	25	2%	3,168	4%	127
Almirante Brown	2	0%	550	1%	275
Chacabuco	4	0%	538	1%	135
Com Fernandez	67	6%	2,675	3%	40
Com Luis Fontana	271	26%	13,635	17%	50
Fray Justo	121	12%	28,463	35%	235
General Belgrano	4	0%	291	0%	73
General Guemes	67	6%	2,869	4%	43
General San Martin	52	5%	1,578	2%	30
Independencia	15	1%	1,079	1%	72
Maipu	97	9%	4,030	5%	42
O Higgins	82	8%	8,540	11%	104
Pte de la Plaza	22	2%	1,339	2%	61
Quitilipi	95	9%	4,632	6%	49
Asan Fernando	4	0%	257	0%	64
San Lorenzo	15	1%	635	1%	42
Sargento Cabral	6	1%	345	0%	58
Total / Average	**1,046**	**100%**	**80,952**	**100%**	**77**

Source: MPCh data at August 2012

Note: [1]. In several Departments the size of cotton farmers considerably exceeds the 100 hectare limit for this class of cotton grower. According to MPCh, the 100 ha limit is applied to the amount of financial assistance government will provide to an individual small and medium farmer rather than a strict definition of their total cotton area.

2.13. ***Back in 2012 MPCh advised the World Bank that this group of small to medium farmers listed in Table 2.2. were the target audience for the macro-level crop WII cover for cotton, linked to seasonal credit provision.*** Under the PRODAF program this has now been refined to cover 600 cotton farmers growing between 60 Ha and a maximum of 150 Ha of cotton and covering a total of 67,500 Ha at full-scale implementation (MPCh 2013). At the time of finalizing this report, MPCh is not able to provide further details of the distribution of the 600 cotton farmers and up to 67,500 Ha of cotton by Department under the PRODAF program.

2.14. ***In theory every cotton producer in Chaco Province is supposed to be registered under***

the Provincial Cotton Register (*Registro Provincial Algodonero*), but it would appear these data are very out of date and during the conduct of this study it has not been possible to access a current up to date data set of the distribution of small, medium and large cotton farmers by department. Equally it has not been possible to obtain cotton production and yield data for different sized farmers. This is an issue for the design of any form of index insurance (See Chapters 4 and 5 for further discussion).

2.15. ***In order to channel technical and financial assistance to farmers in Chaco State, in December 2012 the Provincial Government passed legislation to make it obligatory for all farmers including cotton growers to register their farm cropping details on an annual basis***. This legislation has been enacted through the Chaco Provincial Law No. 7154 of 12 December 2012 and will require that all farmers in Chaco Province are registered with the Chaco Agricultural Producers (*Productores Agricolas Chaquenos*- PAC) data base. In future only those farmers who are registered with PAC will be eligible for credit and technical assistance.

Role of Cooperatives in Cotton Production in Chaco Province

2.16. ***Farmers' cooperatives play an important role for small and medium farmers of Chaco.*** The activities of 21 out of 65 registered agricultural cooperatives in the Province are oriented to cotton production, ginning of raw cotton material, and marketing of cotton fiber. It is estimated that around 70% of the total planted area of cotton in Chaco province comes from the cooperative sector, and about 48% of their members do direct transactions with them. The financial and operational capacity of these institutions provides larges benefits to their members; not only in terms of reducing transaction costs, but also in terms of access to credit. Since the severe national financial sector crisis in the late 1990s, cooperatives have become almost the only available source for financing of cotton productive activities in Chaco. Nevertheless, cooperatives' financial capacity to provide credit loans to farmers has been reduced over the years. Some of the factors that have influenced the reduction in the granting of credit loans to farmers include:

- The installed processing capacity of cotton exceeds the supply of raw material: the volatile cotton price conditions have motivated farmers to displace cotton traditional production areas with less expensive, more stable, agricultural and livestock production activities. This situation as well as the expansion of cotton boll-weevil infestation has reduced the availability of raw cotton for the cooperatives to process and market;

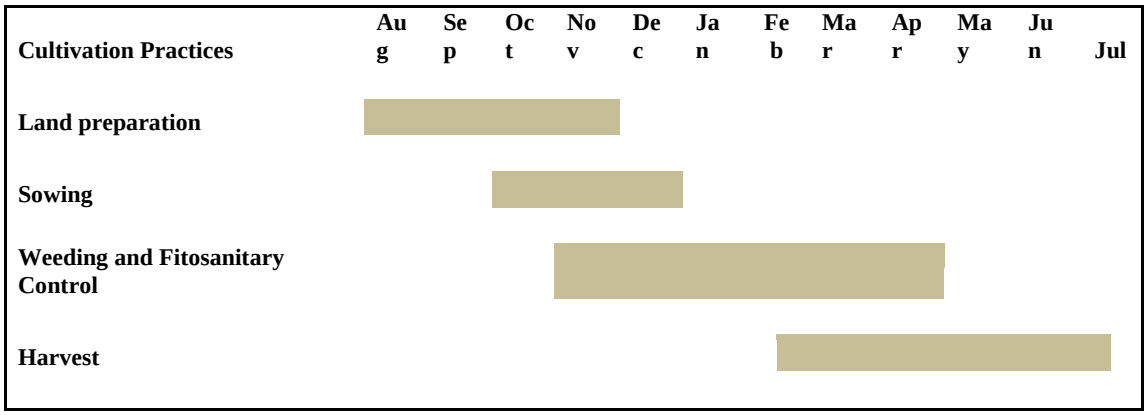
- The irregularity in the delivery of raw seed cotton by farmers prevents the cooperatives from meeting their financial projections. Although the cooperative financial resources may be the only source of credit for small and medium farmers, cotton producers usually deliver their product to a third party who pays in cash at the time the product is delivered. On the other hand, a great percentage of the credit loans approved in favor of farmers are not cancelled during the agreed period of time (CONES, 2012).

Cotton Production Cycle

2.17. ***Cotton is sown in spring in Chaco Province, but there is a very wide range in the planting dates of the crop, starting in late September and running through to December.*** The wide range in sowing dates for cotton is a major limiting factor in the design of any weather index insurance cover for cotton grown in Chaco (See further discussion in Chapter 3). Currently, medium cycle mainly genetically modified (GM) cotton varieties (120 days from germination to

harvest) have substituted the traditional long cycle varieties (180 days)[5][6]. This change in the cotton production system has not only standardized the planting dates among different productive regions, but also it has improved the application of most effective technical packages. The harvest of the crop starts in late February the following year and runs through to end April (see Figure 2.4.).

Figure 2.4. Cotton Cropping Calendar, Chaco Province Argentina



Source: MPCh 2012

2.18. ***In order to control cotton boll weevil, the Ministry of Production and Environment of the Chaco (MPCh) has introduced strict sowing dates for cotton in each region of the province.*** The cotton boll weevil (Anthonomus grandis)[7] entered Argentina in the early 1990's. This insect pest has the potential to cause devastating damage to cotton production and yields and the currently available GM varieties in Argentina are not boll weevil resistant. The MPEC adopts an integrated pest management approach to controlling boll weevil key components of which include respecting strict sowing and final harvest dates to ensure that the life cycle of the weevil is interrupted. Late sown cotton is favorable for the development of the boll weevil. The recommended sowing dates for cotton in each zone and department are shown in Table 2.3.

[5] The most important varieties diffused by INTA and the MPCh include Poriate INTA, Guazuncho 3 INTA, UN OPAL RR, DP 402-BG/RR, DP 604 BG and SP 48114 (MPCh 2012)

[6] According to Arza et al (2012) since the introduction of GM varieties of cotton into Argentina in 1998 these varieties have spread very rapidly and by 2010 nearly all the cotton area is sown with GM varieties.

[7] Adult boll weevils overwinter in well-drained areas in or near cotton fields after diapause. They emerge and enter cotton fields from early spring through midsummer, with peak emergence in late spring, and feed on immature cotton bolls. The female lays about 200 eggs over a 10–12 day period. Theoviposition leaves wounds on the exterior of the flower bud. The eggs hatch in three to five days within the cotton squares (larger buds before flowering), feed for eight to ten days, and finally pupate. The pupal stage lasts another five to seven days. The life cycle from egg to adult spans about three weeks during the summer. Under optimal conditions there may be eight to 10 generations per season. (Wikipedia, INTA 2010).

Table 2.3. Stipulated Sowing Dates and Last Dates for destroying Cotton residue by Department and by Region

Zone	Departments	Sowing Dates		Last date for destroying Cotton Residue
		Start	End	
Northern and Eastern	25 de Mayo, Almirante Brown, Pdcia. De la Plaza, Tapenagá, Gral. Dónovan, Libertad, 1ero de Mayo, San Fernando, Bermejo, Sto. Cabral, Gral. Martín, Gral Guemes.	1st October	15th November	1st June
Central and Southern	Maipu, M. Fontana, San Lorenzo, Independencia, Cte. Fernandez, Quitilipi, O' Higgins	15th October	30th November	30th June
Western	Gral. Belgrano, 9 de Julio, Chacabuco, 12 de Octubre, 2 de Abril, F.J.Santa Maria de Oro	1st November	15th December	15th July

Source: MPEC 2012; MPCh 2012

Cotton Production and Yields

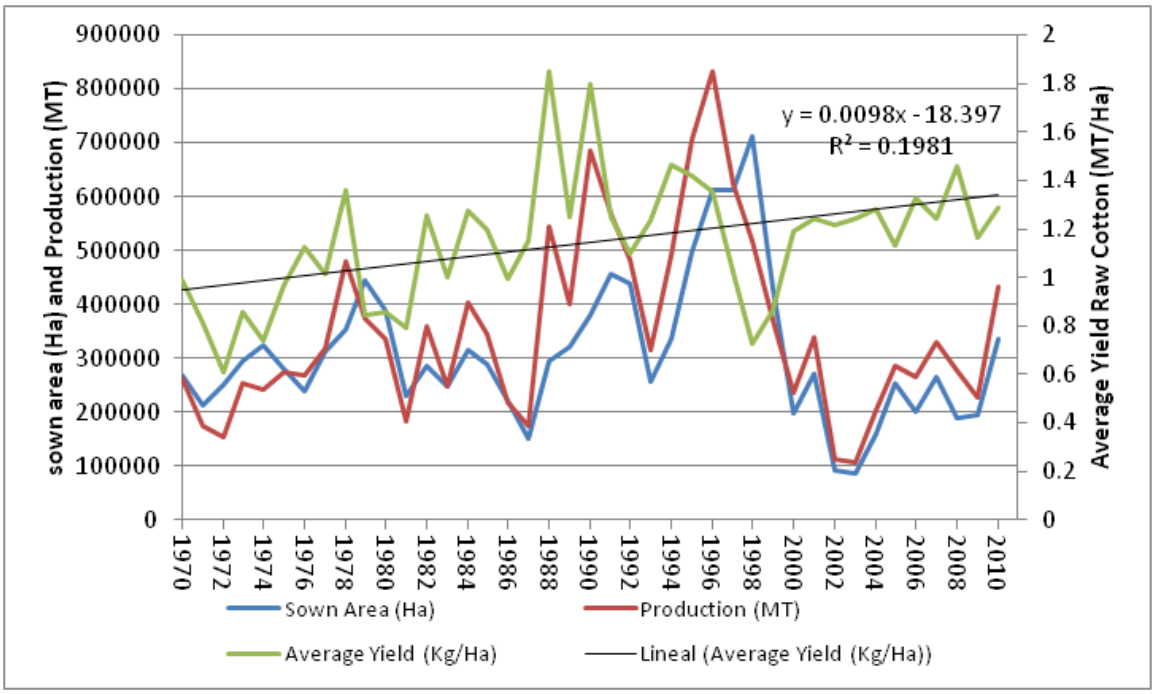
2.19. ***This section reviews the trends in cotton production and yields in Chaco Province.*** There are two sources of official data on cotton sown and harvested area and production and yields of raw cotton namely, (i) data that is collected by **Federal Government** and for which a 40 year historical data series from 1979/80 to 2009/10 has been provided to the World Bank team and (ii) **Provincial Government** data that is collected by MPCh and its network of field extension officers and for which 22 years of data are available from 1989/90 to 2010/11. These two sources of cotton production statistics report somewhat different average yields: on balance the Provincial annual raw cotton yields have been between about 5% and 20% lower that the Federal government estimates. The two sets of yield data are compared by Department in Annex 1. For the purposes of this report and the Area-Yield Index Insurance (AYII) Pre-Feasibility study which is presented in Chapter 5, the Federal Crop Yield database has been used to design and rate a departmental level AYII cover. The reasons for electing to use the Federal cotton yield data include the much longer time series of yields and the lower percentage of missing data and or yield data errors.

2.20. ***Cotton has been produced in Chaco Province since the earliest 20th century and cotton production peaked in 1997/98 with a total sown area of 712,000 hectares***. Figure 2.5 and Annex 1 presents a summary of the annual sown area of cotton, production of raw seed cotton and average per hectare yields over the past 41 years 1969/70 to 2009/10. According to these data, the sown area of cotton peaked at 712,000 Ha in the 1997/98 season, while the highest production year was 1995/96 with total raw cotton production of 832,010 MT. Between 1998/99 and 2002/03 cotton production in Chaco collapsed such that in 2002/03 the sown area was only 85,000 Ha and total harvested production was only 105,735 MT. In Chaco province cotton production has experienced major fluctuations over time, mainly reflecting changes in national policy and international prices for cotton (Arza et al 2012).

2.21. ***In spite of cotton technology improvements, over the past 30 years average yields of raw cotton in Chaco Province have remained relatively unchanged at about 1.2MT/Ha to 1.3 MT/Ha***. (Figure 2.5). The average yield of raw cotton is broken down into 31% cotton fibre or

lint (with range between a low of 26% and a high of 35%), 49% cotton seed from which oil is extracted and the residue fed to livestock and waste material 20% (CONES 2012). This implies that average cotton lint yields are in the order of about 400 to 450 Kg/Ha, which is about 40% lower than average international standards (CONES 2008). There are, however, major differences in the average yields of raw cotton obtained by small-holder producers and large-scale fully mechanised producers who achieve average yields as high as 2.5 MT/Ha.

Figure 2.5. Chaco Province, Cotton Sown Area, Production and Yields Raw Cotton 1969-70 to 2009-10



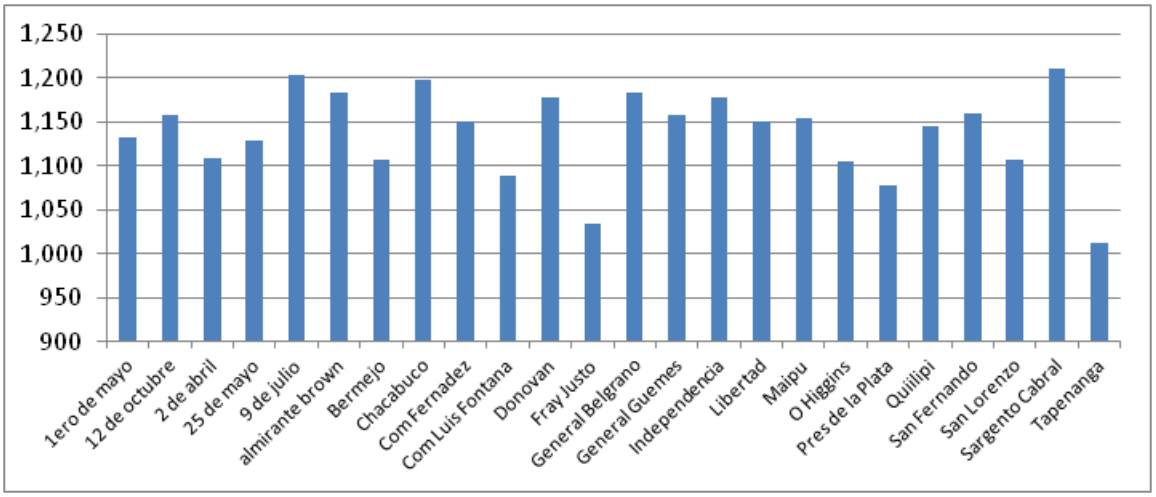
Source: ORA-MAGyP 2011- Federal Cotton Production Statistics

2.22. ***Average annual yields of cotton (sown area basis) vary between Departments***. Over the past 41 years, Fray Justo has recorded the lowest departmental annual average yield of raw cotton of 1,034 Kg/Ha while the highest average yields have been recorded in Sargento Cabral at 1,210 Kg/Ha (Figure 2.6) against a Provincial 41-year long term average yield of 1,146 Kg/Ha. Over the past 5 years the lowest average raw cotton yields have been recorded in Tapenagá at 1,057 Kg/Ha and 9 de Julio has registered the highest average yields of 1,449 Kg/Ha against a Provincial 5-year average yield of 1,296 Kg/Ha.

2.23. ***There is a high level of variation in Departmental average yields of cotton year on year***. Figure 2.7 shows the Coefficients of Variation (COV)[8] in annual yields of raw cotton by department over the same 41-year period. At a Departmental level, the COV's are generally in the order of about 25% or higher indicating that departmental annual average yields are very variable: cotton yields are most variable in Fray Justo Department with a COV of 36%. Yield data is not available at the individual farmer level, but according to INTA data, farmers who use their full technological package can expect to achieve yields of about 2.9 MT/Ha while farmers using lower levels of technology can expect yields of about 1 MT/Ha.

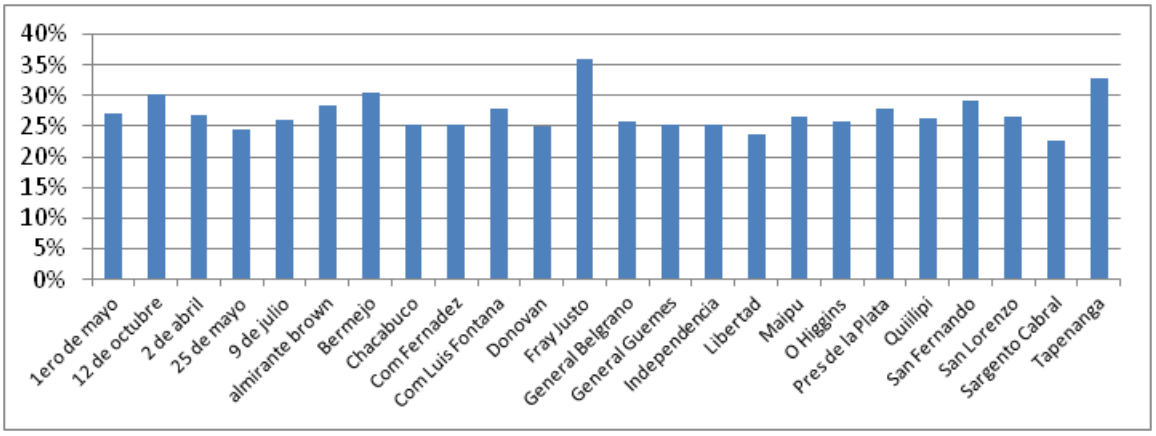
[8] The COV is equal to the standard deviation divided by the mean and expressed as a percentage variation around the mean.

Figure 2.6. Average Annual Yields Raw Cotton 1969/70 to 2009/10 (Sown Area basis) by Department (Kilograms/Hectare)



Source: ORA-MAGyP 2011- Federal Cotton Production Statistics

Figure 2.7. Variation in Annual Yields Raw Cotton 1969/70 to 2009/10 (Sown Area basis) by Department (Coefficient of Variation %)



Source: ORA-MAGyP 2011- Federal Cotton Production Statistics

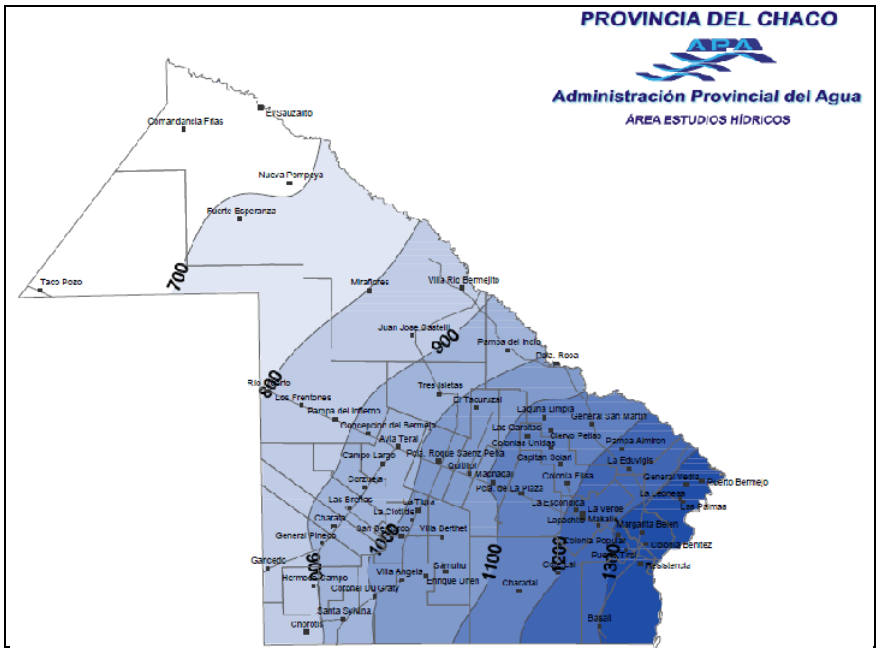
Cotton Production and Climatic Risk in Chaco

Rainfall and Climate in Chaco Province

2.24. ***The rainfall regime in Chaco Province is highly variable.*** The precipitation regime in this Province is referenced to the hydrological year, which runs from September 1st to October 31st of the following year. Although the mean annual rainfall for Chaco Province is around 1000mm, high differences are registered between the 24 Departments. According to a rainfall analysis conducted by APA (2010) for the period 1956-2010, the South eastern regions record the greatest precipitation values of about 1,300 mm, whereas the North eastern regions register in average 700 mm (see Figure 2.8). In terms of the temporal distribution of rainfall, the entire Province shows a similar pattern: higher precipitation records are registered between October and April (80% to 90% of the mean annual rainfall) and dryer conditions between May and

September (10% to 20% of the mean annual rainfall).

Figure 2.8. Average annual precipitation isohyets, 1956 – 2010.



Source: APA

2.25. ***Although the mean annual rainfall in most Chaco Departments should be adequate to meet the water requirements of most crops, the rainfall variability often causes severe limitations for agricultural crop production*** (see Table 2.4). A rainfall analysis conducted by the Office of Agricultural Risks (ORA[9]) shows that both long dry spells conditions and extreme precipitation values are constantly causing crop losses to farmers in Chaco Province. For example, between 1979 and 2009 Las Breñas weather station has registered at least 20 times dry spells with 15 or more consecutive days where precipitation values are equal or less than 2 mm per day. The most severe dry spell in Las Breñas weather station was experienced during the 2008 crop season when no rainfall values were recorded over a period of 25 consecutive days. On the other hand, the precipitation recorded at Las Breñas over 5 consecutive days in April 1985/86 exceeded the total monthly average for April by nearly 2.8 times. These extreme excess rainfall values resulted in crop flooding because both soil water infiltration and soil water holding capacity were exceeded.

[9] The Office of Agricultural Risks is a specialized unit within the Ministry of Agriculture (MAGyP) on agricultural risk management (e.g. agro-climate, price risks). Currently, several private and public institutions have been benefited from ORA´s studies, which includes: weather data analysis (e.g. data cleaning and data de-trending), agro-climate risk zones definition, estimation of crops productivity, crops season monitoring based on estimation of crop water balance models and on vegetation drought risk maps using normalized difference vegetation index (NDVI[9]), and financial and marketing and price related.

Table 2.4. Monthly rainfall variability recorded in Sáenz Peña weather station. Chaco Province.

Month	Avg rainfall (mm) - PPT	DESV. EST (DS)	PPT - DS	PPT + DS	% DS
Jan	156	82	74	238	**53%**
Feb	122	68	54	190	**56%**
Mar	151	95	56	246	**63%**
Apr	138	92	46	230	**67%**
May	54	54	0	108	**100%**
Jun	26	26	0	52	**100%**
Jul	17	17	0	34	**100%**
Aug	28	20	8	48	**71%**
Sep	41	32	9	73	**78%**
Oct	102	64	38	166	**63%**
Nov	129	66	63	195	**51%**
Dec	147	77	70	224	**52%**

Source: Office of Agricultural Risks (ORA-MAGyP).

2.26. ***An analysis conducted with a group of weather stations in Chaco shows a high frequency of both moderate to severe droughts and excess of rainfall events***[10]. Between 1980 and 2009, the number of times in which the weather stations under analysis recorded moderate to severe excess rainfall and rainfall deficit (drought) events were on average 4.16 times and 4.20 times, respectively (see Table 2.5). It is interesting to note, however, that a shift on the frequency of above and below moderate rainfall conditions has been experienced during this 30-year period. While excess rainfall events were more frequent between the 1980s and the 1990s, the number of times in which the group of weather stations recorded such type of events decreased from 43 to 18 events by the end of the 2000s. Conversely, moderate to severe drought conditions almost tripled (2.5 times) between the 1990s and the 2000s.

[10] For the purposes of this analysis, the estimation of moderate to severe events was calculated from the percentage of rain above (below) its norm (1989-2009). The following table shows the percentage of precipitation values that were used as a guidance to differentiate between normal rainfall conditions, Drought (Excess), Moderate Drought (M. Excess) and Severe Drought (S. Excess) events.

Classification	Ranges		
Severe Excess	45.00%	to	more than
Moderate Excess	30.00%	to	45.00%
Excess	15.00%	to	30.00%
Normal	-15.00%	to	15.00%
Drought	-30.00%	to	-15.00%
Moderate Drought	-45.00%	to	-30.00%
Severe Drought	less than	to	-45.00%

Table 2.5. Moderate to Severe Drought (and Excess Rain) events recorded per Weather Station in three different decades (the 1980s, the 1990s and the 2000s)

ID	Subperiod	Moderate to Severe Excess Events				Moderate to Severe Drought Events			
		1980-1989	1990-1999	2000-2009	Total	1980-1989	1990-1999	2000-2009	Total
1	AviaTerai	2	3	1	6	0	1	5	6
2	CampoLargo	2	1	1	4	0	2	3	5
3	Charata	3	1	0	4	1	1	3	5
4	Chorotis	2	2	2	6	3	0	1	4
5	CniasUnidas	2	3	1	6	1	1	3	5
6	CniaElisa	1	3	1	5	1	2	2	5
7	CnelDuGraty	0	2	1	3	1	0	1	2
8	Corzuela	1	0	1	2	1	1	2	4
9	Gancedo	3	0	1	4	2	1	2	5
10	GralPinedo	4	0	0	4	0	0	4	4
11	GralSanMartin	1	1	0	2	0	2	0	2
12	Hcampo	3	1	0	4	1	1	4	6
13	LaClotilde	1	4	1	6	3	1	1	5
14	LaTigra	2	0	1	3	0	2	3	5
15	LasBreñas	2	1	2	5	1	1	1	3
16	LasPalmas	1	1	0	2	1	0	1	2
17	LagunaLimpia	2	3	0	5	1	0	4	5
18	Machagai	1	4	1	6	1	0	3	4
19	PdelIndio	1	1	1	3	0	2	3	5
20	PciadelaPlaza	0	3	1	4	0	2	3	5
21	PRSaenzPeña	1	1	1	3	0	1	1	2
22	Resistencia	1	2	1	4	1	0	2	3
23	SantaSylvina	3	1	0	4	1	1	2	4
24	TresIsletas	2	2	0	4	0	1	4	5
25	VaAngela	2	3	0	5	1	1	2	4
	Total	**43**	**43**	**18**	**104**	**21**	**24**	**60**	**105**
	Avg	**1.72**	**1.72**	**0.72**	**4.16**	**0.84**	**0.96**	**2.40**	**4.20**

Source: The authors.

2.27. ***Floods are a recurring phenomenon which is associated with El Nino event. A research conducted by Gentile (ND) reveals that some of the major flooding events due to excess rainfall recorded in the Northern region of Argentina have been associated with El Niño phenomenon*** (See Figure 2.7 for major Niño and Niña events over the past 60 years). Some of these years include (i) the extraordinary 1982/1983 rainfall season, which cover about 70% of the total territory and affected directly or indirectly about 50% of its population; (ii) 1985/1986 hydrological year; (iii) 1991/1992: according to the National Meteorological Service, the adverse weather conditions affected more than 101,000 persons, and more than 3,000,000 Ha, distributed between Formosa, Chaco, Misiones, Corrientes, Santa Fe and Entre Rios Provinces, were under water. In Chaco, the cotton sector was severely impacted due to the inability of farmers to harvest their crops; (iv) 1998/1999: this event was considered the most catastrophic flood during the 20th Century which impacted about one third of all Argentinean Provinces located on the banks of Parana and Paraguay rivers, (v) 2008 (April)[11], and (vi) 2012: when more than 130 mm were recorded in less than 5 hours in Resistencia, the Capital city of the Province[12].

2.28. ***Droughts are also a common feature of the Chaco and again cause major losses to the crop and livestock Sectors.*** In Argentina droughts are often associated with the La Niña phase of the ENSO cycle.

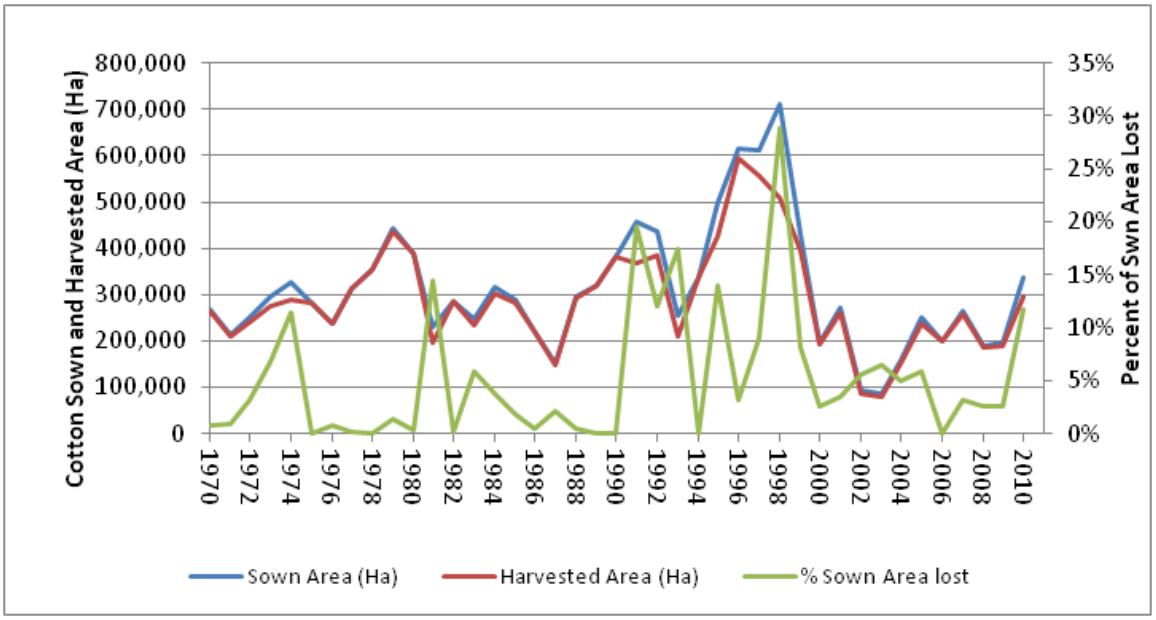
2.29. ***There is very little recorded data of the physical and financial losses caused by floods and droughts and other causes in cotton grown in Chaco Province***. In the absence of useful crop production loss data, an analysis has been performed to compare the ratio of sown area to

[11] http://www.perfil.com/contenidos/2009/11/24/noticia_0024.html
[12] http://tn.com.ar/sociedad/inundacion-en-chaco-hay-2000-evacuados_002275

harvested area of cotton. The un-harvested area provides a good approximation of the area which is 100% destroyed by natural and climatic perils. Over the 41 year period, there have been 8 years in which greater than 10% of the cotton crop sown area has not been harvested (has been lost) which represents a frequency of 1 in every 5 years (Figure 2.9). There is a very close relationship between years of major losses in the cotton crop and the ENSO phenomenon (Figure 2.10). The major cotton area loss event years include: 1997/98 which was the most severe El Niño of the 20th century when 205,000 Ha of sown cotton (29% of sown area) were not harvested due to severe flooding, followed by three consecutive years 1990/91, 1991/92 and 1992/93 when between 12% and 20% of sown cotton area was lost and which again coincides with El Niño conditions, 1994/95 (14% of sown area lost: El Niño conditions); 1980/81 (14% of sown area lost), 1973-74 (12% sown area lost) and which coincided with a severe La Niña drought year, and finally 2009-10 (12% of sown area lost) and which was a severe El Niño year (excess rain and flooding).

2.30. ***The official cotton production statistics for Chaco Province suggest that over the past 41 years an annual average area of 20,174 Ha of cotton or 6.5% of the total sown cotton area has been lost due to climatic and other perils with an estimated value of losses at 2012 cotton prices in the order of AR$ 50 million (US$ 10 million) per year***[13]. In major loss years such as 1997/98 when an estimated 205,000 Ha of the cotton crop was lost due to excess rain and flooding, the value of losses at current prices would be a huge AR$ 513 million (US$ 103 million).

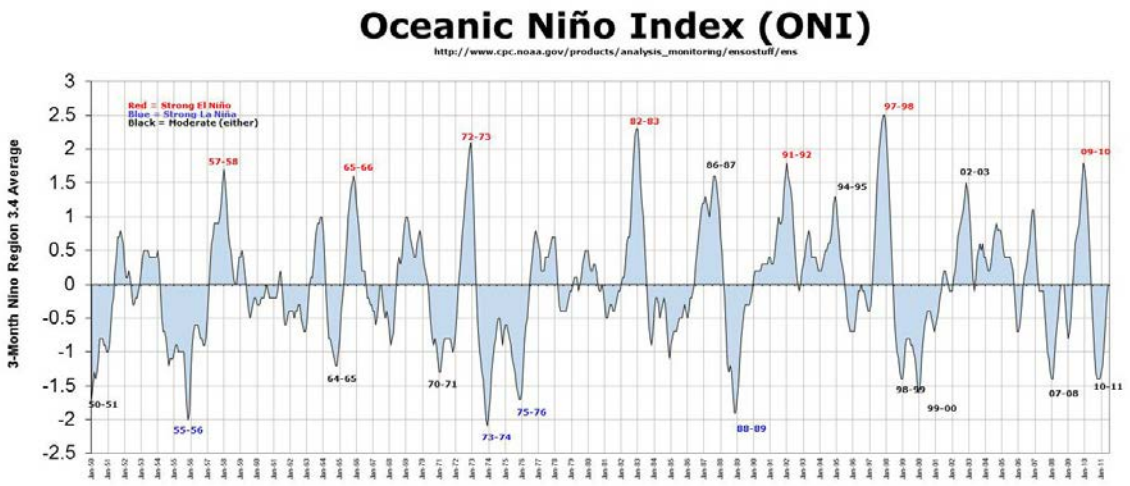
Figure 2.9. Chaco Comparison of Sown and Harvested Cotton Area and % of crop area lost (1969/70 to 2009/10)



Source: ORA-MAGyP 2011- Federal Cotton Production Statistics

[13] This simple calculation assumes an average gross revenue or sale value for cotton of AR$ 2,500/Ha or US$ 500/Ha

Figure 2.10. El Nino Index 1950 to 2011



Source: NOAA

Cotton Crop Insurance Experience in Chaco Province.

2.31. ***Back in 1999, the World Bank developed a risk analysis study and suggested developing an individual insurance scheme for the agricultural and livestock sector in Argentina.*** The objective of this study was to develop a disaster assistance program that could provide adequate coverage for the farming sector when there are catastrophic crop losses. The study proposed to use different frequency values of area yield data by crop and by department for the implementation of an agricultural insurance in several provinces[14], including Chaco. The technical basis of this study was based on the assumption that there was a relationship between farm level yields and regional yields.

2.32. ***In 2006, the Inter-American Development Bank (IADB) financed a feasibility study on the development of rainfall index insurance contracts for individual cotton farmers in Chaco.*** The departments where the study concentrated included Comandante Fernandez, 12 de Octubre, Santa María del Oro, and Mayor L. Fontana. The proposed contract defined rainfall indexes to cover excess rainfall and rainfall deficit (drought) for each of the crop growth stages (i.e. crop development, flowering, buds development and harvesting). All rainfall indexes were set based on the probability of occurrence of the rainfall event resulting in a reduction in the cotton crop yields. Insurance payouts were designed to be triggered when the cumulative rainfall was below (above) the underlying index.

2.33. ***Starting in the 2008/09 season, a group of Argentinean private sector agricultural insurers launched an individual grower MPCI loss of Yield Cover for large-scale cotton producers in Chaco province under an agreement with the GoC to link this program to subsidised crop production credit.*** A financial agreement between the local Government and the insurance companies led to the creation of the cotton MPCI policy to protect an AR$ 265 million trust fund. Due to the lack of credit loans for cotton farmers, the Government of Chaco created the "Chaco Province Produces Cotton" trust fund with the objective to stimulate the cotton sector.

[14] The report "Risk Analysis and Development of Agricultural and Livestock Insurance in Argentina" proposed that the suggested insurance scheme should be made available to farmers located in the provinces of: Buenos Aires, Chaco, Cordoba, Entre Rios, La Pampa, Santa Fe and Santiago del Estero.

Credit loans granted to farmers up to a maximum of AR$ 1,400 per hectare were protected with a MPCI insurance cover designed by Sancor in collaboration with Banco de Inversión y Comercio Exterior (BICE). During the first crop season 2008/2009, the guaranteed cotton yield was about 73.5% of the average yield or 883Kg/Ha of raw seed cotton, but on account of high financial losses, the insurers reduced the level of yield protection to about 55.5% of average yield or only 667 Kg/Ha during the following 2009/10 crop season (CONES 2012). It is worth noting that interviewed farmers expressed their dissatisfaction with the former guaranteed yield set at 55.5% of the department average yield. This level of coverage was considered to be too low by a group of farmers, especially to those cotton producers who apply advanced production systems and achieve average yields in excess of 2.5 MT/Ha. The MPCI cotton insurance program incurred major financial losses both in 2008/09 and again in 2009/10, at which point the private sector insurers declined to renew the program in 2010/11.

2.34. ***During the 2010/2011 crop season, Nación Seguros S.A. – a local insurance company – launched a cumulative rainfall index product to cover cotton farmers against rainfall deficit during the vegetative period and excess rainfall at boll ripening and harvest.*** This insurance contract was linked to credit loans provided to farmers located in the departments of 12 de Octubre, 9 de Julio, Comandante Fernández, Mayor Fontana and Santa María de Oro. Due to lack of financial resources to finance the insurance premiums, the index-based insurance program was discontinued the following crop season. Box 2.1 provides further details of this insurance product.

Box 2.1. Micro level index based insurance for cotton farmers (2010/2011 crop season).

Policy Type: Index-based insurance for individual farmers.

Period and Insured Perils:

- Drought: 15 December to 15 February.
- Excess rainfall: 1 March to 1 April

Sum Insured: Agreed value basis. The total sum insured is defined based on the reported planted area within each weather station, the reference price that has been set for raw cotton, and the reference yield defined for each one of the productive systems. The sum insured for each coverage period was 50% of the total sum insured of each weather station.

Payout Definition: Graduated payouts based on the deviation (positive or negative) of cumulative precipitation values registered during each cover period. For the case of drought, a payout is triggered when the precipitation value recorded at the reference weather station is below 50% of the mean rainfall of the period of interest. Conversely, the excess of rainfall coverage triggers a payout when the precipitation value recorded at the reference weather station exceeds 1.85 times the mean rainfall of the cover period.

Reference Weather Stations: Gancedo, Santa Sylvina, Villa Angela, Las Breñas, Saenz Peña.

Source: the authors, based on discussions held with the senior management team of the Ministry of Agricultural Production and the Environment of Chaco Province.

2.35. ***For 2011/12 the Cotton MPCI-crop credit program for individual cotton producers was underwritten by Nación Insurance Company.*** The results of the 2011/12 season are not known, but during the December 2012 review Mission farmers complained that they were still waiting confirmation of their insurance contracts and in some cases their indemnity payments for yield losses.

2.36. ***During the May 2013 Mission, MPCh confirmed that for the expiring 2012/13 cotton***

campaign they had not been able to purchase cotton insurance cover from any public or private insurance company in Argentina. MPCh is concerned that its loan portfolio to cotton growers is extremely exposed to climatic risk in the absence of any crop insurance protection. MPCh was therefore extremely interested to learn about the findings and conclusions of the World Bank study into macro-level index (WII or AYII) cover to protect public sector lending to small and medium cotton farmers in Chaco Province. These findings are presented in the following sections: Chapter 3 presents the findings and conclusions of the rainfall index feasibility study and then in Chapter 4 options are presented for a macro-level Area-yield index insurance (AYII) cover.

3. Weather Index Insurance Opportunities for Cotton in Chaco Province

Features of Weather Index Insurance, Advantages and Challenges

3.1. ***The essential feature of weather index-based insurance (WII) is that the insurance contract responds to an objective parameter (e.g., measurement of rainfall or temperature) at a defined weather station during an agreed-upon time period.*** The parameters of the contract are set so as to correlate, as accurately as possible, with the loss of a specific crop type suffered by the policyholder. All policyholders within a defined area receive payouts based on the same contract and index measurement at the same station, eliminating the need for field loss assessment.

3.2. ***WII is best suited to weather hazards that are well-correlated over a widespread area and where there is a close correlation between weather and crop yield.*** The strongest relationships typically involve a single crop, a marked rainy season, and no irrigation. WII is less useful where more complex conditions exist. Localized risks, such as hail, or where microclimates exist (for example, in mountainous areas) are not suitable for WII. Similarly, the scope for WII is limited where crop production is impacted by many or complex causes of loss or where pest and disease are major influences on yields. For a given environment, other insurance products may be more appropriate (such as area-yield index insurance or named-peril crop insurance).

3.3. ***Basis Risk is the key constraint of WII and is defined as the difference between the loss experienced by the farmer and the payout triggered by the weather index.*** Basis risk could result in a farmer experiencing a yield loss, but not receiving a payout, or conversely in a payout being triggered without any loss being experienced. WII works best where losses are homogenous in the defined area, and highly correlated with the weather peril. The main advantages and disadvantages of WII are described in Box 3.1.

Box 3.1. Advantages and Disadvantages of Weather Index Insurance

Advantages

- **Standardized and transparent contract structure:** Index insurance contract parameters are usually designed in collaboration with the policyholder and key stakeholders; therefore, contract details as well as the information on which the payouts will be calculated are easily accessed by all the parties.
- **Lower administrative costs:** The index uses a proxy variable that is set at a level in which crop losses are expected to occur, and as farm-level or regional loss adjustments are not required by the insurance industry there are potentially major costs savings.
- **Lack of adverse selection:** Adverse selection occurs when potential insured parties have hidden information about their risk exposure that is not available to the insurer, who then becomes more likely to erroneously assess the risk of the insured. Traditional insurance encourages high-risk producers to insure, whereas risk (and premium) is calculated on the average producer. Index insurance requires that all insured farmers within the defined area have the same insurance payout conditions, regardless of their specific risk exposure. Hence, insurers and clients benefit from reduced adverse selection.
- **Lack of moral hazard**: Moral hazard occurs when a party, by intent, manipulates the normal operation of the insurance scheme in a way that his actions alters both the magnitude and frequency of payments. With WII, the possibility to influence claims is considerably diminished because the magnitude and frequency of the payout is linked to the measurement of a weather variable. All producers in the defined area are treated equally under an index insurance.
- **Addresses correlated risks**: Index products work best where there are correlated risks. Perils such as drought are challenging to insure under traditional products.
- **Low operational and transaction costs**: Index insurance requires limited individual underwriting (client assessment). It can be distributed, and claims can be settled, at relatively lower cost. Education in the product remains important, both prior to product launch and ongoing.
- **Rapid payout**: Measurement of weather station data, with no field loss adjustment, allows rapid payouts to be made.

Disadvantages

- **Basis Risk:** Basis risk in WII is a key constraint. Basis risk is the difference between the loss experienced by the farmer and the payout triggered. It could result in a farmer experiencing yield loss, but not receiving a payout or also in a payout being triggered without any loss being experienced. Index insurance works best where losses are homogenous in the defined area, and highly correlated with the indexed peril. Basis risk occurs when there is a poor correlation between the index and the actual losses experienced by the policyholder, Basis risk can arise from:
  - **Spatial basis risk**: Local variations in the peril occurrence (e.g., rainfall) within the area surrounding a weather station.
  - **Temporal basis risk:** Inter-annual variations in seasonal crop phases, meaning that the insurance phases are not aligned in time with the intended crop growth stage.
  - **Product basis risk:** Crop losses can be caused by many factors. Where there is not a clear-cut relationship between loss and the indexed weather peril, basis risk can be high. WII is most likely to work for rainfed crops, and at severe levels of the event, when losses may be more widespread and homogenous.
- **Limited perils:** WII normally only covers one, and sometimes two, weather perils. Although reducing cost compared to MPCI, the product may not provide broad enough coverage to satisfy risk management needs.
- **Replication**: The triggers, limits, and increments of a specific product need to be adjusted to reflect the weather parameters of each weather station. Different product designs are required for different crop types (or at least generic crop types). WII requires considerable technical work to implement and be sustained.
- **Technical capacity and expertise** is required, particularly during the initial design phase for new products, in agro-meteorology and in operationalizing the products.
- **Lack of weather data:** WII depends on the availability and quality of weather data, which can drastically vary from country to country. In developing countries, the shortage of historical and real-time weather data is often a major hurdle.

Source: World Bank 2010

Options for Weather Index Insurance at Micro, Meso and Macro-levels

3.4. ***WII can be implemented at different levels of aggregation according to who is the intended target group and classification is usually carried out according to who the actual policyholder is.***

3.5. ***At the micro level, the policyholders (the insurer's customer) are farmers, households, or small business owners who purchase insurance to protect themselves from potential losses caused by adverse weather events.*** Micro-level individual farmer insurance policies are typically marketed by the insurance companies and their sales agents. Micro policies can also be distributed to farmers by organizations such as financial service providers, farmer associations, input suppliers, processors, or NGOs[15]. In addition to having wider outreach to the target group than most insurers, these intermediaries also have vested social or commercial interests in protecting themselves and their smallholder clients against the weather risk. For example, insuring the farmers can help financial service providers, input suppliers, and other intermediaries manage their risks of default by farmers. This in turn can help to unlock development opportunities for poor smallholders, such as access to credit, or higher quality inputs.

3.6. ***At the meso-level, organizations such as financial service providers, input suppliers, and other intermediaries can act as the policyholder.*** At this level, WII can be structured through a policy issued to the organization, but with payout rules which could either directly or indirectly benefit farmers– for example to alleviate mass loan defaults in a microfinance institution (MFI).

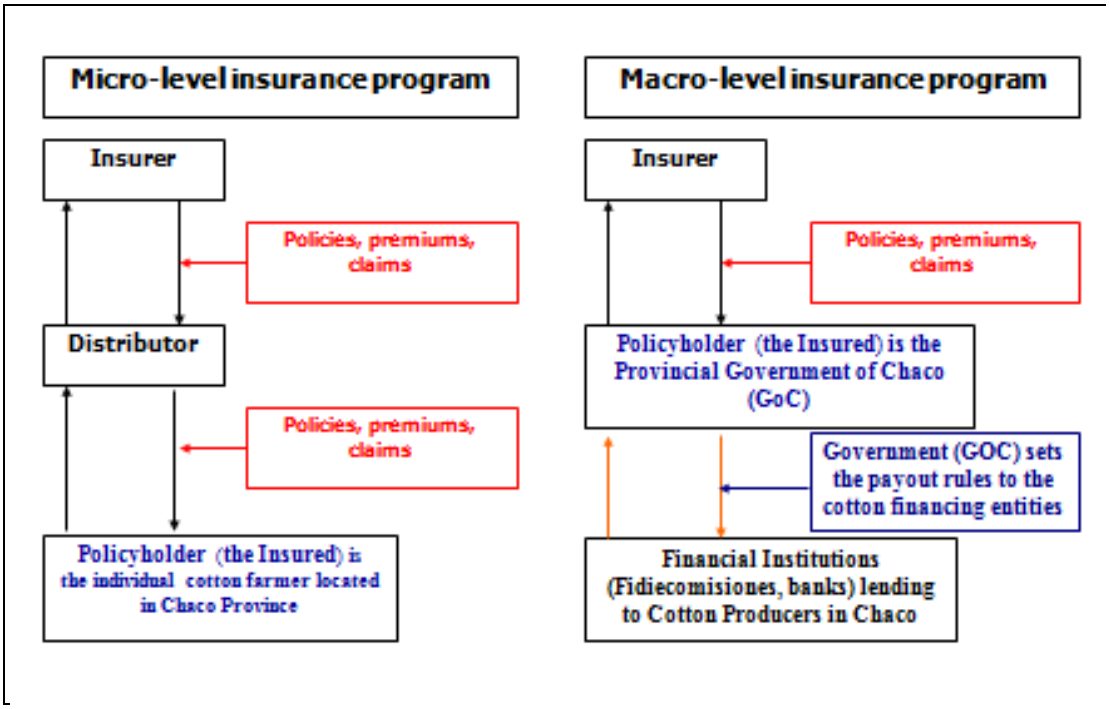
3.7. ***Finally, index insurance can also be sold at the macro-level, to aid governments and relief agencies in development and disaster management.*** Traditional national disaster relief programs rely on ex-post financing of losses incurred by the rural or urban communities. Few Governments have adequate budgeted and readily accessible funds to cover the full losses caused by natural disasters and then have to resort to ad hoc measures to try to generate additional funding from local and international sources. Conversely macro-level index insurance has been used successfully as an ex-ante planned risk financing approach where Government for the payment of a given up front premium can guarantee timely access to a given amount of contingency funding with which to finance emergency food aid to farmers in the affected regions.

3.8. ***In the context of this Feasibility Study, from the outset the proposals have centered on the development for Government of Chaco (GoC) of a meso-level WII (Or AYII) index cover designed to protect its credit lending through appointed financial institutions to the selected small and medium cotton producers in Chaco Province***. Figure 3.1 illustrates the main differences between an individual farmer micro-level WII program where the farmer is the Insured and pays a premium in return for a direct payout if the WII policy is triggered during the cover period. The second half of the figure shows a macro-level WII cover aimed at protecting GoC's-MPCh's credit exposure under the planned PRODAF program for up to 600 small and medium cotton producers who will be the beneficiaries of the program over the next 4 years. Under the Macro-level cover, GoC would be the Policy holder and responsible for the payment of premium. GoC would also be responsible for setting the payout rules, which might center on (i) payouts being made to the financial institution appointed under the program in order to secure the loans they are making to individual cotton producers in each Insured Unit (as defined by a weather station if a WII product is designed, or in the case of AYII a department); or (ii) if the

[15] Intermediaries may be subject to regulatory approval, and the potential regulatory implication of such a scheme should be carefully assessed.

payout exceeds the amount of loan owed by a cotton producer to the financial institution, it would then be appropriate to channel the balance of the payout back to the individual producer under rules which would have to be agreed by all parties (the Insured, the Insurer(s) and the financing institutions). Under no circumstances is it recommended in the start-up stage of a new macro-level program for cotton in Chaco that the individual farmer is named as a beneficiary in the policy that is issued as this may convey unintended rights to the farmer to claim on the Policy in the event of climate related losses in his/her own fields of cotton. (See Chapters 4 and 5 for further discussion).

Figure 3.1. Comparison of Micro-Level WII Insurance for Cotton Production in Chaco with a Macro-level program for Government to Protect Financial lending to Cotton Producers



Source: Authors based on CRMG 2010

International Experience with Weather Index Insurance

3.9. ***The majority of WII experience has been with micro-level applications and rainfall deficit (drought).*** To date, many initiatives have been piloted, but only in India has a market-based scale-up of WII taken place. Table 3.1 provides a synoptic summary of the countries in which WII has been piloted.

Table 3.1. International Experience with WII

Micro level	Weather-indexed insurance for smallholder farmers: Examples: India, Nicaragua, Malawi, Ukraine, Thailand, Ethiopia, Kenya, Ghana, The Philippines, China. Over 30 projects in about 25 countries. Scale-up only in India
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 (Caribbean Catastrophe Risk Insurance Facility, 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 Pan Africa WFP macro-level satellite rainfall drought index initiative linked to food security (awaiting launch)

Source: World Bank 2010, updated by Authors to 2013

Assessment of Macro-level Rainfall Deficit and Excess Rainfall Indexes for Cotton in Chaco Province]

3.10. ***The World Bank has conducted an analysis for a group of selected weather stations of a macro-level rainfall index cover to protect small and medium[16] cotton producers in Chaco Province.*** The contract details tested under this technical assistance are described below:

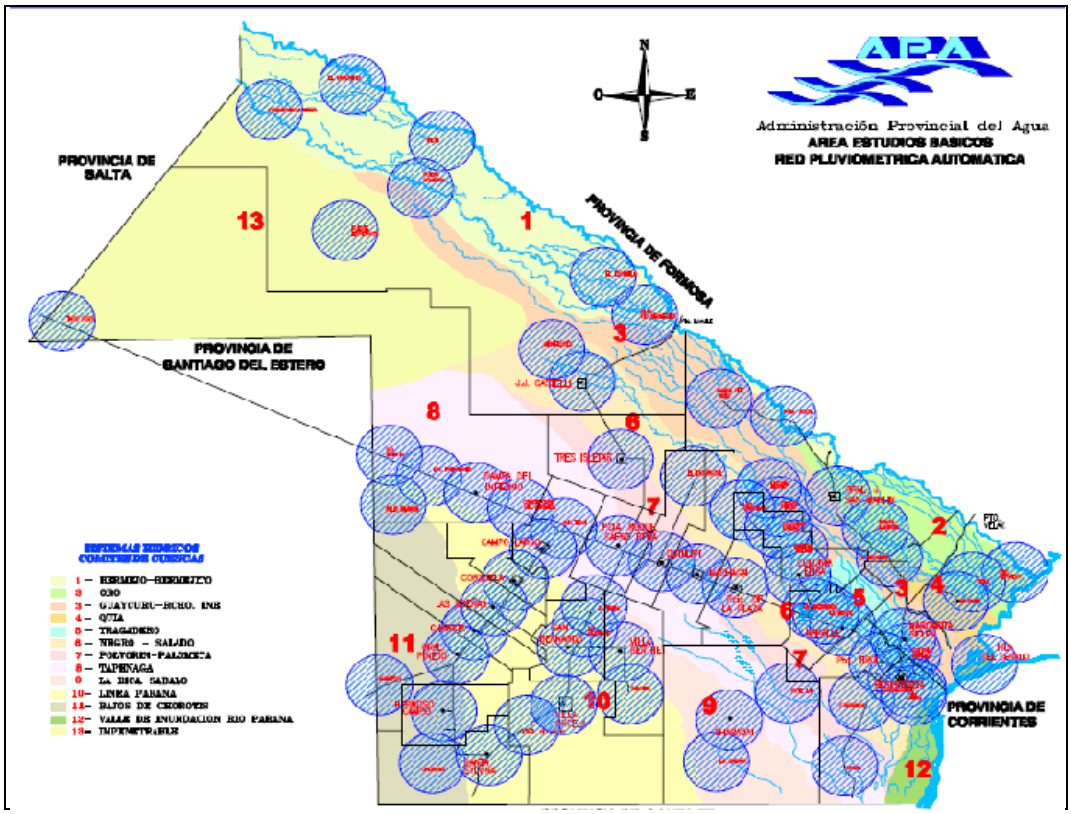
Data Assessment

3.11. ***The analysis of the impact of extreme rainfall events (both drought and excess of rainfall) was conducted with historical precipitation values recorded by the Provincial Administration of Water (APA) weather stations.*** APA, the maximum authority for monitoring and assessing water and weather dynamics in Chaco Province, owns valuable historical rainfall datasets for the conduction of risk analysis and to assess the potential impact of adverse weather conditions on crop production. Since it was created, APA has installed, improved and provided maintenance to the provincial rain gauge network[17] (45 electronic rain gauges, and 19 class "B" rain gauges) distributed in 13 basins, and whose coverage period extends from 1954 to present (see Figure 3.2).

[16] Small and medium cotton farmers are described as those whose farm size ranges between 10 and 100 Ha of planted area.

[17] Since 1997, APA has installed rain gauges that are fully recognized and used by the National Meteorological Service. A great proportion of the rain gauges are installed in police office buildings in order to facilitate data transmission though the police radio communication system twice a day (7 AM and 7 PM) all days of the year.

Figure 3.2. APA rain gauge network distribution, Chaco Province, 2010.



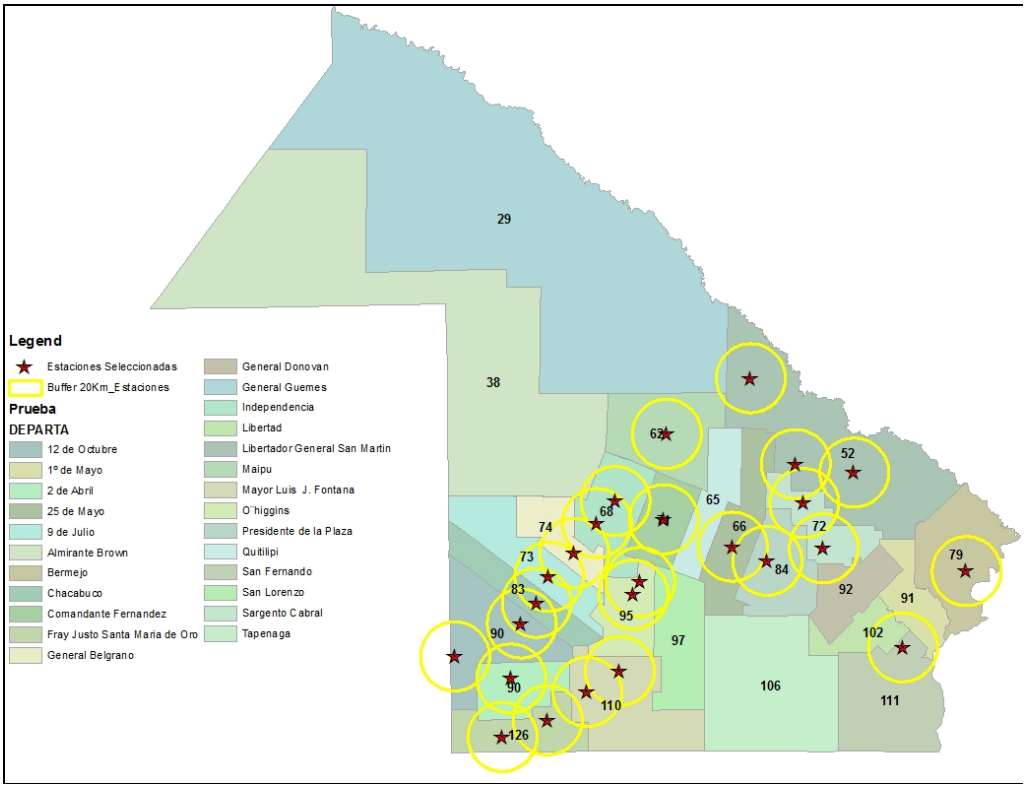
Source: APA, 2005

3.12. ***The design of a weather index insurance contract starts with the analysis of the variable of interest and the adequacy of existing infrastructure for data recording and data transmission.*** The World Bank team took advantage of the technical worked performed by the Office of Agricultural Risks (ORA) on APA rainfall database. In 2005, ORA completed a consistency rainfall data analysis for 25 rain gauges (see Table 2.4, Chapter 2). A detrended dataset (1980 – 2009) of this very well distributed group of weather stations (See Figure 3.3) across the main cotton production areas allowed ORA and the authorities from the MPCh working on the generation of agro-meteorological products such as: water balance model for cotton[18] (Figure 3.4 shows critical values of soil moisture throughout the crop season) and the definition of hydrological risk maps. The later product was created based on the definition of different return periods for maximum precipitations recorded over a 60-day period19. The study conducted by ORA, covered an important agricultural production area which comprises more than 2,000 hectares including the basins of Bajos de Chorotis, Línea Praná, La Rica-Sábalo and Tapenagá. No missing values were identified on any of the selected weather stations during the period 1980 – 2009; for this reason, no additional work was needed to be performed to full fill gaps and/or outliers.

[18] Sunflower, maize, and soybean were also analyzed under the water balance model.

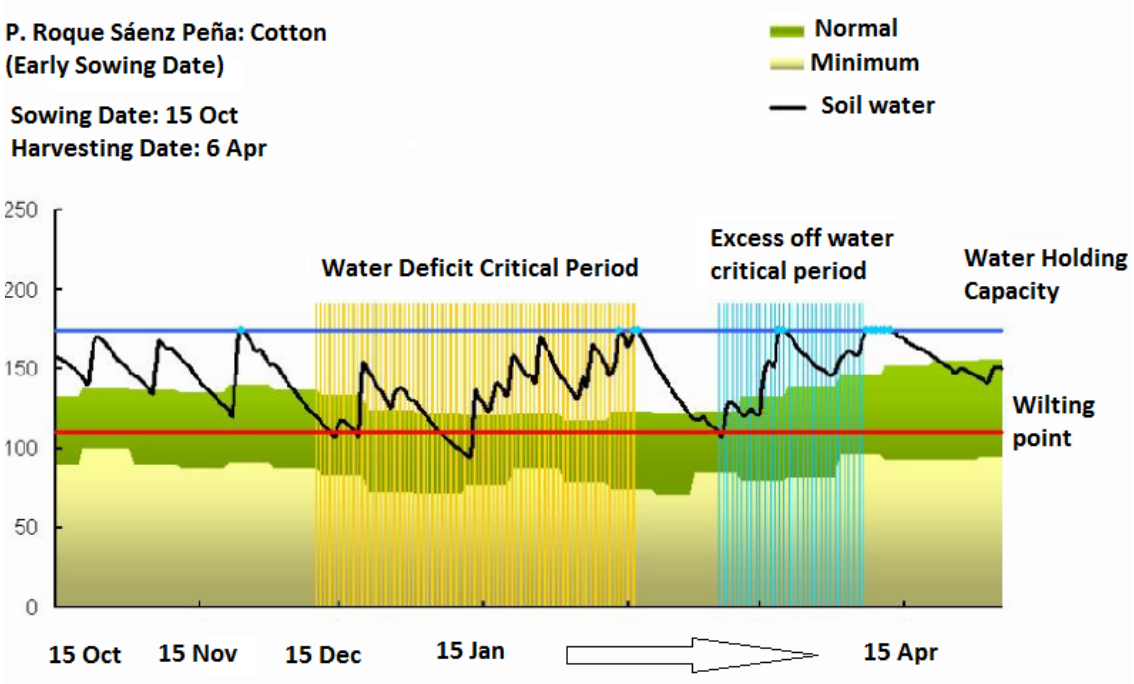
[19] A classification of affected areas due to floods was performed according to the following criteria: i) Severe Risk of flooding: return period < 2 years, ii) High Risk of flooding: return period between 2 and 5 years; iii) Moderate Risk of flooding: return period between 5 and 15 years, and iv) Low Risk of flooding: return period greater than 15 years.

Figure 3.3. Location of selected weather stations in cotton production areas



Source: APA 2012

Figure 3.4. Water balance example for cotton, P. Roque Sáenz Peña weather station.



Source. ORA-MAGyP.

3.13. ***Department cotton yields were used to estimate the correlation between negative yield deviations and modeled index based payouts.*** Area yield data per department was supplied by ORA and the Ministry of Production for 1969/70 – 2009/10. This dataset was used to examine whether there exist a positive correlation between departmental yields and modeled payouts that were triggered when the underlying index for each crop stage exceeded or fell below a pre-defined threshold. A technical limitation on the analysis conducted by the World Bank consists on the assumption that the crop yield is similar throughout the entire department. This means that local yield variations due to differences on cotton production systems among farmers, or due to soil and climatic conditions are not accurately reflected.

Chaco Cotton Rainfall Index Feasibility Study

3.14. ***The World Bank tested two types of rainfall index cover for cotton:*** (i) cumulative rainfall in millimeters during four different cotton vegetative growth stages; and (ii) a number of consecutive days drought[20] cover during each of the four crop growth stages. In both cases, the total length of the cotton crop cycle (or Cover Period) was assumed to be 120 days (in accordance with the widely sown short-duration GM varieties in Chaco province) divided into four stages: stage 1 comprises 20 days or 2 dekads; stage 2 comprises 30 days or 3 dekads; stage 3 comprises 30 days or 3 dekads; and finally, stage 4 comprises 40 days of 4 dekads. The Sum Insured was set at a revenue based valuation of AR$2,200 per hectare. For the purposes of this analysis, the maximum liability was related to the cumulative production cost at the end of each crop growth stage. The Sum Insured, however, can be modified by the interest parties in order to reflect other insurable amounts (i.e. cost of financing).

3.15. ***The proposed WII contract start date was set according to the location of the weather station.*** The selection of the sowing date per weather station varies according to each cotton production region: the authorities from the MPCh together with the National Agricultural Sanitary Agency (SENASA[21]) have defined different sowing dates for cotton production across the province (15 Oct – 15 Dec). The above was made as part of an initiative of the provincial authorities to improve the level of infestation of the cotton boll-weevil. Given that the duration of the cotton sowing window is extensive (2 months in total), the contract start date was defined to start at a central date of the planting dates specified by the authorities. Table 3.2 summarizes the plantings dates per production region, and per weather station.

[20] Due to the characteristic high spatial rainfall variability in Chaco Province, the World Bank considered that defining an excess rainfall cover based on the count of consecutive rainy days in which each day the rainfall amount exceeds a predefined threshold would not add any value. Therefore, such type of cover was not included as part of the analysis.

[21] Through SENASA's resolution No. 74/2010, the sowing window for both **the North and East region**, both of which comprise the Departments of 25th of May, Presidencia de la Plaza, Tapenagá, General Donovan, Libertad, 1° de Mayo, San Fernando, Bermejo, Sargento Cabral, General San Martin, General Güemes y Almirante Brown, was set between **1st Oct – 15th Nov.** For the **Central and South regions** (Maipú, Independencia, Comandante Fernández, O´Higgins, Mayor Luis Fontana y San Lorenzo) the sowing window has been set between the **15th Oct – 30th Nov**; and for the **West region** (General Güemes, 9 de Julio, 12 de Octubre, 2 de Abril y Fray Justo Santa María de Oro), the sowing window was set for the period of **1st Nov – 15th Dec.**

Table 3.2 Contract start date and sowing window per cotton production zone.

ID	WS Name	Department	Production Region	Sowing Window	Contract Start Date	Contract End Date
1	CniaElisa	Sgnto. Cabral	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
2	CniasUnidas	Sgnto. Cabral	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
3	GralSanMartin	L. Gnral. Sn Martín	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
4	LagunaLimpia	L. Gnral. Sn Martín	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
5	LasPalmas	Bermejo	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
6	Machagai	25 Mayo	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
7	PciadelaPlaza	Presidente de la Plaza	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
8	PdelIndio	L. Gnral. Sn Martín	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
9	Resistencia	San Fernando	North & East	1 Oct - 15 Nov	1-Nov	1-Mar
10	Charata	Chacabuco	West	1 Nov - 15 Dec	15-Nov	15-Mar
11	Chorotis	F. Sta. María Oro	West	1 Nov - 15 Dec	15-Nov	15-Mar
12	Corzuela	Gnral. Belgrano	West	1 Nov - 15 Dec	15-Nov	15-Mar
13	Gancedo	12 Octubre	West	1 Nov - 15 Dec	15-Nov	15-Mar
14	GralPinedo	12 Octubre	West	1 Nov - 15 Dec	15-Nov	15-Mar
15	Hcampo	2 Abril	West	1 Nov - 15 Dec	15-Nov	15-Mar
16	LasBreñas	9 Julio	West	1 Nov - 15 Dec	15-Nov	15-Mar
17	SantaSylvina	F. Sta. María Oro	West	1 Nov - 15 Dec	15-Nov	15-Mar
18	AviaTerai	Independencia	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar
19	CampoLargo	Independencia	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar
20	CnelDuGraty	M. Fontana	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar
21	LaClotilde	O´Higgins	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar
22	LaTigra	O´Higgins	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar
23	PRSaenzPeña	Cnte. Fernández	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar
24	TresIsletas	Maipu	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar
25	VaAngela	M. Fontana	Central & South	15 Oct - 30 Nov	30-Nov	30-Mar

Source: authors based on information provided by the MPCh.

3.16. ***The contract parameters for cumulative rainfall cover in Las Breñas Weather Station are provided in Table 3.3.*** The formula for triggering a payout in each vegetative growth stage is given as ($Trigger_i$ – Cumulative $Rainfall_i$) x $Tick_i$. This formula applies only when there are "partial losses", that is when the cumulative rainfall amount is below the Trigger and above the Limit (also known as the Exit). In this case, the total payout will be the sum of all the payouts registered in each crop stage. On the other hand, when the cumulative rainfall is below the Limit, the total payout will be the sum insured amount allocated to the crop stage where the event was recorded. If such an event is triggered and there are still other crop stages remaining, it is assumed that a total crop loss is experienced; therefore, producers will not make additional investments in their fields. Contract parameters for each weather station under this study are shown in Annex 3.

Table 3.3. Example of cumulative rainfall contract parameters, Las Breñas weather station.

Stage	Length		Cost Distribution	Drought			Excess Rainfall		
	Start	End		Trigger	Limit	Tick (US$/mm)	Trigger	Limit	Tick (US$/mm)
1	1	2	$ 660.00	37.44	10.00	$ 24.05	274.23	182.82	$ 7.22
2	3	5	$ 1,100.00	47.81	10.00	$ 29.09	370.29	246.86	$ 8.91
3	6	8	$ 1,540.00	63.61	10.00	$ 28.72	421.68	281.12	$ 10.96
4	9	12	$ 2,200.00	70.10	10.00	$ 36.61	382.98	255.32	$ 17.23

Source: Authors' WII analysis

3.17. ***The estimation of payouts for the consecutive days drought contract is calculated based***

on the construction of a binomial table in which a percentage payout of the sum insured per crop stage is given for a pre-agreed number of consecutive days drought (see Table 3.4). A "drought day" is defined when the precipitation value is equal or lower than 2 mm per day. In this vein, a payout will be received in stage one when there are more than 6 consecutive days drought; in stage two, payouts will be disbursed when registering over 9 consecutive days drought, and so forth and so on. The total payout will be the sum of all the partial payouts registered on each crop stage. Table 3.4 summarizes the payout scale according to the crop stage in which an Insured Event is registered.

Table 3.4. Example of consecutive drought days contract parameters, Las Breñas weather station.

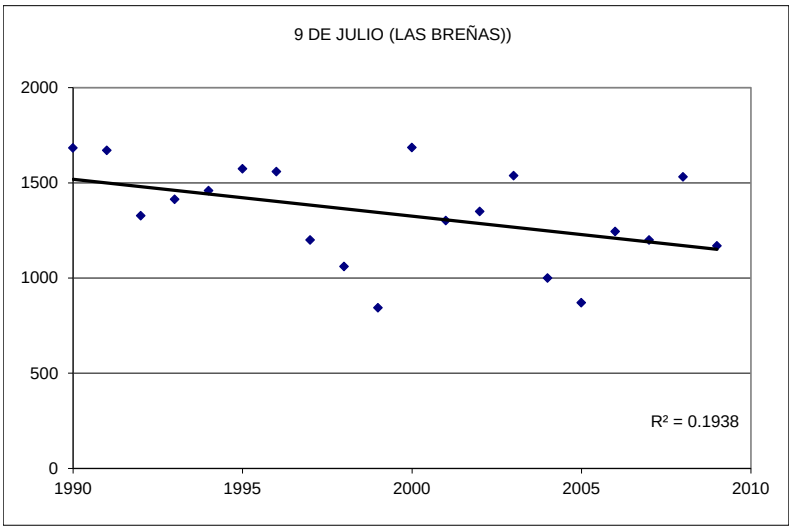
Consecutive	Loss per Crop Stage (%)			
Days Drought	Stage 1	Stage 2	Stage 3	Stage 4
0	0%	0%	0%	0%
1	0%	0%	0%	0%
2	0%	0%	0%	0%
3	0%	0%	0%	0%
4	0%	0%	0%	0%
5	0%	0%	0%	0%
6	0%	0%	0%	0%
7	5%	0%	0%	0%
8	6%	0%	0%	0%
9	7%	0%	0%	0%
10	8%	10%	0%	0%
11	9%	11%	0%	0%
12	10%	12%	0%	0%
13	11%	13%	13%	0%
14	12%	14%	14%	0%
15	13%	15%	15%	0%
16	14%	16%	16%	11%
17	15%	17%	17%	12%
18	16%	18%	18%	13%
19	17%	19%	19%	14%
20	18%	20%	20%	15%
21	19%	21%	21%	16%
22	20%	22%	22%	17%
23	20%	23%	23%	18%
24	20%	24%	24%	19%
25	20%	25%	25%	20%

Source: Author's WII analysis

Key Issues, Challenges and Conclusions

3.18. ***For both rainfall index covers modeled (cumulative rainfall and a number of consecutive days rainfall), the analysis showed a very poor correlation between Departmental yield data and modeled annual loss values and index payouts.*** For example, the highest correlation values obtained in Las Breñas weather station correspond to the drought cumulative rainfall index cover with an R^2 of 0.0431, and consecutive day's drought cover with an R^2 of 0.0415. On the other hand, the cumulative excess rainfall index cover only explained 1.47% of the department cotton yield variability. The results of this analysis are consistent with those found by ORA when comparing water balance outputs with Departmental average raw cotton yields (see Figure 3.5). The very low correlation found in both rainfall index cover suggest that rainfall is only one of many factors affecting cotton production and yields in the Chaco; therefore, none of the evaluated rainfall index contracts are a suitable proxy to cover extreme negative yield deviations.

Figure 3.5. Yield variability measured in 9 de Julio Department at las Breñas Weather Station.



Source: ORA-MAGyP (2011)

3.19. ***Some of the reasons that may explain why such poor correlation exists between the proposed indexes and district-level cotton yields include***:

(i) ***There is a very wide sowing window (mid-October to end of December) for cotton in most departments; therefore, it is extremely difficult to select the optimal contract start date that accurately reflect the planted area by productive region.*** During the conduct of this study it was not possible to determine the percentage of planted cotton area per region throughout the sowing window. For this reason, it was assumed that the greatest percentage of the planted area would be concentrated during the central dates of the sowing window. Since rainfall patterns in Chaco province are both erratic and localized it is therefore likely that some sub-regions (i.e. large Departments) define their own planting dates based on their own criteria (i.e. soil humidity). Unfortunately, the rainfall index cover could not capture both the very wide sowing dates for cotton and the localized variability in rainfall patterns.

(ii) ***Cotton plants are very resilient to extreme weather conditions, particularly to drought events.*** During discussions with farmers and technicians from the MPCh, it was pointed out several times that cotton plants show much greater tolerance to drought or excess rainfall conditions than other crops (i.e. sunflowers, soya beans). Under water-stress conditions, cotton plants tend to slow their growth and to extend the total crop cycle. This particular physiology condition of cotton also allows the plants to recover. In consequence, cotton plants re-sprout and can provide a marginal production while other crops may have suffered total losses under the same drought stress. The lack of a linear relationship between the amount of rainfall and cotton production and yields makes it extremely difficult to calibrate a rainfall deficit or excess rainfall index insurance cover. This is in contrast to a cereal such as maize where the R^2 values for rainfall and yield are often in the order of 0.65 to 0.75 or greater.

(iii) High incidence of boll weevil infestation and difficulties on applying effective best management practices. Over the past 17 years, the boll weevil pest has been one of the major problems in the cotton sector. Despite of the efforts conducted by key stakeholders (i.e. farmers association, processors, the national and representatives from Chaco Province) through the

implementation of different programs, including the National Programme for Prevention and Elimination of Cotton Boll Weevil (PNPEPA, acronym in Spanish), the level of pest infestation is of great concern in some crop seasons. For example, due to favorable conditions (i.e. climatic conditions, harvest delays due to the lack of cotton combine-harvesters, lack of ground transportation to the processing plants) the number of boll weevils trapped during the 2011/12 crop season was more than 5 times higher compared to the previous crop cycle[22].

3.20. ***In conclusion the WII Feasibility Study has shown that the correlation between rainfall (excess rainfall and rainfall deficit) and cotton yields is so low that it is not possible to capture this peril through a Weather Index Insurance (WII) policy.*** The World Bank-ORA-MAGyP team cannot on this basis recommend the use of a rainfall index cover to insure losses in cotton grown in Chaco Province.

[22] Cámara Algodonera Argentina, 2011.

4. Area-Yield Index Insurance Opportunities for Cotton in Chaco Province

4.1. ***This chapter presents an analysis of the key design and rating issues and methodology for a commercial Area-Yield Index Insurance (AYII) program for the cotton sector in Chaco Province,*** and draws, where relevant, on international experience. Outline proposals are presented for a Pilot cotton AYII program for the Provincial Government of Chaco Province which would operate at the Department-level (Insured Unit).

4.2. ***This original Term of Reference (TORs) did not include provision for a study into AYII for cotton in Chaco Province.*** In 2012 when it became evident to the World Bank-ORA team that a macro-level excess rainfall and rainfall deficit WII cover would not work for cotton grown in Chaco Province, it was agreed to consider alternative products namely the possibility of developing AYII cover for the cotton sector. Due to the budgetary and time restrictions for the Chaco crop index insurance component of this technical assistance project, the additional work on AYII insurance for cotton has been limited to a prefeasibility analysis and the presentation of outline proposals and recommendations. It is stressed that further design work will be required in any pilot implementation phase and this will fall outside the current World Bank feasibility study which is due to be completed by 30 June 2013.

4.3. ***The findings presented in this section are intended to assist MAGyP and the Provincial Government of Chaco and the Insurance Sector to decide whether to move to the detailed design and implementation of the proposed AYII program for cotton***. Full details of the AYII product design and pricing are given in Annex 4.

Features of Area-Yield Index Insurance and International Experience

Features of Crop Area-Yield Index Insurance (AYII)

4.4. ***Traditional individual grower multiple-peril agricultural crop insurance (MPCI) is widely practiced throughout the world***: the product is very popular with farmers because it offers very broad loss of yield coverage against a wide range of natural, climatic and often biological perils. The international experience with individual grower MPCI has, however, often been poor with problems of low uptake, high anti-selection and moral hazard, high administrative costs and underwriting results which have generally been negative and the programs have been very exposed to systemic losses in severe drought or flood years. Most MPCI programs are highly dependent on government premium subsidies and/or subsidies on claims payments. In developing countries which are dominated by very small farm size, the costs associated with administering individual grower MPCI, where individual farm data are required, are often prohibitively high and operationally infeasible (Mahul & Stutley 2010).

4.5. ***In Chaco Province, Insurers who have offered individual grower MPCI cover for Cotton have achieved very poor underwriting results and for this reason it is important to consider alternative options including, in this case, AYII.*** Individual grower MPCI is a very technical product with high associated administrative and operating costs including the need to conduct pre-inspections and to establish individual farmer historical yields on which basis to calculate a normal average yield and an insured yield coverage level, through to the need to establish procedures for measuring in-field losses at the time of harvest. From an operational viewpoint voluntary MPCI programs generally suffer from severe problems of adverse selection

namely, the tendency whereby the better farmers located in low risk areas (e.g. with good soils and good drainage) prefer to manage their own risks without any crop insurance protection, while those farmers who purchase crop insurance cover are often lower technology producers located in the highest risk areas (poor soils, poor drainage, subject to flooding etc.). In addition MPCI is often subject to moral hazard whereby farmers who have purchased this "all risk" cover fail to adopt the normal technical practices recommended for growing the crop in the knowledge that they are protected by their insurance cover: moral hazard is a particular issue for MPCI policies which afford cover against pests and diseases. The fact that all public and private insurance companies which have attempted to underwrite individual grower MPCI cover for cotton in Chaco have experienced very poor underwriting results suggests that an alternative approach is now needed to insuring this crop.

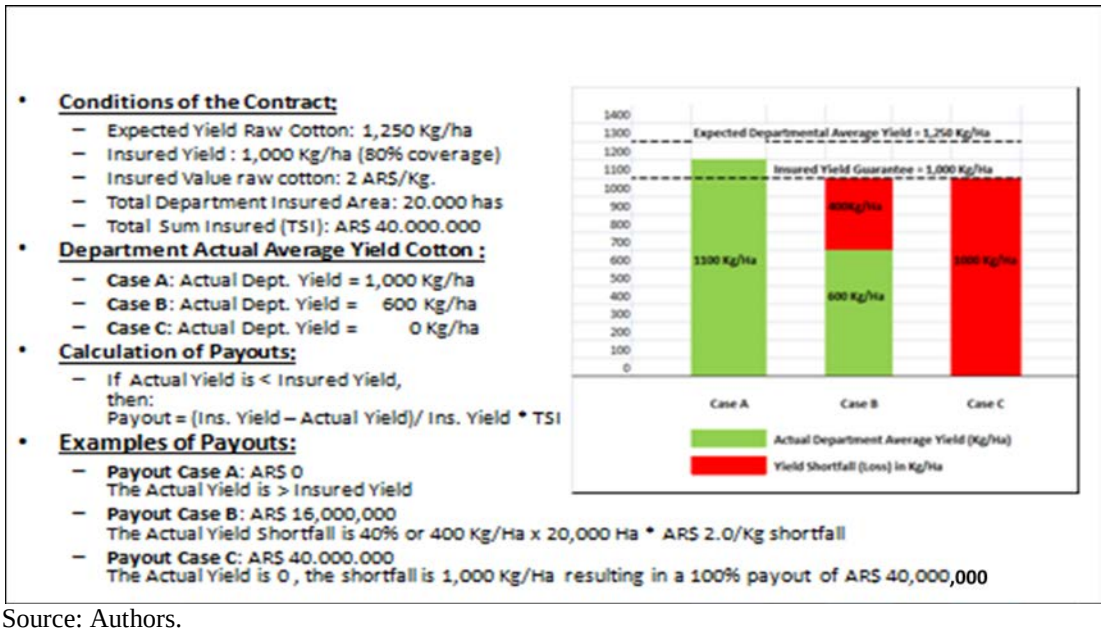
4.6. ***Area-Yield Index Insurance (AYII) represents an alternative approach which aims to overcome many of the drawbacks of traditional MPCI crop insurance***, and which may have application to the cotton sector in Chaco Province. The key feature of this product is that it does not indemnify crop yield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

4.7. ***The basis of insurance and indemnity (payouts) on an AYII policy is illustrated in Figure 4.1.*** In this case the Insured area is the cotton grown in a single Department "X", which has a 5-year average yield (expected yield) for raw cotton of 1,250 Kg/Ha (which is very close to the actual average cotton yields in Chaco Province). The insurance contract offers an Insured Yield Coverage level of 80% of the Departmental average yield or 1,000 Kg/Ha. The Insured Yield is valued at AR$ 2.0 per Kg equivalent to a sum insured of AR$ 2,000/Hectare and a total sum insured (TSI) for the department of AR$ 40,000 (based on an estimated cultivated area of 20,000 hectares of insured cotton in the forthcoming season). The basis of insurance and indemnity is that IF actual average raw cotton yield in Department "X" falls below the Insured Yield guarantee of 1,000 Kg/ha the policy will compensate the shortfall over the entire insured area at the agreed sum insured value per kilogram of cotton. In this worked example, 3 different actual yield scenarios are presented: Case "A" where the actual average yield in Department "X" is 1,100 Kg/Ha which is greater than the 80% Insured Yield and therefore no payouts would arise. In Case "B", the actual Departmental cotton yield is 600 Kg/Ha with a shortfall of 400 Kg/Ha: a payout is due of 400 Kg over the entire 20,000 Ha, irrespective of whether individual farmers' actual yields were higher or lower than the estimated Department average of 600 Kg/Ha. For Case "B" the insurance payout would be AR$ 16 million (400 Kg/Ha at an insured value of AR$ 2 each, in a total area of 20,000 Has). Finally in Case "C" the estimated actual average yield of cotton in Department "X" is zero, the yield shortfall is therefore 1,000 Kg/Ha and a 100% payout of the TSI will be due of AR$ 40 million.

4.8. ***This cotton AYII cover could either operate as an individual farmer micro-level policy in Department "X", or as a macro-level cover purchased by Government as part of its natural***

disaster relief support for small and medium cotton producers in Chaco Province. The authors strongly recommend the latter approach be adopted of a macro-level program purchased by GoC, at least in the start-up phase of any possible new AYII program in this province.

Figure 4.1. Worked example of the Basis of Insurance and Indemnity for an AYII cover for Cotton



Source: Authors.

4.9. ***The key advantages of the Area-Yield approach are that moral hazard and anti-selection are minimized, and the costs of administering such a policy are much reduced*** and this offers the potential to market this product at lower premium costs to growers. As the policy responds to yield loss at the county or Department area-level and not at the level of the individual farmer, no farmer can influence the yield indemnity payments and as such anti-selection and moral hazard are minimized. Administration costs are also greatly reduced because there is no need for pre-inspections on individual farms and loss assessment is not conducted on an individual farmer and field by field basis, but rather according to a pre-agreed random sampling of crop yields on plots within the IU. These costs savings can be passed on to farmers in the form of lower crop insurance premiums (Table 4.1.).

4.10. ***The main drawback of an AYII policy is "Basis Risk" or the potential difference between the insured area-yield outcome and the actual yields achieved by individual insured farmers within the insured area***. Basis risk arises where an individual grower may incur severe crop yield losses due to a localized peril e.g. hail, or flooding by a nearby river, but because these localized losses do not impact on the department-level average yield, the farmer who has incurred severe crop damage does not receive an indemnity. In addition, basis risk may arise where individual farmer crop production and yields are highly heterogeneous (different) within the same department, which will invalidate using an Area-based approach (Table 4.1). (See below for further discussion of Basis Risk in the context of cotton production in Chaco Province).

Table 4.1. Preconditions, Advantages and Disadvantages of AYII

Preconditions	Advantages	Disadvantages
• Homogeneous cropping systems in the defined geographical area (e.g. region, district, county) which form the Insured Unit	• No need for individual grower time-series yields	• Basis risk (but lower than weather index)
• Accuracy of historical regional yield data	• Data Availability: regional yield statistics recorded in most countries	• Not suitable for localized perils (e.g. hail)
• Timely, accurate and impartial procedures for estimating "actual" average yield in the Insured Unit	• Lower delivery cost to growers	• Problems of accurate measurement of "actual" average yields in Insured Units
• Special insurance regulation may be required	• Suited to systemic risk (e.g. drought)	• Farmers' acceptance
	• Adverse selection and moral hazard are minimized	
	• No in-field loss assessment required	
	• Reduced cost of loss assessment	
	• Yield-based so picks up all weather risks and other causes of shortfalls	

Source: Authors

International Experience with Crop Area-Yield Index Insurance (AYII)

4.11. ***The origins of Area-Yield Index crop insurance date back to 1952 in Sweden***. India introduced Area-based crop insurance in the late 1970's and the USA and Canada introduced area-yield index crop insurance in the early 1990's. Other countries which have developed Area-based crop insurance in the past decade include Morocco, Sudan, Brazil and Peru[23]. In recent years the World Bank has assisted technical feasibility studies into AYII in Senegal (rain fed food crops and oilseeds), Nepal, (rain fed and irrigated food crops and oilseeds) Bangladesh (paddy rice), Guyana (paddy rice), Kazakhstan (rain fed spring wheat) and Burkina Faso (cotton). Only in Senegal has AYII moved to an implementation phase, and in the other countries no implementation has yet been undertaken.

4.12. ***In India AYII has been widely adopted for smallholder rain-fed and irrigated food crops, oilseeds and industrial crops including most importantly, cotton***. India has operated a public-sector AYII program for more than 30 years under its public-sector National Crop Insurance Scheme, NAIS. Crop insurance is compulsory for farmers who borrow seasonal production credit. Currently this program insures about 25 million Indian farmers each year. The program has traditionally been very heavily subsidized by Federal and state governments. Starting in 2010 the government has begun to introduce market reform and to transform the NAIS AYII program into a commercial crop insurance scheme (see Box 4.1. for further details).

[23] In Peru the AYII program covers a range of crop types from quinoa, potatoes, cereals (e.g. barley) through to cotton.

Box 4.1. India. National Agricultural Insurance Scheme: Area-based crop insurance

Implementing Agencies. In India, the Agricultural Insurance Company of India (AICI), a public sector specialist crop insurer, is responsible for implementing Area-Yield Index Insurance (AYII) under the National Agricultural Insurance Scheme (NAIS). The program started implementation in 1980.

Target Audience. The program is targeted at small and marginal farmers (with less than 2 hectares), and whom are highly dependent on access to seasonal crop credit. Crop Insurance is compulsory for borrowing farmers and voluntary for non-borrowing farmers.

Insured Crops. Wheat, paddy rice, maize, other cereals, oilseeds, pulses, industrial crops including cotton and sugar cane, etc.

Insured Unit. The Insured Unit is normally the block or panchayet which comprises a group of nearby villages and which may include up to 10,000 Ha or more of a single crop and several thousands of small and marginal farmers. Farmers may select coverage levels of 60%, 80% or maximum of 90% of the 5-year average area-yield.

Sum Insured. The sum insured for each insured yield coverage level is based on the amount of seasonal crop credit borrowed by the farmer.

Premium Rates. Premium rates are capped by government at between 2.5% to 3.5% for most food crops, oilseeds and pulses in order to make the program affordable to India's small and marginal farmers. Commercial crops are charged at the full actuarially determined premium rates.

Administration and Distribution channels. The program is marketed through the rural agricultural bank branch network in each state and department and block (group of villages). The AICI maintains a national headquarters staff and a small regional team in each state. It has not, however, attempted to establish branch offices as there is no need to duplicate the rural bank branch network. The Insurers' administrative costs are kept to a minimum by linking insurance with rural finance.

Area-Yield Measurement. Actual area-yields are established through sample crop-cutting and weighing of crop yields from randomly selected farms in each Insured Unit: the crop-cut yields are averaged to calculate the actual average Area Yield in each Insured Unit. This is a major and costly exercise and suffers from delays in processing the results. Indemnity payments are therefore often delayed for 6 months or more.

Scale and Outreach. By virtue of being a mainly compulsory program, the NAIS scheme is the world's largest crop insurance program currently insuring about 25 million Indian farmers (representing an insurance uptake rate of about 22% percent of all farmers).

Government Financial and Reinsurance Support. The program is highly dependent on government subsidies and operates at a major financial loss. The Federal and State Governments provide excess of loss claims reinsurance protection to AICI and also fund premium subsidies. AICI's A&O expenses are subsidized by government.

Modified NAIS. Since the Rabi 2010/11 season AICI have been operating a fully commercial NAIS in about 10% of the departments covered by the program: under this market-based program, AYII is charged at the full commercial premium rates and AICI places a combination of proportional and non-proportional reinsurance with international reinsurers.

Source: Authors

4.13. ***In Brazil a small farmer maize-seed AYII program was introduced in 2001 under a public-private partnership between the state government of Rio Grande do Sul State, local insurers and international reinsurers.*** The AYII cover known as the Municipalized Risk Group (*Grupo de Risco Municipalizado, GRM*) program was linked to the state government maize seed

swap program[24] aimed at introducing new hybrid maize and was a voluntary individual farmer crop insurance program. The Insured Unit was the municipality and in year 1 the program provided a fixed insured yield coverage level of 90% of the municipality expected or average maize yield, which was reduced to 80% coverage in subsequent years. The state government provided very high premium subsidies in the order of 90% of the premium costs in order to promote the program and make it more affordable to the small farmers (defined as those with less than 80 Ha). The Brazilian Institute of Geography and Statistics, IBGE, provided historical municipality maize production and yield data for contract design and rating purposes and was also appointed as the official organization responsible for declaring the actual or real average maize yield in each municipality and on which basis payouts were triggered to individual farmers if the actual municipality average maize yield fell short of the 80% trigger yield. The program operated up to 2007/08 when the maize seed swap program terminated: over its lifespan the program insured a total of 194,100 maize farmers with claims payments to nearly 58,000 farmers and an overall loss ratio of 80.3% or a near break-even situation for local insurers and international reinsurers. One of the key lessons from this program was that great caution should be taken in the start-up phase of a new AYII program to avoid over-estimating expected yield potential and also in setting the maximum insured yield coverage level at a realistic level of no more than 80% (IFAD and WFP, 2010). Further details of the program are included in Box 4.2.

Box 4.2. Maize AYII Program, Rio Grande do Sul, Brazil

The Group Risk Municipalized (GRP) plan was a crop insurance program for small maize farmers located in Rio Grande State of Brazil and represented a public private partnership between the state government Department of Agriculture and Supply (SSAA), the State bank of Rio Grande do Sul (BANRISUL), the State Data Processing Company (PROCERGIS) and various private local insurers and IRB the national reinsurer and international reinsurers. In the launch year 2001, the program was underwritten by Porto Seguro Insurance Company with reinsurance support from PartnerRe and responsibility for program implementation was through AgroBrazil. a private risk management agency based in Rio Grande do Sul. The GRM. The GRM Product was an area-yield index insurance, AYII, program which used the municipality average maize yield as an index against which to trigger payouts to insured maize farmers in each municipality in Rio Grande do Sul. The Brazilian Institute of Geography and Statistics, IBGE was responsible for providing historical and real time (i.e. during the insurance cover period), maize production and yield data in each municipality (the Insured Unit). The Insured Yield coverage level was initially set in 2001/02 at 90% of the expected yield in each municipality, but then adjusted downwards to 80% coverage across all states in 2002/03 in order to avoid situations of over-insurance of actual average yields. The program was marketed on a voluntary basis to farmers participating in the state-wise maize seed swap program, or *Programa Troca Troca de Sementes* (PTTS). The sum insured was based on the costs of maize production and specifically included the costs of the hybrid seeds provided under the PTTS program and could vary from a low of R$200 per hectare to a maximum of R$ 1000/Ha. The premium rates varied from an average low of 11.1% in 2001/02 for 90% coverage level through to a maxim average of 17.1% for 80% coverage in 2007/08. The program insured a high loss ratio in year 1 of 215% largely on account of over-estimation of the expected yields which were subsequently corrected, and then a loss ratio of 377% in 2004/05 which was very severe drought year in Rio Grande do Sul. The overall loss ratio was 80.1% over the life for the insurance program. The main operational drawback of the scheme was that IBGE only publishes its national crop yield estimates by municipality and by state in October and this meant that farmers had to wait 3 to 6 months to receive an insurance payout.

[24] Programa Troca Troca de Sementes (PTTS)

GRM Maize Results 2001/02 to 2007/08

Crop Year	No. Insured Framers	Sum Insured (RS)	Premium (R$)	Average premium rate %	No. Claims Payouts	Value of Payouts (R$)	Loss Ratio %
2001/02	25,068	17,804,385	1,978,154	11.1%	17,590	4,247,742	215%
2002/03	38,620	28,445,320	4,174,436	14.7%	59	5,550	0%
2003/04	20,122	14,993,630	2,278,775	15.2%	4,254	1,063,611	47%
2004/05	24,151	19,320,800	2,749,323	14.2%	23,248	10,364,084	377%
2005/06	46,175	36,940,000	6,139,370	16.6%	9,547	1,914,202	31%
2006/07	25,071	20,056,800	3,343,580	16.7%	129	30,461	1%
2007/08	14,893	11,914,400	2,037,171	17.1%	2,951	593,551	29%
Total	**194,100**	**149,475,335**	**22,700,809**	**15.2%**	**57,778**	**18,219,201**	**80%**

Source: IFAD and WFP 2010.

4.14. ***In Argentina the insurance sector introduced an AYII cover for cereals grown in the Pampa Humeda in the early 2000s under the "Cielo Abierto" program*** which was marketed on a voluntary basis to individual farmers (micro-level insurance) with the department (*partido*) as the Insured Unit. The demand for this cover was, however, very low and the program was terminated after a few years. At the time Cielo Abierto AYII cover was not available for cotton grown in Chaco Province. The important point is that although Cielo Abierto was discontinued, the private commercial insurance sector in Argentina already has experience with underwriting AYII and furthermore that this micro-level index insurance product was approved by the Superintendent of Insurance of the Nation (SSN).

Pre-Conditions for AYII for Cotton in Chaco Province

4.15. ***There are several pre-conditions for the operation of AYII for rain-fed cotton in Chaco Province***, which are listed in Table 4.1 and which include:

- definable homogeneous cotton producing zones (the Insured Unit) with low yield variation between farmers in the Insured Unit (IU);
- for the defined Insured Unit, historical cotton sown area, production and average yield data for the past 15 years or more on which basis to establish the Insured Yield and technical premium rates for an AYII policy, and
- an independent and statistically accurate system of measuring actual average Area-yields in the defined Insured Unit and on which basis to trigger claims payments where actual yields fall short of the Insured Yield(s).

4.16. These pre-conditions are reviewed below in the context of cotton production in Chaco Province.

Definition of the Insured Unit

4.17. ***In Chaco Province, cotton planted (sown) area, harvested area, cotton production and yield data is collected both by the Federal Government and by the Ministry of Production (MPCh) at a Departmental-level each year, but is not available at a higher level of resolution.*** Lower levels of disaggregation of cotton area, production and yield statistics, for example, at the sub-departmental-level or municipality-level are not, however, available in Chaco Province. This

means that the smallest size of Insured Unit that could be adopted for a cotton AYII program in Chaco Province would be the Department and this may or may not represent a homogeneous cotton growing area (i.e. with similar varieties, planting dates, technology levels and individual farm-level cotton yields). As previously noted cotton is grown in 25 Departments in Chaco Province, but there is a huge range in sown area between departments with a 3-year average low of 1,140 Ha in Tapenagá Department to a high of 41,790 Ha in Coronel Luis Fontana Department (Chapter 2, Figure 2.3). Furthermore neither the Federal Government or MPCh record cotton production statistics for different types of cotton producer (small, medium, large). This means that if an area yield index is constructed this would have to be based on Departmental average cotton yield data alone and cannot take into account either variations in soil types and yield potential within a single department, nor can the AYII product be tailored to the actual technology levels and normal average yields achieved by each target group of cotton producers. These are key issues which will have to be carefully considered in the design of any AYII cover for Chaco Province (See Chapter 5 for further discussion of the issue of different yield potential for different types of cotton producer in each Department).

4.18. ***In summary the Insured Unit for the purposes of operating a cotton AYII program in Chaco Province will be the individual cotton growing Department.*** The policy will therefore establish an Insured Yield of cotton in each Department based on a percentage of the historical average Department-level yield and will compensate losses for yield shortfall against the Departmental average yield.

Minimum Time-Series historical yield data and Procedures for estimating average cotton yields in each Department (Insured Unit)

4.19. ***Under an Area-Yield Index Insurance program for field crops, it is necessary to have an independent, accurate and timely system of establishing the actual average yield in the Insured Unit in order to determine whether yield loss has occurred at the level of the insured unit and to then effect payouts accordingly to insured farmers in that Unit.*** Furthermore the yield recording system needs to have been in operation for a minimum of 15 years or more in order to provide historical area-yields which can be used to establish (i) an average yield, (ii) an Insured Yield coverage level(s) and (iii) technical premium rates.

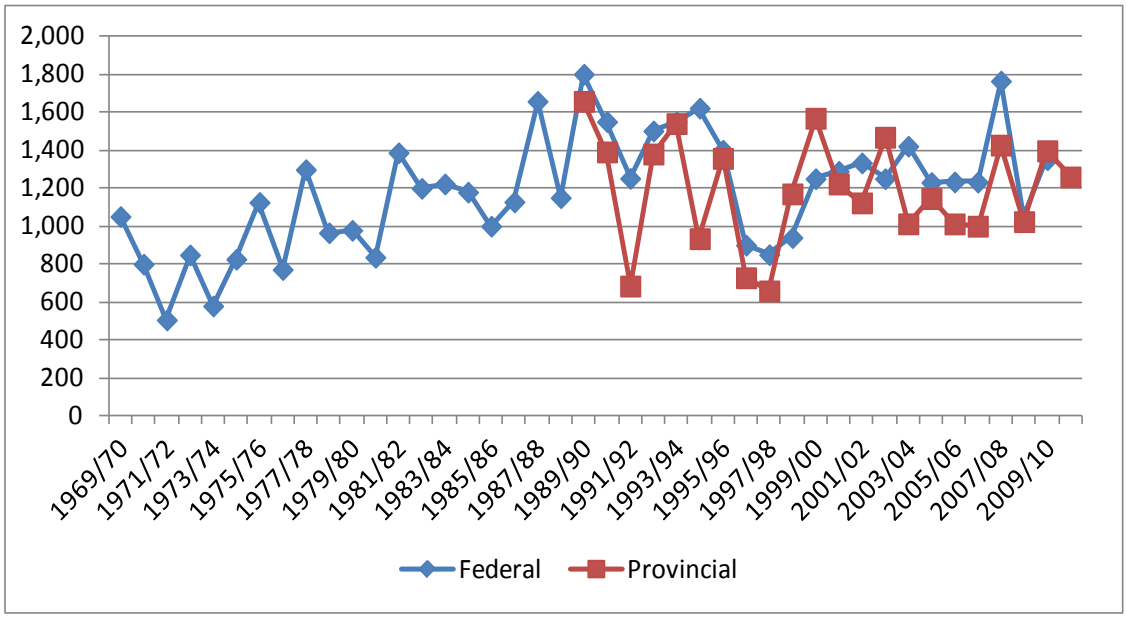
4.20. ***In Chaco Province, cotton planted (sown) area, harvested area, and crop production data at a department level has been collected both by the federal Government and by extension officers from the Ministry of Production (MPCh) for many years.*** In the conduct of this study, the World Bank team was first provided in late 2011 with Federal Government Cotton sown and harvested area, production and yield statistics by Department from the 1969/1970 crop season and there is therefore a very long time-series of more than 40 years of Federal Cotton insurance data. In May 2012 the team was provided a second set of cotton sown area, harvested area, production and yield data for 22 years from 1998/99 to 2009/10. The procedure adopted by MPCh for estimating sown area is based on the weekly reports submitted by the field extension officers in each municipality or local extension area and who are involved in monitoring cotton sowing and in advising farmers on best sowing practices during the planting season. This information is collated at a Departmental level and then provided to MPCh head office in Resistencia. In Chaco, cotton production raw yields and ginned lint and seed cotton production and yields are estimated from a variety of sources including the extension officers, directly from the ginneries and from the local traders and again this data is collected and updated on a weekly basis in each Department. The collected cotton area, production and yield data is double checked with other sources (i.e. INTA, and MAGyP) in order to assess whether it is consistent with actual data. The systems for reporting crop area, production and yields are similar to those adopted in the USA

and where AYII has operated for more than two decades. In Chaco Province MPCh does not practice a separate system of random field sampling and crop-cutting to validate actual average yields of cotton in each Department. In contrast, in India there is a national system of area-yield estimation through the implementation of sample crop cuts and yield weighing for all major crops grown in each administrative area (see Box 4.1 for further details).

4.21. ***The long term historical cotton yield data is considered to be a possible basis for the design and rating of a macro-level cotton Area Yield (AYII) program for GoC to implement on behalf of targeted small and medium cotton growers located in Chaco Province.*** There are, however, as noted in Chapter 2, a series of issues and challenges with this data including most importantly there are considerable differences between the 41-years (1969/70 to 2009/10) of Federal Government cotton production and yield statistics and the 22-years (1989/90 to 2010/11) of Provincial-level cotton production and yield data. These differences are illustrated in Figure 4.2. and Table 4.2. for one Department in Chaco and full details for all 25 cotton departments are presented in Annex 1. The reported Provincial annual yields of raw cotton tend to be lower than those estimated by the Federal Government, but the reasons for these differences are not yet fully understood by the World Bank team. Table 4.2. shows that over the past 5, 10 and then 20 years the Provincial cotton yields have been as much as 10% lower than the Federal yields and this has important implications for the design of an AYII product which requires accurate historical yield data at a Departmental level in order to construct a yield index.

4.22. ***For the purposes of this AYII design and rating study, the team decided to use the Federal Government cotton data set for reasons*** which include: it provides a considerably longer time series of up to 40 years data which is very useful for rating purposes as the longer time series captures more yield loss events; there are fewer missing data in the Federal yield data series and finally there are fewer outliers and anomalous yields in this data set.

Figure 4.2. Comandante Luis Fontano Department: Comparison of Federal Government cotton yield data from 1969/70 with Provincial level yield data from 1989/90 (Kg/Ha)



Source: Federal and Provincial cotton production and yield data provided by ORA-MAGyP

Table 4.2. Comandante Luis Fontano Department: Comparison of Federal and Provincial cotton yield estimates, over 5, 10 and 20 years

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,326	1,172	88%
10 years	1,315	1,183	90%
20 years	1,298	1,162	90%

Source: Federal and Provincial cotton production and yield data provided by ORA-MAGyP

4.23. ***A further drawback of the Departmental-level cotton time-series data in Chaco Province is that the cotton production and yield data cannot be disaggregated by type of farmer***: there are major differences in the cotton technology packages and cotton yields achieved by the large fully mechanized cotton producers and small and medium scale low technology cotton producers. However, as neither the Federal or the Provincial authorities report cotton production and yield data for these different types of farmer, any AYII product designed for Chaco Province with have to be based on the departmental average yield alone.

4.24. ***If a Cotton AYII program is to be launched in Chaco Province, it will first be necessary for Insurers to review the procedures adopted by MPCh and other government departments to estimate and report the actual average yield of cotton in each insured Department to ensure that the procedures meet Insurers' and Reinsurers' standards and requirements***. In order to avoid any potential conflict of interest under a situation where GoC is the Insured and where GoC through its various government Ministries and Departments is also involved in estimating and reporting cotton yields, the Insurers and their Reinsurers may require that a system of independent measurement of Departmental average yields of cotton is put in place to validate their estimates. This is a very important challenge which is discussed further at the end of this Chapter.

Area-Yield Index Insurance Contract Design Considerations

Minimum Cultivated Area for AYII Purposes

4.25. ***For the operation of an AYII cover it is necessary to have a minimum sown area of the insured crop in each Insured Unit (Department)***. The setting of a minimum sown area is to avoid moral hazard, or in other words, to ensure that individual farmers are not able to influence the area yield outcomes in the Insured Unit. In the USA the minimum area is 15,000 acres (about 6,000 Ha) per county (Skees et al 1997)[25].

4.26. ***In Chaco Province, based on an analysis of the actual average sown areas of cotton in each department, the minimum area was set at an average of 2,000 Hectares for the past five years 2005/06 to 2009/10***. By setting a minimum area of 2,000 Ha of sown cotton 6 of the 25 cotton departments would not be eligible for the AYII program: the 6 Departments where the sown are of cotton is too small to be insurable includes 1ero de Mayo, Bermejo, Gral. Donovan, Libertad, San Fernando and Tapenga. In addition, 2 de Abril Department which is a relatively

[25] Skees, J.R., R Black and B. J. Barnett (1997). *"Designing and Rating and Area Yield Crop Insurance Contract.* American Journal of Agricultural Economics 79 (May 1997).

important cotton growing area with an average of 11,213 Ha of sown cotton over the past 5 years, has currently been excluded from the AYII Product design and rating analysis because cotton area, production and yield data are only available for the 14-year period 1996/97 to 2009/10, while in other departments the analysis is based on the full 41-year's data in most cases. This reduces the total number of cotton departments which are eligible for the AYII program from 25 to 18 Departments (see Table 4.3).

Expected Yields and Insured Yield Coverage Levels

4.27. ***For the Insured Unit (in this case the Department), it is necessary to establish the normal average or "Expected Yield" for the insured crop (in this case raw seed cotton)***. AYII programs conventionally adopt one of two approaches for establishing the Expected Yield:

- The simplest approach is to take an average of the past 5 to 7 years actual area yields. This is the approach adopted by the NAIS in India which uses the average of the 3 out of 5 middle years (after elimination of the highest and lowest annual yields) to calculate the Expected Yield[26].

- The alternative is to de-trend and smooth the time series yields using appropriate statistical curve-fitting procedures and to extend the de-trended yields to calculate the expected yield in the forthcoming insurance season. In the USA under the GRP program Skees et al (1996) recommended the use of "linear spline regression" to detrend county average yield data. Conversely in Romania, Varangis and Skees (2003) recommended the use of LOESS econometric procedures in SAS software to adjust Oblast area yields for trends.

4.28. ***The proposed approach for the Chaco cotton AYII program is to calculate the "expected yield" of raw cotton in each Department based on the 5-year actual average yield from 2005/06 to 2009/10***. It is very important to note that in Chaco Province most official reports present average cotton yields calculated on the basis of total Production (MT) divided by the Harvested Area (Ha) of cotton. From a crop insurance viewpoint, however, crop yields should always be calculated on a "Sown area basis" and not a harvested area basis: average yields calculated on a harvested area basis will result in over-estimation of the true average yield, especially in years where a high percentage of the sown crop area is totally destroyed by climatic or natural perils. For this reason all cotton yield data which has been analyzed by the Authors for the AYII program is calculated on a sown area basis. The resulting average expected yields (sown area basis) are presented for the 18 qualifying departments in Table 4.3. Over this 5-year period the overall average yield for raw seed cotton in Chaco Province is 1,303 Kg/Ha (sown area basis), with a range from a low expected yield of 1,176 Kg/Ha in Presidente de Plaza Department to a high of 1,449 Kg/Ha in 9 de Julio Department.

4.29. ***AYII policies typically offer optional Insured Yield Coverage levels of between a maximum of 90% and a minimum of 50% of the average area-yield***. In India, the NAIS has traditionally offered 3 coverage levels, 60%, 80% or a maximum of 90% of the past 5-year average yield in the IU: the decision over which coverage level will apply in an IU is based on the coefficient of variation around mean yield such that in IU's with low yield CV's the maximum 90% coverage level will be applied and in IUs with a high CV only 60% coverage is offered.

[26] However in recognition that this relatively short period of only 5 years did not always represent the average yield, India is now using the middle 5 out f the most recent 7 years yield data to establish the expected yield.

Under the US Group Risk Plan (GRP), farmers may select from optional coverage levels of between 50% and 90% of the county average yield. However, in recognition that some farmers achieve much higher average yields than the 90% of county average maximum insured yield, the GRP allows farmer to insure their crop at up to 150% of the reference value[27].

4.30. ***In Chaco Province Insured Yield Coverage levels have been calculated for 50% up to 90% maximum of the Expected Yield and these are presented in Table 4.3.*** The analysis shows that, under an AYII program with an 80% Insured Yield coverage level across the 18 qualifying departments, the Insured Yield of raw cotton would be in the order of about 1 MT/Ha with range from a minimum of 941 Kg/Ha in Presidente la Plaza to a high of 1,159 Kg/Ha in 9 de Julio. In practice, GoC, as the Insured under the proposed macro-level cotton AYII policy for Chaco would be responsible for deciding on the insured yield coverage levels in each Department: as the next section will show each Insured Yield level in each Department carries its own actuarially estimated premium rate and the higher the Insured Yield Coverage level, the higher the premium rate.

[27] Ibid Skees et al 1997.

Table 4.3. Average Sown Area Cotton 2007/08 to 2009/10 (hectares), 5-Year (2005/06 to 2009/10) Average Yields Raw Cotton (Kg/Ha) and Insured Yield Coverage Levels (50% to 90% of Average Yield)

Department	3-Year Average Sown Area (Ha)	5-Year Average "Expected Yield" Raw Cotton (Kg/Ha)[1]	Insured Yield Cotton by Coverage Level (Kg/Ha)				
			90%	80%	70%	60%	50%
1ero de mayo [2]	1,297						
12 de Octubre	23,433	1,313	1,181	1,050	919	788	656
2 de Abril [3]	11,213						
25 de Mayo	3,607	1,251	1,126	1,001	876	750	625
9 de julio	9,043	1,449	1,304	1,159	1,014	870	725
Almirante brown	3,937	1,354	1,219	1,083	948	812	677
Bermejo [2]	1,780						
Chacabuco	6,447	1,228	1,105	982	860	737	614
Com Fernandez	14,823	1,334	1,200	1,067	934	800	667
Com Luis Fontana	41,790	1,292	1,163	1,033	904	775	646
Gral Donovan	1,923						
Fray Justo	23,700	1,283	1,154	1,026	898	770	641
General Belgrano	4,857	1,237	1,113	990	866	742	619
General Guemes	15,640	1,289	1,160	1,031	902	773	644
General San Martin	5,627	1,316	1,185	1,053	921	790	658
Independencia	13,547	1,305	1,174	1,044	913	783	652
Libertad [2]	1,440						
Maipu	13,427	1,351	1,216	1,081	945	810	675
O Higgins	20,280	1,302	1,172	1,042	911	781	651
Pte de la Plaza	2,890	1,176	1,058	941	823	705	588
Quitilipi	11,880	1,314	1,183	1,051	920	789	657
San Fernando [2]	1,883						
San Lorenzo	4,357	1,232	1,109	986	863	739	616
Sargento Cabral	2,023	1,205	1,085	964	844	723	603
Tapenaga [2]	1,140						
Total	**241,983[4]**	**1,192**	**1,073**	**953**	**834**	**715**	**596**

Source: MPCh Cotton Sown Area, Production and Yield Data
Notes:
[1] Average Expected Yield is calculated on a sown area basis (total production (MT) / sown area (Ha))
[2] Departments excluded from AYII program as average cotton sown area < 2,000 Ha/year
[3] Department excluded as there are only 14 years of cotton area, production and yield data
[4] The total of 241,983 Ha of sown cotton is reduced to 221,307 Ha (91.4% of total with the elimination of the 7 Departments which are not eligible for the AYII program

Sum Insured for Cotton AYII

4.31. ***Under an AYII policy, the insured crop yields can be valued either on a "costs of production basis" through to a "farm-gate sale price" or revenue basis.*** In India the NAIS

commonly sets the sum insured according to the amount of seasonal production credit provided to the farmers (see Box 4.1). In the USA, the GRP permits farmers to insure their selected coverage level yield at up to 150% of the sales' reference price.

4.32. ***In Chaco Province the unit sum insured valuation price for cotton could be based on any valuation criteria agreed between GoC and the cotton sector*** and could be based on (i) the value of cotton credit provided by the "*Fideicomiso Chaco Produce Algodón"* and Banco de Inversión y Comercio Exterior (BICE) up to a maximum of AR$ 1,400 per hectare for cotton or, (ii) a costs of production valuation for cotton, through to (iii) an expected revenue based valuation based on the expected sale price of cotton. However, unlike the USA it is recommended that the maximum unit sum insured value should not exceed 100% of the expected price for cotton in the current insurance year.

4.33. ***For the purposes of this AYII prototype policy design exercise the World Bank-ORA Team has assumed a standard valuation price for cotton of AR$ 2.0 per kilogram of raw seed cotton***. With average cotton yields over the past 5 years of 1,303 Kg/Ha (Table 4.3), this would produce an average valuation per hectare of AR$ 2,606/Ha. This figure compares with the 2009/10 average total costs of production reported by INTA of AR$ 3,617/Ha for improved cotton grown in Chaco province using the full recommended technology package and obtaining a very high average yield of 2.9 MT/Ha of raw cotton (Elena de Banconi 2010).

4.34. ***Some illustrative estimates are presented for the Departmental and Total Sum Insured (TSI) on an AYII Program for cotton in Chaco Province*** for Insured Yield Coverage levels ranging from a minimum 50% coverage level up to the maximum recommended 90% coverage level. Reference to Table 4.4. shows that at the minimum 50% Insured Yield coverage level the total sum insured for the 18 qualifying departments would be in the order of AR$ 288 million (US$ 58 million), rising to a TSI of AR$ 519 million (US$ 104 million) at the at the maximum recommended 90% coverage level.

Table 4.4. Departmental Sum Insured and Total Sum Insured for Insured Yield Coverage levels 50% to 90% of Expected Yield (AR$)

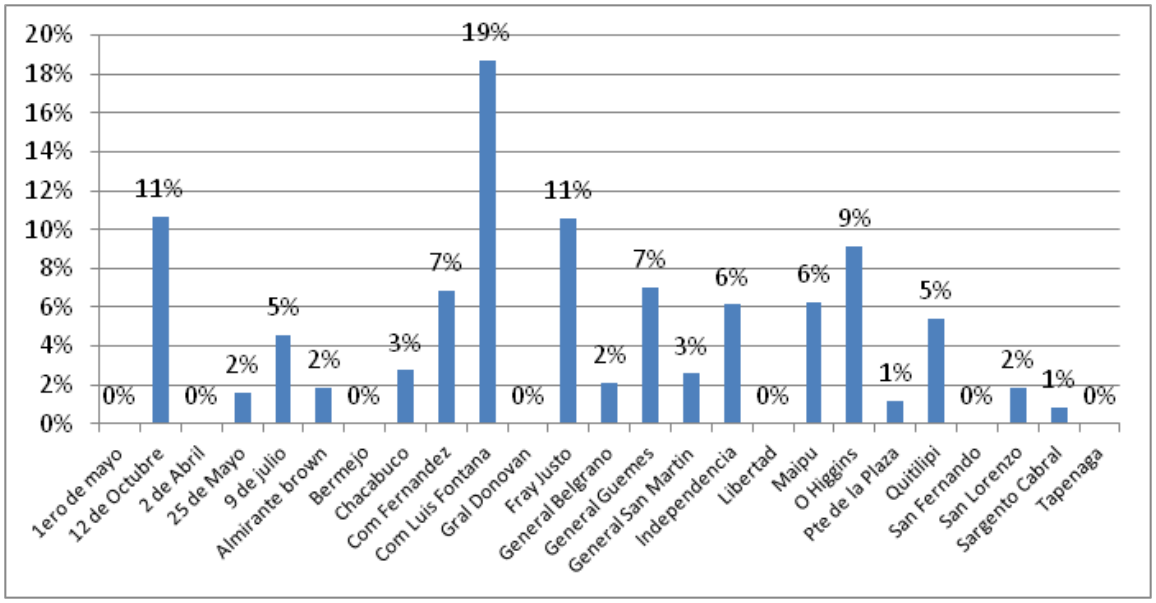
Department / Insured Yield Coverage level	Departmental Sum Insured (AR$ Million)				
	90%	**80%**	**70%**	**60%**	**50%**
1ero de mayo					
12 de Octubre	55,366,769	49,214,906	43,063,043	36,911,179	30,759,316
2 de Abril					
25 de Mayo	8,119,798	7,217,598	6,315,398	5,413,198	4,510,999
9 de Julio	23,590,238	20,969,101	18,347,963	15,726,826	13,105,688
Almirante brown	9,594,214	8,528,190	7,462,167	6,396,143	5,330,119
Bermejo					
Chacabuco	14,250,122	12,666,775	11,083,428	9,500,081	7,916,734
Com Fernandez	35,588,072	31,633,842	27,679,611	23,725,381	19,771,151
Com Luis Fontana	97,173,605	86,376,538	75,579,471	64,782,403	53,985,336
Gral Donovan					
Fray Justo	54,717,269	48,637,572	42,557,876	36,478,179	30,398,483
General Belgrano	10,815,314	9,613,612	8,411,911	7,210,209	6,008,508
General Guemes	36,276,366	32,245,659	28,214,951	24,184,244	20,153,537
General San Martin	13,332,395	11,851,018	10,369,640	8,888,263	7,406,886
Independencia	31,816,504	28,281,337	24,746,170	21,211,003	17,675,835
Libertad					
Maipu	32,643,637	29,016,566	25,389,495	21,762,424	18,135,354
O Higgins	47,529,077	42,248,068	36,967,060	31,686,051	26,405,043
Pte de la Plaza	6,115,914	5,436,368	4,756,822	4,077,276	3,397,730
Quitilipi	28,103,106	24,980,539	21,857,971	18,735,404	15,612,837
San Fernando					
San Lorenzo	9,662,973	8,589,309	7,515,646	6,441,982	5,368,318
Sargento Cabral	4,390,091	3,902,303	3,414,515	2,926,727	2,438,939
Tapenaga					
Total AR$	**519,085,462**	**461,409,300**	**403,733,137**	**346,056,975**	**288,380,812**
Average AR$/Ha	2,145	1,907	1,668	1,430	1,192
Total US$ Equivalent	103,817,092	92,281,860	80,746,627	69,211,395	57,676,162
Average US$/Ha	429	381	334	286	238

Source: Authors' AYII Crop Risk Assessment Model for Chaco Cotton

4.35. ***The distribution of the AYII program total liability by department shows that Comandante Luis Fontana has the highest Sum Insured (SI) value of AR$ 97.2 million or 18.7% of TSI at the 90% coverage level***, followed by 12 de Octubre with SI of AR$ 55.4 million (10.7% of total) and Fray Justo, SI of AR$ 54.7 million (10.5% of total). Conversely in other departments, with a low 5-year average sown cotton area and low average and therefore insured yields, the calculated sums insured are much lower, and in the case of Sargento Cabral only AR$

4.4 million (0.8% of TSI) for 90% coverage (see Table 4.4 and Figure 4.3).

Figure 4.3. Percentage Distribution of TSI by Department (90% Coverage level)



Source: Authors' AYII Crop Risk Assessment Model for Chaco Cotton.

AYII Rating Methodology, Indicative Rates and Estimated Probable Maximum Loss

AYII Rating Methodology

4.36. ***The World Bank-ORA team has conducted an actuarial rating analysis for a macro-level AYII insurance program for cotton grown in Chaco Province.*** An Excel-based rating model was designed by the World Bank's Actuary and which conforms to international standards for rating AYII programs. The AYII Rating model is designed to enable the user to first decide on the minimum planted area of cotton in each department for the department to be included in the rating exercise. As noted above, only those Departments with a minimum planted area of 2,000[28] hectares of cotton were included as part of the rating analysis, along with the requirement of a minimum of 15 years of historical cotton production statistics. The AYII Rating model is also designed to enable the user set the desired insured yield coverage level (expressed as a percentage from say 50% up a maximum of 90% of the average yield, sown area basis[29]) in each Department and the model then calculates the corresponding Departmental pure loss cost rate and technical premium rate adjusted by an uncertainty or catastrophe risk load. A copy of the Excel rating tool has been made available to ORA along with the full results of the AYII rating analysis..

[28] During discussions with senior and technical staff from MPCh, it was advised to increase the minimum area to consider a Department as a traditional cotton production Department up to 10,000 Hectares. However, the AYII model considers the minimum planted areas as a parameter that may be modified by the insured or by the insurance companies in order to include or to exclude cotton production departments.

[29] It is noted that in MPCh report average cotton yields per Department on a harvested area basis (total production in MT raw cotton, divided by total harvested area in Ha, per Department). However for crop insurance purposes the average yields should be reported on a sown area basis.

4.37. ***The rating procedure adopted involved de-trending the 41-year cotton actual yields in each department and curve fitting to then simulate[30] the estimated yield shortfall at each Insured Yield coverage level from 50% to 90% of the average yield over 5000 iterations (years) to derive the average pure loss cost rates for each department.*** The pure loss cost rates were then smoothed and a "security load" added based on the calculated PML for each coverage level to derive the technical rates for each department and each coverage level from 50% to a maximum of 90% of Expected Yield. Given the fact that a very long time series of 41 years departmental cotton production and yield data are available for cotton in Chaco Province, the security load was calculated on the assumption that the 1 in 100 year PML should be reserved in a period of 20 year (see below for the details of the PML calculation). Finally, in order to estimate illustrative Commercial Premium Rates, an assumption has been made that underwriters would set a target loss ratio of 70% on this scheme. It is stressed, however, that in practice the insurers and their reinsurers will be responsible for estimating their costs and profit margins and in setting their target loss ratios accordingly, to arrive at commercial rates (see Annex 4 for rating methodology).

Pure Loss Cost and Technical Premium Rates

4.38. ***For each Insured Yield Coverage level, the burning costs or pure risk rates were simulated and then smoothed using industry accepted procedures***: a security load which was calculated as a percentage of the 1 in 100 Year PML was then added to the smoothed burning costs to derive the Technical Rate. The calculated smoothed pure loss cost rates and technical rates for each of the 18 departments and Insured Yield coverage level are presented in Table 4.5.

4.39. ***The average calculated Technical Rates at 90% coverage level range from a minimum of 6.30% in 9 de Julio Department up to a maximum of 11.82% in Fray Justo Department on account of the much higher variability in annual cotton yields in this department.*** The overall average Technical premium rate for 90% coverage is 8.00%. The calculated pure loss cost rates and technical premium rates for Insured Yield coverage levels of 80% down to 50% of Expected Yield are also shown in Table 4.4. It is notable that the calculated technical rates are much lower at the 80% Insured Yield coverage level than at the 90% coverage level: this implies that for a small reduction in the Insured Yield there are major potential savings in the costs of the premiums charged on this cotton AYII cover. The overall average technical premium rate at 80% coverage level is only 4.9%. GoC in conjunction with Insurers can use the Excel-based rating tool to set the Insured yields at any level it chooses.

[30] Curve fitting and Monte Carlo Simulation analysis was performed using the Software Package "At Risk"

Table 4.5. Chaco Cotton: Calculated Pure Loss Cost Rates (smoothed) and Technical Premium Rates for Coverage levels 50% top 90% of Expected Department Yield

Department / Insured Yield Coverage level	Smoothed Pure Loss Cost Rates (%)					Technical Premium Rates (%)				
	90%	80%	70%	60%	50%	90%	80%	70%	60%	50%
1ero de mayo										
12 de Octubre	7.04%	4.18%	2.20%	1.02%	0.42%	8.94%	5.69%	3.25%	1.65%	0.75%
2 de Abril										
25 de Mayo	4.93%	2.36%	0.90%	0.25%	0.05%	6.83%	3.87%	1.95%	0.89%	0.37%
9 de Julio	4.41%	1.96%	0.67%	0.16%	0.02%	6.30%	3.47%	1.72%	0.79%	0.35%
Almirante Brown	4.71%	2.17%	0.77%	0.19%	0.03%	6.61%	3.68%	1.82%	0.82%	0.36%
Bermejo										
Chacabuco	4.94%	2.37%	0.90%	0.26%	0.05%	6.84%	3.87%	1.95%	0.89%	0.38%
Com Fernandez	5.41%	2.72%	1.10%	0.33%	0.06%	7.30%	4.23%	2.15%	0.96%	0.39%
Com Luis Fontana	6.59%	3.80%	1.94%	0.88%	0.36%	8.49%	5.31%	2.99%	1.51%	0.69%
Gral Donovan										
Fray Justo	9.92%	6.88%	4.45%	2.65%	1.41%	11.82%	8.39%	5.50%	3.28%	1.73%
General Belgrano	4.52%	2.03%	0.70%	0.17%	0.02%	6.42%	3.54%	1.74%	0.80%	0.35%
General Guemes	4.88%	2.32%	0.87%	0.24%	0.04%	6.78%	3.83%	1.92%	0.87%	0.37%
General San Martin	5.80%	3.05%	1.31%	0.44%	0.10%	7.70%	4.55%	2.36%	1.07%	0.43%
Independencia	4.98%	2.38%	0.89%	0.24%	0.04%	6.88%	3.89%	1.94%	0.87%	0.37%
Libertad										
Maipu	5.29%	2.64%	1.05%	0.31%	0.06%	7.19%	4.14%	2.10%	0.94%	0.39%
O Higgins	5.16%	2.54%	1.00%	0.29%	0.06%	7.05%	4.05%	2.05%	0.92%	0.38%
Pte de la Plaza	5.66%	2.95%	1.27%	0.43%	0.10%	7.56%	4.46%	2.32%	1.06%	0.43%
Quitilipi	5.59%	2.87%	1.19%	0.37%	0.08%	7.49%	4.38%	2.24%	1.00%	0.40%
San Fernando										
San Lorenzo	5.35%	2.69%	1.08%	0.32%	0.06%	7.24%	4.20%	2.13%	0.96%	0.39%
Sargento Cabral	4.86%	2.30%	0.87%	0.25%	0.05%	6.75%	3.81%	1.92%	0.88%	0.38%
Tapenaga										
Total / Average	**6.11%**	**3.39%**	**1.65%**	**0.72%**	**0.29%**	**8.00%**	**4.90%**	**2.70%**	**1.35%**	**0.62%**

Source: Authors' AYII Crop Risk Assessment Model for Chaco Cotton

Indicative Commercial Premium rates

4.40. ***Under this study the World Bank team has not had an opportunity to conduct a detailed analysis of the potentially interested insurance companies' cost structures - acquisition cost, administrative cost, insurers and reinsurers profit margins expectations.*** However, based on international experience, a realistic target loss ratio for an AYII policy may be in the order of 70% loss ratio. Using this criterion, the calculated technical premium rates have been grossed up by a factor of 30% (a straight loading of 43%) to achieve a target loss ratio of 70% in each Department and for each Insured Yield Coverage level. The results of this analysis to derive illustrative commercial premium rates are presented in Table 4.6. It should be noted that these rates equate to Net Commercial Premium rates as they have not been loaded for IVA

(Argentinean Value Added Tax which is very high on insurance policies with an average load of 20% to 23%) and other local taxes. For the maximum 90% Insured Yield coverage level the calculated commercial premium rates are high with an average of 11.4% and range from a minimum of 9.00% in 9 de Julio to a high of 16.8% in Fray Justo. At the 80% coverage level, however, the departmental commercial premium rates are much more affordable.

4.41. ***It is stressed that the commercial premium rates are presented purely for illustrative purposes and that final decisions on commercial premium rates will be taken by Argentinean insurers in conjunction with their local and international reinsurers***.

Table 4.6. Departmental-level Illustrative Commercial Premium Rates for Chaco Cotton with target loss ratio of 70%

Department / Insured Yield Coverage level	Commercial Premium Rates (%) for Target 70% Loss Ratio				
	90%	**80%**	**70%**	**60%**	**50%**
1ero de mayo					
12 de Octubre	12.77%	8.12%	4.64%	2.36%	1.07%
2 de Abril					
25 de Mayo	9.75%	5.53%	2.78%	1.26%	0.53%
9 de Julio	9.00%	4.96%	2.45%	1.13%	0.50%
Almirante Brown	9.44%	5.26%	2.60%	1.18%	0.51%
Bermejo					
Chacabuco	9.77%	5.53%	2.79%	1.27%	0.54%
Com Fernandez	10.43%	6.04%	3.07%	1.37%	0.56%
Com Luis Fontana	12.13%	7.59%	4.27%	2.16%	0.98%
Gral Donovan					
Fray Justo	16.89%	11.98%	7.86%	4.68%	2.48%
General Belgrano	9.17%	5.06%	2.49%	1.14%	0.50%
General Guemes	9.68%	5.48%	2.75%	1.24%	0.53%
General San Martin	11.00%	6.51%	3.38%	1.53%	0.61%
Independencia	9.83%	5.56%	2.77%	1.25%	0.52%
Libertad					
Maipu	10.27%	5.92%	3.00%	1.35%	0.55%
O Higgins	10.08%	5.79%	2.93%	1.32%	0.54%
Pte de la Plaza	10.79%	6.37%	3.32%	1.52%	0.62%
Quitilipi	10.70%	6.25%	3.20%	1.43%	0.58%
San Fernando					
San Lorenzo	10.35%	5.99%	3.05%	1.37%	0.56%
Sargento Cabral	9.65%	5.44%	2.74%	1.26%	0.54%
Tapenaga	NC	NC	NC	NC	NC
Total / Average	**11.43%**	**7.00%**	**3.86%**	**1.93%**	**0.89%**

Source: Authors' AYII Crop Risk Assessment Model for Chaco Cotton

4.42. ***As an extension to this analysis, Table 4.7 presents the costs of the commercial premiums on this AYII scheme for cotton grown in Chaco Province.*** (The premiums are derived by applying the commercial rates in Table 4.5 to the sums insured in Table 4.3 for each coverage level). At the 90% coverage level the indicative costs of premiums to GoC would amount to AR$ 59.3 million (US$ 11.9 million) and at the 80% coverage level the premium costs would be reduced to AR$ 32.3 million (US$ 6.5 million).

Table 4.7. Chaco Cotton AYII Program: Estimated Commercial Premium Costs (AR$)

Department / Insured Yield Coverage level	Commercial Premium AR$ for Target 70% Loss Ratio				
	90%	**80%**	**70%**	**60%**	**50%**
1ero de mayo					
12 de Octubre	7,071,337	3,998,445	1,997,956	870,617	328,042
2 de Abril					
25 de Mayo	791,835	399,022	175,669	68,438	24,088
9 de Julio	2,124,288	1,040,478	449,906	177,359	65,309
Almirante Brown	905,362	448,532	194,224	75,355	27,049
Bermejo					
Chacabuco	1,391,948	700,942	308,692	120,503	42,503
Com Fernandez	3,712,699	1,910,836	848,674	325,122	110,135
Com Luis Fontana	11,786,329	6,555,521	3,228,704	1,398,485	531,222
Gral Donovan					
Fray Justo	9,239,898	5,829,135	3,343,149	1,708,443	753,089
General Belgrano	991,990	486,205	209,677	82,165	30,110
General Guemes	3,512,563	1,765,591	774,523	301,090	106,460
General San Martin	1,466,114	770,944	350,115	135,702	45,232
Independencia	3,126,339	1,572,181	686,700	264,284	92,470
Libertad					
Maipu	3,351,171	1,718,064	761,777	292,753	99,934
O Higgins	4,789,266	2,446,207	1,083,164	417,756	143,854
Pte de la Plaza	660,111	346,058	157,738	61,908	20,916
Quitilipi	3,006,051	1,562,473	699,899	268,457	89,807
San Fernando					
San Lorenzo	1,000,091	514,887	229,047	88,039	29,946
Sargento Cabral	423,608	212,336	93,606	36,864	13,141
Tapenaga					
Total / Average	**59,351,001**	**32,277,857**	**15,593,220**	**6,693,340**	**2,553,306**
US$ Equivalent	11,870,200	6,455,571	3,118,644	1,338,668	510,661

Source: Authors' AYII Crop Risk Assessment Model for Chaco Cotton

Probable Maximum Loss

4.43. ***Underwriters typically base their risk retention and reinsurance purchasing decisions on an analysis of the Probable Maximum Loss, PML.*** The Probable Maximum Loss is defined as "An estimate of the maximum loss that is likely to arise on the occurrence of a single event considered to be within the realms of probability, remote coincidences and possible but unlikely catastrophes being ignored". The analysis of the PML is an invaluable aid to structuring an insurance and reinsurance program and to determining how much capital must be reserved to cover the PML loss year. The Chaco Cotton Rating Tool is programmed to provide estimates of the Probable Maximum Loss (PML) for return periods of 1 up to 250 years (or more if required) for Insured Yield Coverage levels of 50% to a maximum of 90%. The results of this analysis are presented in Figure 4.4 and Table 4.8.

4.44. ***For the maximum 90% coverage level the 1-in-a-100 year PML is estimated at 37.9% of TSI*** or a loss of AR$ 197 million (US$ 39 million); and this would be equivalent to a loss ratio of 331%[31]. At lower levels of Insured Yield Coverage the exposure to yield loss in cotton is very much reduced such that the expected 1-in-a-100 year PML for 80% coverage is a loss cost of 30.2% (AR$ 139 million), for 70% coverage the PML is reduced to 21% loss cost (AR$ 85 million) and at the lowest 50% coverage level the PML would only be 12.6% of TSI or AR$ 19 million (US$ 4 million). If underwriters require a more conservative estimate of the PML, the 1 in 250 year return period figures are also shown in Table 4.6.

Figure 4.4. Probable Maximum Loss for Chaco AYII Program with Insured Yield Coverage Levels 50% to 90% and Return periods of up to 250 Years (% of liability)

Source: Authors Crop Risk Assessment Model for Chaco Cotton

[31] The loss ratio is equivalent to losses (claims) divided by premium. In this case, the average indicative commercial premium rate for the portfolio of 11.43% in Table 4.5 has been compared with the 1 in 100 year PML loss cost of 37.9% to derive an average 1 in 100 year PML loss ratio of about 331% (rounded).

Table 4.8. Probable Maximum Loss for Chaco AYII Cotton Insurance Program with Insured Yield Coverage Levels 50% to 90% of Expected Yield and Return periods 10 to 250 Years (Loss Cost % and AR$)

Item	Total Sum Insured (AR$ Million)	10-Years	50-Years	100-Years	150-Years	200-Years	250-Years
90% Coverage level	519						
Loss Cost (%) of TSI		19.4%	33.9%	37.9%	39.9%	41.5%	42.0%
Loss Cost (AR$ Million)		101	176	197	207	215	218
80% Coverage level	461						
Loss Cost (%) of TSI		11.4%	26.3%	30.2%	32.5%	34.2%	34.8%
Loss Cost (AR$ Million)		53	121	139	150	158	161
70% Coverage level	404						
Loss Cost (%) of TSI		5.5%	17.4%	21.0%	23.3%	24.9%	25.7%
Loss Cost (AR$ Million)		22	70	85	94	101	104
60% Coverage level	346						
Loss Cost (%) of TSI		2.3%	9.1%	12.6%	13.9%	14.8%	15.3%
Loss Cost (AR$ Million)		8	31	44	48	51	53
50% Coverage level	288						
Loss Cost (%) of TSI		0.2%	4.5%	6.5%	7.4%	8.4%	8.9%
Loss Cost (AR$ Million)		1	13	19	21	24	26

Source: Authors Crop Risk Assessment Model for Chaco Cotton

Illustrative Portfolio for GoC Macro-level Cotton AYII insurance program for Small and Medium Cotton Producers in Chaco Province

4.45. ***This section presents an illustrative cotton insurance portfolio targeted at the small and medium cotton producing sector in Chaco Province***. So far the analysis in this Chapter has been based on the 100% figures for the cotton sector in Chaco Province. However, as this AYII product is targeted at the small and medium farm sector and not all cotton growers, this section develops the figures provided by MPCh for the distribution by department of the 1,046 small and medium cotton farmers cultivating a total of about 81,000 Ha of cotton.

4.46. ***On the assumption that GoC requests Insurers to provide it with an AYII program for cotton with 80% Insured Yield coverage level***, Table 4.9 shows the financial details of the insured portfolio including sums insured and illustrative premiums by Department and in total. At the time of submitting its cotton insurance application, GoC would need to inform the Insurer(s) of the expected planted area of cotton in each department that it wishes to insure and to then pay a minimum and deposit premium based on the estimated planted area. This figure would then be adjusted at the completion of sowing according to the actual sown declared area for the targeted small and medium farmers and a premium adjustment applied. GoC would also need to advise the Insurer of the required insured yield coverage level which in principle could be between 50% and a maximum of 90% of the average or expected Departmental yield of raw cotton. In this worked example an 80% coverage level has been assumed and the 80% Insured Yields are shown in column 5. The sum insured is determined by multiplying the Insured Area times the 80% coverage Insured Yield times the agreed insured value per kilogram of raw cotton.

4.47. ***Under this proposed cover which is designed to protect against the loss of the costs invested in growing the cotton crop (including the credit element) a value of AR$ 2.0 per*** kilogram has been assumed giving an average sum insured value of about AR$ 2,000/Ha for 80% coverage. Under these assumptions the Total Sum Insured (TSI) would be AR$ 161.4 million. The premium rates corresponding to the 80% coverage level in each Department with an average of 7.0% and a range from a low of 5.1% in General Belgrano (which exhibits the lowest variability in Departmental average annual cotton yields) to a high of 12.0% in Fray Justo Department (on account of the much higher yield variability). The corresponding premium that GoC would be responsible for paying would be in the order of AR$ 13.6 million.

4.48. ***The analysis shows that in many of the departments there are only a very small number of small and medium cotton farmers*** and from an operational viewpoint it would not be cost effective to insure 4 or 5 farmers with less than 1000 insured hectares in a single department where Insurers will need to introduce a system of in-field yield sampling to establish the actual average departmental cotton yield. Equally it would not be very cost-effective for PRODAF to operate a program of technical assistance in Departments with such a small number of participating farmers. This is an operational issue for the Insurers and GoC to discuss and resolve going forward.

Table 4.9. Chaco Province: Illustrative AYII Cotton Insurance Portfolio for Small and Medium Farmers for 80% Insured Yield Coverage level

Department	No. of Small and Medium Cotton Producers	Insured Area of Cotton (Ha)	Department Average Expected Yield Cotton (Kg/Ha)	Insured Yield Cotton 80% Coverage (Kg/Ha)	Sum Insured 80% Cover (AR$)	Commercial Premium Rate 80% Cover (%)	Commercial Premium 80% Cover (AR$)
12 de Octubre	35	2,500	1,313	1,050	5,252,000	8.1%	426,462
2 de Abril	32	3,074					
25 de Mayo	30	754	1,251	1,001	1,509,206	5.5%	83,459
9 de Julio	25	3,168	1,449	1,159	7,344,691	5.0%	364,297
Almirante Brown	2	550	1,354	1,083	1,191,520	5.3%	62,674
Chacabuco	4	538	1,228	982	1,057,062	5.5%	58,456
Com Fernandez	67	2,675	1,334	1,067	5,709,520	6.0%	344,855
Com Luis Fontana	271	13,635	1,292	1,034	28,186,272	7.6%	2,139,338
Fray Justo	121	28,463	1,283	1,026	58,428,846	12.0%	6,999,776
General Belgrano	4	291	1,237	990	575,947	5.1%	29,143
General Guemes	67	2,869	1,289	1,031	5,917,026	5.5%	324,253
General San Martin	52	1,578	1,316	1,053	3,322,637	6.5%	216,304
Independencia	15	1,079	1,305	1,044	2,252,952	5.6%	125,264
Maipu	97	4,030	1,351	1,081	8,711,248	5.9%	515,706
O Higgins	82	8,540	1,302	1,042	17,790,528	5.8%	1,030,072
Pte de la Plaza	22	1,339	1,176	941	2,519,462	6.4%	160,490
Quitilipi	95	4,632	1,314	1,051	9,738,317	6.3%	608,645
Asan Fernando	4	257					
San Lorenzo	15	635	1,232	986	1,251,712	6.0%	74,978
Sargento Cabral	6	345	1,205	964	665,160	5.4%	36,185
Total / Average	**1,046**	**80,952**	**1,192**		**161,424,107**	**7.0%**	**13,600,355**

Source: Authors' analysis of Federal Government Cotton production and Yields (Sown area basis)

4.49. ***In due course once MPCh is able to provide details for the PRODAP program, and planned area of cotton in each Department the portfolio analysis shown in Table 4.9 can be refined and finalized.***

Legal, Organizational and Operational Requirements for Area-Yield Index Insurance for Cotton in Chaco Province

4.50. ***This section deals with the key legal, institutional, operational and financial options and requirements for the implementation of the possible Macro-level AYII program for cotton grown in Chaco Province.*** It is noted that at the time of completing this final report it has not been possible to finalize with GoC or the Ministry of Production and Environment Chaco Province (MPCh) key aspects for the operation of the macro-level cotton insurance program including: (i) to confirm GoC's approval for a macro-level program under which it would be the Insured and be responsible for the payment of premium; (ii) to obtain details of the location and cultivated area of the 600 cotton farmers with between 60 Ha and 150 Ha of cotton who will benefit under the PRADF project, (iii) to consider how the cotton insurance program would relate to the existing agricultural and livestock emergency schemes (termed Emergencia Agropecuaria) which is operated by Federal and Provincial Governments and the separate provincial Plan for the Sustainable Development and Promotion of Cotton Production (*Plan de Desarollo Sustentable y Fomento de la Produccion Algodonera*) which is managed by the MPCh, (iv) whether the insurance companies and their reinsurers will be willing to underwrite an AYII cover where there are currently no independent systems and procedures for estimating actual average cotton yields in each Department and which is critical to the operation of the AYII product, and finally (v) whether the Insurance Companies would agree to underwrite this scheme as a Pool or whether one company should be awarded the contract through a tender process. The options set out in this Chapter will therefore need to be discussed and agreed between GoC and the Insurance Companies, and then approved by the Superintendent of Insurance of the Nation (SSN).

Legal Considerations for AYII Insurance

4.51. ***Area Yield Index insurance differs from standard indemnity based insurance in several key ways which in some countries may require changes or amendments to standard insurance legislation.*** 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 (which could be pasture), is replaced by a proxy index, in this case the average area yield of cotton at a Departmental level which is designed to approximate as accurately as possible the actual yields obtained by individual cotton producers located in that Department. A second major difference with conventional crop insurance is that the AYII product does not indemnify individual farmers for yield reduction or losses on their own farms, but rather it makes payouts to farmers according to the reduction or losses in the Departmental average yield of cotton. Thirdly under the AYII index cover there is no measurement of actual physical loss or damage suffered by the individual insured cotton producer, but rather an insurance payout is made according to the amount of yield shortfall or loss in the Departmental average yield index. A key difference between traditional indemnity and new index insurance is that an index may result in payouts to an Insured even if the Insured has not incurred any physical loss or damage to the object or good which the index is designed to approximate, and conversely, the index may not trigger any payout even though the Insured has incurred in a loss.

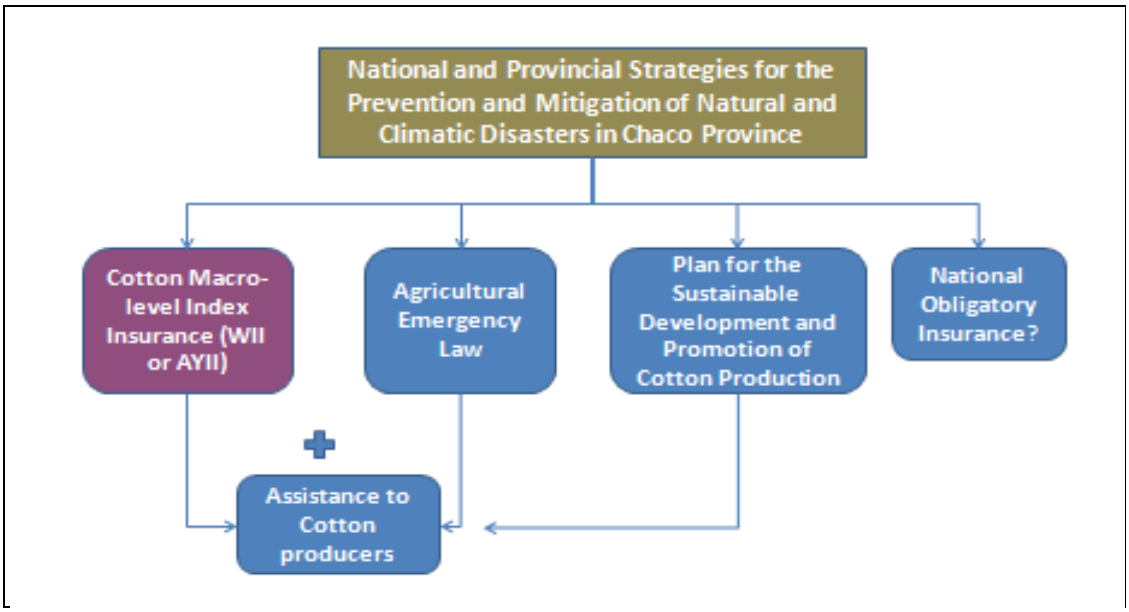
4.52. ***It will be important for the Superintendent of Insurance (SSN) to check Argentinean insurance legislation (laws and regulations) to ensure that there are no restrictions to the***

introduction of AYII index insurance. Given the fact that the Insurance sector already has experience of underwriting AYII under the Cielo Abierto program in the early 2000s and that this product was approved back then, it is considered very unlikely that there will be any legal impediments to the introduction of a macro-level AYII program for cotton grown in Chaco Province.

4.53. ***Under the option to issue a macro-level AYII insurance policy to GoC (the Insured), it will be important for the participating Insurance Companies to confirm the legal requirements and procedures for issuing such a cover, with the SSN***. Under this proposal, GoC would be the Insured on behalf of the 600small and medium cotton producers with between 60 in Chaco Province (See Chapter 1 for further details on PRODAF). The Insured would receive a Master Policy document and special conditions attaching and would be responsible for payment of premium on the agreed Total Sum Insured (TSI). It is understood that the PRODAF selected cotton producers will be registered and that full details of their planned cultivated area of cotton in each Department will be made available to the Insurer(s) in order to establish the total insured area and the sum insured and premium per Department and in total. The farmer registers would also be used to calculate the value of payouts due to each registered cotton farmer in any Department where a payout is triggered by the AYII policy.

4.54. ***If GoC elects to introduce a macro-level AYII cotton insurance program for specific farm-size categories of cotton producer, it will be necessary to consider their continued eligibility for compensation under the existing national and provincial natural disaster relief programs*** including (i) the Law 22913/81 Agricultural and Livestock Emergency Law (*Ley de Emergencia Agropecuaria*) and Provincial Law of Agricultural Disaster Relief (Law 10,390) and (iii) the Plan for the Sustainable Development and Promotion of Cotton Production (*Plan de Desarollo Sustentable y Fomento de la Produccion Algodonera)*. In addition if the Argentinean Congress approves the introduction of some form of minimum obligatory crop insurance for all farmers, this program would also have to be taken into consideration (see Figure 4.5).

Figure 4.5. Range of Public Sector Programs for the Prevention and Mitigation of natural and Climatic Disasters in the Agricultural Sector



Source: Authors

Institutional Considerations for Chaco Cotton AYII Program

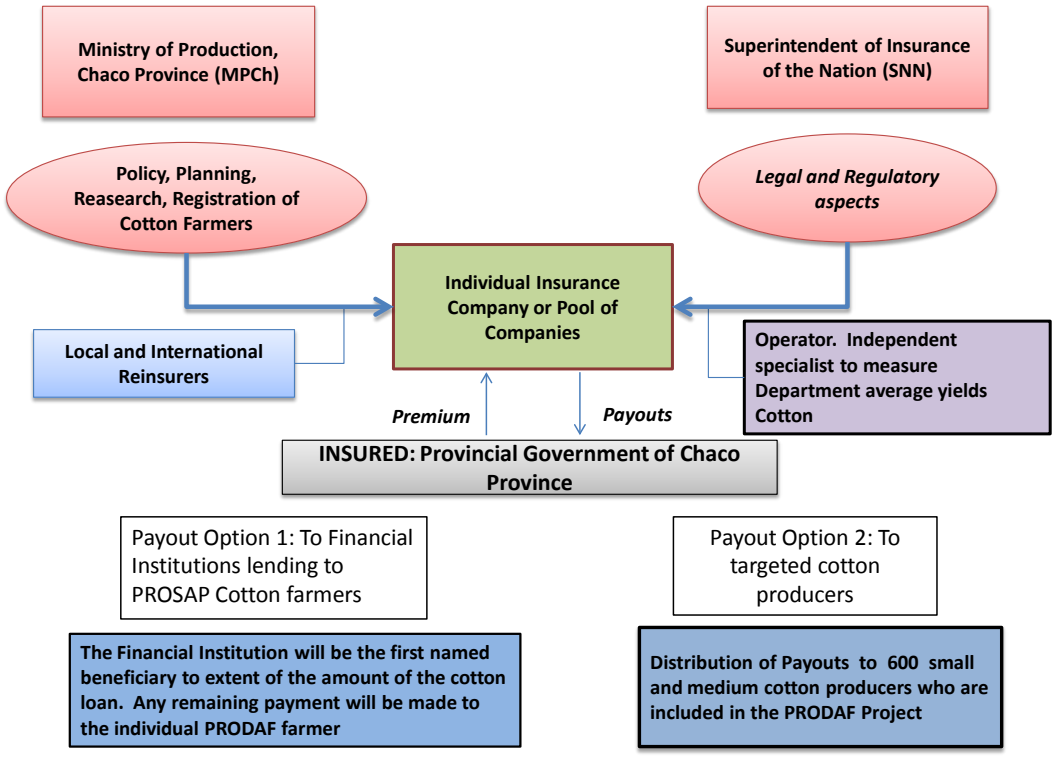
4.55. ***During the conduct of the Chaco Cotton Feasibility Index Insurance Feasibility study the World Bank-ORA team has regularly briefed a group of the largest private agricultural insurance companies in Argentinean the progress with this study.*** In each of the previous Missions the World Bank team has met a group of 5 leading insurance companies including La Segunda, Mapfre Seguros, Provincia Seguros, Sancor and San Cristobal to brief them on the progress with the Chaco Feasibility study. To date the companies have expressed an interest in this study and index insurance as an alternative to individual grower MPCI cover, but they have not committed themselves to underwriting any possible WII or AYII program for cotton grown in Chaco Province pending the results of the final report[32]. In addition, Nation Insurance Company may be interested in the Chaco AYII cotton insurance proposals.

4.56. ***If the Chaco AYII macro-level cotton insurance program is approved by GoC, at that stage GoC will need to consider whether to place this program (a) with a single agricultural insurance company or (b) with a group of insurance companies under some form of suitable Pool agreement.*** Potential advantages of Pools include: (i) cost-sharing in the research and development and start-up stages, (ii) cost-savings in establishing a single underwriting unit, staffing and equipment, either within the lead coinsurer or as a separate underwriting entity, and (iii) major cost savings in purchasing pooled reinsurance (common account) protection. An outline Institutional structure for the macro-level cotton program is shown in Figure 4.6 and under the assumption the program is targeted at PRODAF small and medium cotton farmers. Under the Coinsurance option it is assumed that one of the participating companies will act as the Pool leader with regard to issuing a Master Policy to the Insured (Government of Chaco or its representative). GoC would be responsible for payment of premium to the Pool leader. The Pool coinsurers would purchase common account reinsurance protection from local and or international reinsurers. The Pool would need to enter into a contractual agreement with a third party to provide timely and accurate estimates of the actual average yield of cotton in each insured Unit (Department) at the time of the cotton harvest in order to determine whether a claims payouts is due or not.

4.57. ***Figure 4.6 shows two options for the distribution of payouts. If the PRODAF project is linked to cotton production credit, the payouts in any department would be made directly to the financial lending agency*** to settle the individual PRODAF farmer's loan exposure with the lender: any payouts in excess of the amount of the loan would then be settled by the lending agency to the PRODAF registered cotton farmers. Under payout option 2 where no financial lending agency is involved in the PRODAF project, GoC would need to establish distributional procedures to settle payouts directly to each PRODAF cotton grower according to the amount of cotton each one has grown and which has been insured under the macro-level policy.

[32] At the final meetings held with the Insurance companies in Buenos Aires on 30 May the companies expressed their interest in studying the AYII proposals further including the final report and recommendations. before they make any firm decisions either way.

Figure 4.6. Outline Institutional Framework for Chaco Province Macro-level Government AYII crop insurance program for PRODAF Cotton Farmers



Source: Authors

Operational Considerations for Chaco Cotton AYII Program

Farmer Registration:

4.58. ***For the purposes of the AYII insurance program for PRODAF cotton producers, it will be necessary to obtain a register all the 600 targeted small and medium cotton producers (cultivating between 60 and 150 Ha of cotton) in each Department and the best estimates of the sown area of cotton in the forthcoming season for the purposes of establishing the Sum Insured per Department and Total Sum Insured (TSI)***. The need to register all eligible (targeted) cotton producers according to their planned area of sown cotton prior to the onset of the cotton cropping season includes: (i) this information is necessary to establish the insured area of cotton in each Department and the corresponding sum insured per hectare, per Department and in total; (ii) premium will be calculated on the basis of the sum insured and the calculated premium rate that applies to the selected yield coverage level in each Department; and (iii) for insurance compensation payout purposes it is necessary to have these registers of the targeted cotton producers in each Department and their individual cotton area and thus sum insured.

4.59. ***The task of identifying and registering cotton farmers for crop insurance purposes should be very much simpler in future following GoC's decision in December 2012 i to pass legislation making it mandatory for all cotton farmers in Chaco province to register their***

holding details with the Chaco Agricultural Producers (Productores Agricolas Chaquenos-PAC) data base. Chapter 2 noted that this legislation was enacted through the Chaco Provincial Law No. 7154 of 12 December 2012 and requires all farmers in Chaco Province to register their cotton crop cultivation details with the Chaco Agricultural Producers (*Productores Agricolas Chaquenos*- PAC) on an annual basis. In future only those farmers who are registered with PAC will be eligible for credit and technical assistance.

Third Party Operator to measure and verify actual Departmental average yields of cotton:

4.60. ***For the operation of this AYII Cotton insurance policy it is unlikely that the Insurers and their Reinsurers will accept MPCh's estimates of the actual average yields without some form of independent monitoring and measurement and validation of these departmental level cotton yields.*** The most practical option would be to appoint an independent and reputable local agricultural services organization with expertise in cotton yield estimation through in-field sample measurement and weighing of the cotton bolls using standard procedures which are used by the cotton industry for yield forecasting purposes (see INTA-RIAN Field Manual for a description of these procedures). Argentina is fortunate to have a number of independent agricultural inspection and field loss assessment companies who provide services to the agricultural insurance industry[33]. A statistical procedure should be adopted for randomly selecting cotton farms and fields for the sample cotton boll counts and yield estimation in each Department: the samples must be drawn from the whole population of cotton growers in each department. The number of cotton sample crop-cuts to be taken in each department for yield estimation procedures will be a function (a) of the size of the cultivated area in hectares of cotton in each department and (b) the degree of variability between each sample crop cut yield and (c) the required statistical confidence-level of the estimated mean yield in each Department[34]. As a rule of thumb between 30 to 50 crop cuts may need to be taken in each Department to establish the actual average yield against which payouts will be made if the actual yield is below the insured yield. The appointed specialist crop loss assessment company should be required to provide a full description of the sampling procedure they will use to select cotton farms and selected fields for crop cutting and to provide a standard procedural manual explaining the in-field procedures for locating the sample crop cuts, the size of the crop-cut, the cotton count and weighing procedures to be adopted and procedures for conducting a second crop count in the event that the cotton crop is not fully mature at the first visit. . It is essential that the yield estimation procedures are agreed by the GoC and Insurers and the cotton farmers' representatives and that the estimation of actual average yields is conducted in a timely fashion to avoid delays in settling payouts in Departments where major cotton yield losses/shortfall have been experienced. The costs of the yield estimation procedures will need to be built into the final commercial premium rates charged on the AYII program: as a guideline these costs should not exceed 3% to 5% of the premium costs for a cotton AYII insurance program covering 50,000 Ha to 100,000 Ha and spread over about 10 to 12 Departments.

Options for Distribution of AYII Payouts:

4.61. ***Under the assumption that the AYII program is linked to the PRODAF Project which is targeted at 600 small and medium farmers, there are two main options for districting payouts as illustrated in Figure 4.6.*** Option 1 assumes that the PRODAF project is linked to cotton

[33] The leading companies include: (i) LEA-TAGH (owner Ignacio Murtgah, formerly of PartnerRe Agricultural Services and Agricultural Risk Management (Argentina) Ltd), (ii) PPD (Pousa Pazutti Dick); (iii) Roney (Neil Ross, formerly with Buenos Aires Insurance Company), and (iv) Taipe (Aquaroni).

[34] The Standard Error around the mean yield is reduced by increasing sample size, in this case the number of crop cuts. Typically a 90% to 95% confidence limit is adequate for yield estimation procedures.

production credit, in which case the payouts would be made to the lending agency up to the maximum of the amount of credit borrowed by each farmer and any surplus payouts would then be settled to the individual cotton farmer. Under payout option 2 where no financial lending agency is involved in the PRODAF project, GoC would settle payouts directly to each PRODAF cotton grower. The task of calculating the payouts due to each targeted beneficiary of the program can only be made if an *a priori* list of these cotton farmers and their cultivated area of cotton in the current season exists. The Insurance Company(ies) will need to agree with GoC (the Insured) the most cost effective way of distributing the payouts to the individual cotton farmers.

Financial and Reinsurance Considerations for AYII Insurance

4.62. ***It is currently not possible to provide portfolio estimates for the 600 small and medium cotton farmers with between 60 Ha and 150 Ha who will be targeted by the PRODAF project between 2013/14 and 2016/17 and therefore the estimates presented in this section are based on the earlier portfolio parameters provided by MPCh for the 1,046 small and medium farmers with between 10 ha and 100 Ha of cotton in Chaco Province.***

4.63. ***Under the proposed macro-level policy, the GoC would be responsible for settling the due premium to the Insurer (or Pool Insurers).*** The Insurers would first need to confirm their commercial premium rates corresponding to each Insured Yield coverage level and to then confirm the level of coverage GoC wishes to purchase in each Department and the unit sum insured values and therefore the per hectare sums insured and Department and Total Sum Insured for the program. The illustrative commercial premiums for a program that insured 100% of the eligible cotton acreage (including all farm-size categories of cotton producers) were presented in Table 4.6 and then in Table 4.9 estimated were provided for an AYII program for small and marginal farmers with 10 to 100 Ha with an estimated commercial premium of AR$ 13.5 million for 80% coverage level.

Cotton Insurance Portfolio Financial Projections for Small and Medium Cotton Producers:

4.64. ***Table 4.10 presents some illustrative estimates of the sum insured, commercial premium and PML for 80% coverage level for the 1,046 targeted small and medium cotton farmers with between 10 Ha and 100 ha of cotton.*** The insured area of cotton would be 80,952 Ha and with an 80% coverage level the TSI would amount of AR$ 160 million (About US$ 31 million) with commercial premium of AR$ 13.5 million (about US$ 2.6 million). The estimated 1 in 100 year PML liability would be in the order of AR$ 48 million.

Table 4.10. Illustrative Portfolio Projections for an AYII Program with 80% Coverage level, targeted at Small and Marginal Cotton Farmers (10 to 100 Ha of cotton)

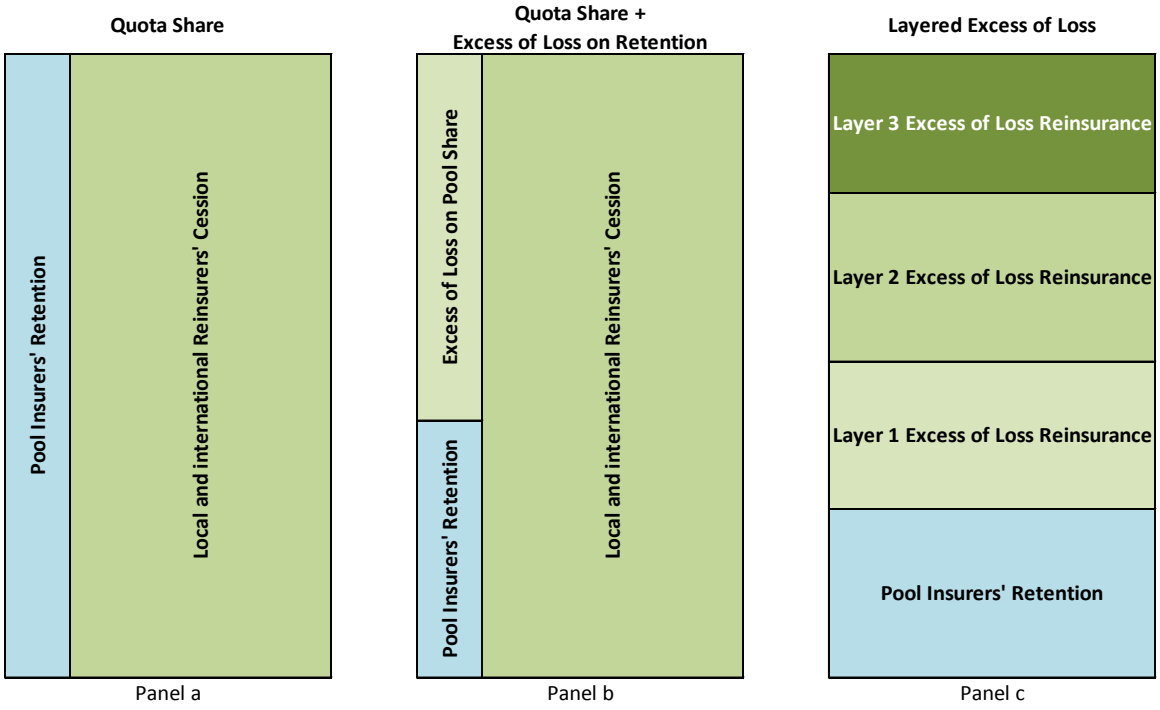
Item	100% Figures for all cotton in Chaco	Figures for Small and Medium Cotton Producers
No. Insured cotton farmers (34% of farmers)	18,000	1,046
Insured Area Cotton (Ha)	221,307	80,952
80% Coverage Sum Insured AR$	461,409,300	159,914,901
80% Coverage Commercial Premium rate (%)	7.0%	8.5%
80% Commercial Premium (AR$)	32,277,857	13,526,895
1 in 100 year PML (AR$)	139,214,157	48,294,300

Source: Authors analysis. See Tables 4.2. to 4.7 for details

Risk Layering and Reinsurance:

4.65. ***There are several options for the Chaco Cotton AYII Insurer (or Pool Coinsurers) to consider for reinsuring the program for small and medium farmers.*** The first option would be to purchase proportional or quota share reinsurance under which the pool members would decide on the share of risk they could prudently retain, for example 20% of the risk which on a sum insured basis would amount to AR$ 32 million (considering 80% coverage), and to then seek to cede the remaining 80% of the risk or AR$ 128 million, to international reinsurers (Figure 4.7, Panel a.). The Insurer (Pool) may also decide to purchase Excess of Loss Reinsurance (XOL) on its retention, for example for losses excess of 100% of Gross Net Premium Income (GNPI) (Figure 4.7, panel b.). The third option would be for the Insurer (Pool) to purchase a layered XOL Reinsurance program again for losses excess of say 100% of GNPI (Figure 4.7, panel c.). It is not possible to predict at this stage if international reinsurers would agree to provide unlimited liability to the Insurer (Pool) on any XOL program, or whether they would only provide cover up to an agreed limit beyond which liability would revert to the pool.

Figure 4.7. Examples of Proportional Quota Share and Non-Proportional Excess of Loss Reinsurance open to the Pool Insurers



Source: Authors

4.66. ***There will be a need to involve both local Argentinean and international reinsurers at an early stage in the negotiations over the final cover design and rating and sums insured for this cotton AYII program in Chaco Province.*** The specialist international agricultural reinsurers are familiar with AYII insurance and their support will be important to the implementation of this new AYII program for cotton grown in Chaco Province. This report has presented a rating tool to derive pure loss cost rates and technical premium rates. Furthermore indicative commercial premium rates are presented. However, it is stressed that final rating decisions will need to be made by the local insurers and their local and international reinsurers.

4.67. ***The changes in Argentinean reinsurance legislation that came into effect in the 1st quarter 2012 may have important implications for the layering of the reinsurance program and for the balance of retention by local reinsurers and their international reinsurers.*** In 2011 SSN by Resolution No 35,615 amended the reinsurance regulatory framework for Argentina by requiring that any international reinsurer wishing to transact reinsurance business in the Argentinean market would in future need either to establish and capitalize a local reinsurance company in Argentina, or to qualify as an admitted reinsurer. The purpose of this legislation was to encourage the formation of a private reinsurance capability in Argentina and to retain a higher share of the market insurance premiums. This legislation came into effect in early 2012. The main implications going forward are that most reinsurance business will have to be transacted as a retrocession by a local reinsurer and this will add significantly to the costs of transacting international reinsurance arrangements.

5. Discussion, Conclusions and Recommendations

Conclusions on the Role of Weather Index Insurance for Cotton Grown in Chaco

5.1. ***The technical analysis conducted by The World Bank-ORA team for key selected weather stations indicates that it is not feasible to implement a macro-level WII rainfall index policy to protect cotton producers against extreme excess rainfall and deficit rainfall (drought) events.*** During the conduct of the study a series of rainfall index models were designed and tested in attempt to capture the effects of excess rain and rainfall deficit (drought) on cotton production and yields. These models included 3 and 4 vegetative growth stage rainfall index models using both cumulative rainfall amount and also number of consecutive days excess rainfall/rainfall deficit as defined: such rainfall indexes have been widely developed for cereals and oilseeds and are being pilot tested or implemented on a commercial scale in over 30 countries. However, only a few countries including India have successfully implanted a cotton excess rainfall and rainfall deficit cover to date. At each stage of the Chaco cotton rainfall index feasibility study, the models were tested and refined in discussion with cotton specialists from MPCh. In spite of these refinements the indexes performed very poorly in terms of the extremely low correlations between district-level cotton yields and the rainfall index (both the cumulative rainfall index and the number of consecutive days drought cover).

5.2. ***Key issues that appear to explain the very poor correlations include*** (i) the wide sowing window for cotton in Chaco Province which makes it very difficult for a single index product to capture the different planting dates and thus different crop cycles, (ii) the localized variability in rainfall patterns which means that a single weather station in a single Department may not reflect the actual rainfall received throughout that Department, (iii) the fact that cotton is crop which is capable of regeneration and recovery in the vegetative growth stage and which complicates the setting of threshold and exit triggers and payouts for each vegetative growth stage, (iv) the fact that there is an extended crop maturity and harvesting period for cotton and which is not applicable in cereals, and (v) the evidence that there are many other factors which affect cotton yields in Chaco including pest and disease damage and technology levels which differ widely among the cotton farmers.

5.3. ***On the basis of these findings, the World Bank-ORA team cannot therefore recommend an excess rainfall/rainfall deficit WII product for cotton grown in Chaco Province.***

Discussion, Conclusions and Recommendations on the Potential Role of AYII Insurance for Cotton Grown in Chaco

5.4. ***If AYII cover is to be considered for Chaco cotton it is important to note that there are several key technical and operational issues and challenges which will have to be addressed.*** These challenges are reviewed below.

Technical Considerations

5.5. ***There are two different cotton area, production and yield data bases in Chaco Province and it will be necessary to obtain a clear explanation of the reasons for these differences and to decide which data set should be used for the design and rating of the AYII program.*** The AYII product depends on a unique, officially recognized and accurate time-series of cotton sown area, production and yield data at the Departmental-level in order to design and rate the AYII Index.

However, during this study the design team has been advised there are two different cotton production and yield data sets, (a) Federal government cotton data and (b) Provincial data collected by GoC-MPCh, and in Chapter 4 an illustration of these differences was given for the cotton yield history in one Department – Comandante Luis Fontana.

5.6. ***For the purposes of the AYII feasibility study a decision was made to use the Federal Government Departmental-level cotton production and yield data to design and rate the area-yield index insurance***. This decision was based on the longer 41 years time-series cotton production and yield data and the lower level of missing and or implausible (outliers) data. This decision needs to be approved by the key stakeholders including GoC and MPCh and the insurance company or companies that are interested in underwriting this AYII program.

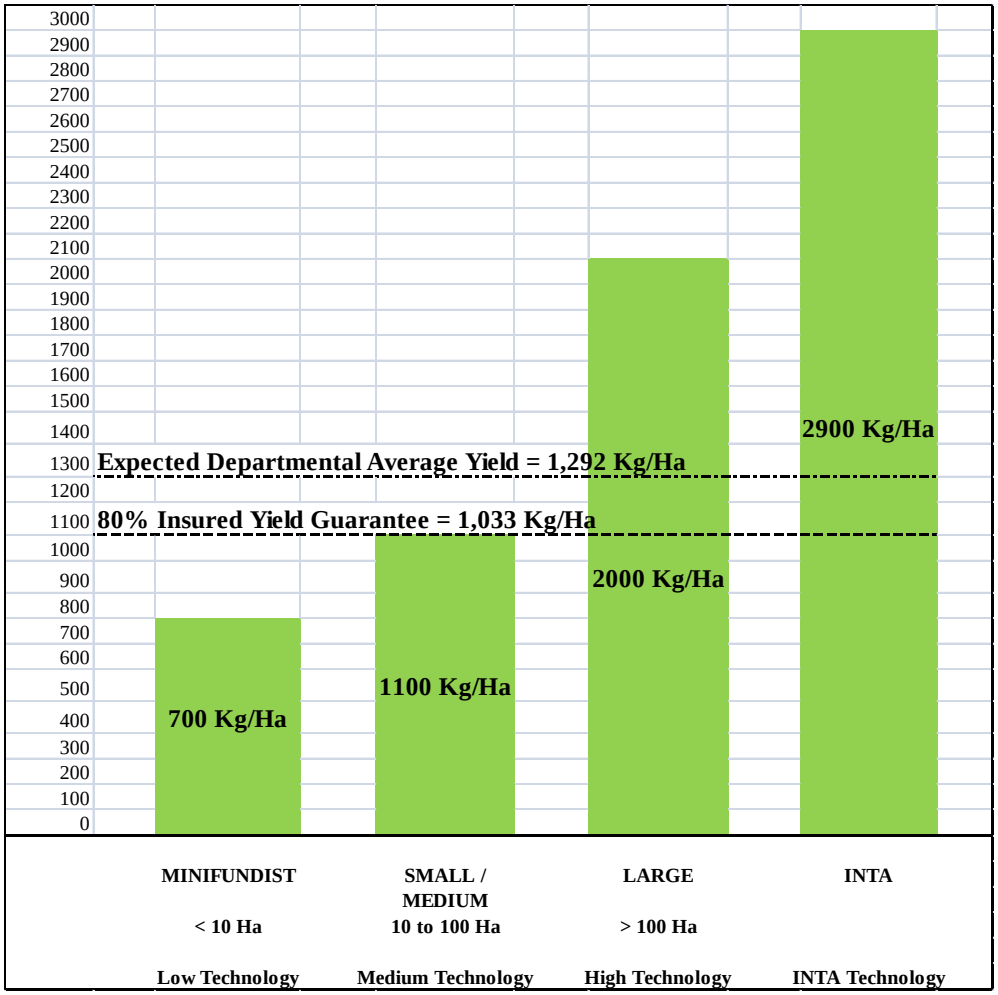
5.7. ***The Federal Government cotton statistics are only updated to the 2009/10 season***, and it will be necessary in due course to update the yield estimation and rating exercise for the past three seasons 2010/11 and 2011/12 and 2012/13. It is likely that the stakeholders will need to contract an actuary to assist them in this exercise.

5.8. ***MPCh advise that the cotton production and yields vary widely between different types of cotton producer according to their technology levels within the same Department.*** Area-based crop insurance (AYII) only works well in regions where farming practices and average crop yields achieved by farmers are relatively homogeneous – if not severe problems of basis risk may arise. During discussions with farmers and representatives from farmers' associations about the performance of current insurance programs being promoted in Chaco, it was pointed out that districts within the same department may show large differences in terms of cotton production characteristics and yield variability. For an AYII insurance program the larger the area based on which the actual yield is estimated, the less opportunity an individual farmer has to influence the yield outcome. Nevertheless, there must be a good correlation between the yield variation of a definable area (i.e. department) and the individual farmer's yield; otherwise, there is the risk that the insurance program triggers a payout when there has not been reported a drastic reduction in cotton yields or vice versa ("basis risk"). In Chaco, it is understood that the large high-technology cotton producers obtain average yields of raw cotton which are between 1.75 and 2.0 MT/Ha or even higher if they follow the full recommended technology package by INTA which is supposed to provide average yields of 2.9 MT/Ha. This compares with average yields obtained by small and medium farmers which are close to the departmental average yields of about 1.0 to 1.3 MT/Ha of raw cotton, while low technology farmers obtain average yields which are well below the Departmental average. The wide variation in cotton farmers' technology levels and yields within each department complicates the operation of an AYII cover. (See below for further discussion).

5.9. ***Currently, the cotton statistical production data collected by the local authorities does not disaggregate information based on farmers' typology (i.e. famers' size, technology applied, husbandry levels, etc.).*** In this sense, if an AYII macro-level insurance program is implemented with the objective to make use of payouts to assist small and medium cotton farmers, but if the Departmental average yield and thus the cover level (yield index) that has been set is influenced more by the cotton production and yields obtained by big commercial farmers, the target beneficiary group of smaller farmers may in fact incur losses before the AYII insurance program triggers a payout. Under this situation, the effectiveness of the AYII crop insurance program may not work for the most vulnerable farmers' group (beneficiaries), thus it may require the use of other risk financing instruments to provide assistance to those farmers for which this AYII insurance program does not work. This issue is illustrated in Figure 5.1 below for Comandante Luis Fontano Department using the most recent 5-year actual average yield of raw cotton of 1,292

Kg/Ha and an 80% Insured Yield Coverage level of 1,033 Kg/Ha. The normal or average yields produced by the three categories of cotton producer recognized in Chaco Province are presented based on the authors' best estimates with normal average yields of: 700 Kg/Ha for Minifundists, 1,100 Kg/Ha for semi-technified small and medium farmers with between 10 Ha and 100 Ha of cotton and finally an average of 2,000 Kg/Ha for the large high technology cotton producers and then finally the 2.9 MT/Ha yield reported by INTA for farmers adopting their full recommended INTA technology package for cotton. In this illustrative example, the 80% AYII cover level Department yield shortfall guarantee of 1,033 Kg/Ha would provide a very high level of protection (of 93% of the normal average yields of 1,100 Kg/Ha for the group of small-medium farmers with 10 to 100 Ha of cotton. However, for the very large mechanized cotton producer incurring very high costs of production the 80% Insured Yield coverage level would represent 52% only of their expected normal average yield and the cover is unlikely to be attractive to this group of cotton producers. Finally the cover would be extremely beneficial to the group of Minifundist cotton producers because the 80% insured yield guarantee level of 1,033Kg/Ha is about 48% higher than their normal average yields.

Figure 5.1. Comandante Luis Fontano Department: Comparison of Departmental average raw cotton yield, AYII 80% Insured Coverage Yield and illustrative average Yields achieved by Different Types of Cotton Farmer



Source: Authors' analysis

Operational Considerations

5.10. ***Although the procedures used by the local authorities to collect cotton planted and harvested area, production, and yield statistics in each Department seems to have been consistent over time, the insurance industry may request the introduction of an independent, accurate system of measuring actual yields in each Department*** in order to avoid conflict of interest and moral hazard. In Chaco, the MPCh regional and departmental-level technical and extension staff are responsible for estimating the sown area of cotton on a weekly basis during the planting season and then in estimating the harvested area of the crop and the raw cotton production obtained during the harvest season. These estimates are reported at a Departmental level and the average yields are calculated by dividing the total estimated production per Department by the estimated total harvested cotton area per department[35]. There is, however, no actual in-field measurement of average yields for cotton grown on selected farms in each Department.

5.11. ***AYII insurers are likely to insist that a system of independent crop-cutting is implemented to establish the actual average departmental yields and on which basis any insurance payouts would be made***. During discussions with the senior staff from MPCh, the Council of Agricultural Engineers of Chaco Province (Consejo Profesional de Ingenieros Agrónomos de la Provincia del Chaco) was identified as a potential candidate that may audit the required statistic data for the operation of a macro-level Area Yield Index Insurance. Conversely, the National Institute of Agricultural Technology (INTA, in Spanish) has also experience in estimating cotton production and yields. During the 1990´s, the insurance industry of Argentina promoted an initiative called "Cielo Abierto" which was commercialized as a double trigger policy. When a loss claim was submitted to the insurance company by famers, payouts were disbursed only when INTA´s department level sampling reported yields below the agreed cover level. One of the advantages of introducing a system of field-level cotton yield sampling in each department is that this could potentially speed up the process of estimating the departmental actual average yield and in making insurance payouts where these are due. Under the existing reporting procedures, MPCh can only declare the final total cotton production and therefore average yield in each Department when the harvest has been fully completed and the statistics compiled in August or September. **Finally, this report has recommended the appointment of an independent specialist loss adjuster to conduct in-field random sampling of cotton plots to establish the actual average yield of cotton in each department**.

5.12. ***The proposed AYII Cotton Insurance Program can only operate if GoC introduce a formal system for registering the targeted group of small and medium cotton producers in each Department.*** MPCh has now defined this target group as cotton growers who will be registered under the PRODAF project with between 60 and 150 Ha of cotton. The review of the technical design and operational requirements for the operation of the AYII cover in Chapter 4 has shown that farmer registration data is required in each Department which (i) provides best estimates of the area of cotton which will be sown by each farmer in the forthcoming season for the purposes of calculating the insured area and sum insured in each department and (ii) this register is then used to calculate the value of the payouts due to each protected farmer in the event the AYII policy is triggered in that department. MPCh will need to put in place such a system which can be updated each year and at least one month prior to actual planting decisions are taken in order to confirm insurance is in place well before the start of the cotton cropping season. This is to avoid

[35] As noted in Chapter 4, from an insurance viewpoint we recommend under the operation of an AYII program that all cotton yields are calculated on a sown-area basis and not harvested area basis as this is much fairer to the Insured.

situations where pre-existing climatic conditions are developing pre-sowing and which might lead to anti-selection by the Insured against underwriters. It is therefore positive to note that following the enactment of the new Provincial Law No. 7154 of 12 December 2012, all farmers will be legally required to register their planned and actual cultivated area for each crop with Chaco Agricultural Producers (*Productores Agricolas Chaquenos*- PAC) data base.

5.13. ***The system for disbursing AYII insurance Payouts in a timely and cost-effective manner either to (i) the financial institutions if cotton credit is provided or (ii) directly to individual farmers where no credit is involved, must also be discussed and agreed between the Insured (GoC) and Insurers***. Ideally where payouts are made to cotton farmers, it would be most efficient to make these payments directly to each farmers' bank account, but on the assumption that many farmers do not have bank accounts, a system of redeemable bank-drafts may need to be considered.

5.14. ***Any AYII program for cotton in Chaco Province must be accompanied by grower awareness and education programs*** to explain carefully who the eligible farmers under this program are, how AYII operates and specifically that the product does not indemnify losses at the individual farmer level. There is likely to be a very important role for GoC-MPCh and its cotton extension staff to assist the Insurance Company (or Pool) in implementing these AYII training programs. Training in AYII concepts should also be provided to key MPCh staff.

Other Considerations (Legal, Institutional and Financial)

5.15. ***The Chaco Cotton Pre-feasibility study final report and AYII rating tool and manual of instructions will need to be formally presented to SSN for its review and approval***. This task will be performed by ORA-MAGyP in early June 2013. .

5.16. ***It will also be necessary to present the Chaco Cotton Feasibility study final report and AYII rating tool to the group of specialist agricultural insurers that have expressed their interest in this Index program. ORA-MAGyP will again assume responsibility for distributing the AYII Pre-feasibility study report, rating tool and users' manual to the*** Once the insurers have had an opportunity fully to review the proposed contract design and rating tool it is hoped that one or more will express an interest in designing and implementing a scheme for GoC. If this program were to start up in the 2013-14 cotton season all planning and operating systems and procedures would need to be in place by end July 2013. This time-frame is not realistic and therefore any AYII program implementation is likely to have to be deferred to the 2014/15 season incepting on 1st September 2014. The Cotton AYII Pre-feasibility study report and rating tool will also be made available at the earliest opportunity to the GoC-MPCh for them to review and to make their decisions whether to buy the AYII cover for the PRODAF registered small and medium cotton producers.

5.17. ***If GoC agree to the proposed macro-level AYII program for small and medium cotton producers in Chaco Province it would then need to agree on the mechanism for financing cotton insurance premiums.*** This report has presented calculated technical premiums and illustrative commercial premiums to assist GoC to assess the likely magnitude of the costs of premiums for different coverage levels and for a scheme for all cotton producers or a sub-group of small and medium cotton farmers in Chaco Province**.**

Conclusions on AYII for Cotton in Chaco Province

5.18. ***Area-yield Index insurance for cotton, operating at a Departmental Inured Unit level, appears to be technically and operationally feasible in Chaco Province*** if an independent system of verifying actual average Departmental cotton yields can be introduced in order to confirm the cotton industry's existing procedure for recording planted cotton area, harvested cotton area, raw seed cotton production and yields in each department. It is recommended that an independent Argentinean firm of crop loss adjusters is appointed to do field-level sampling of cotton yields and on which basis to estimate the actual average yield of raw cotton in each department.

5.19. ***The preliminary analysis of AYII Insured Yield coverage levels and technical premium rates suggests that the maximum coverage levels that should be offered in any start-up phase should be 80% of Expected Yield any one department*** and in high risk departments where cotton yields are very variable that maximum coverage levels may need to be reduced to 70%. This recommendation is made to avoid potential situations in departments with high yield variability that the policy ends up making payouts to small-medium farmers even if they have not incurred major yield loss (as illustrated in the example in Figure 5.1). In addition, these recommendations are made to maintain commercial premium levels to affordable levels. As experience is gained with the program over time, it may be feasible to consider raising the insured yield coverage level in selected departments to the maximum 90% coverage level.

5.20. ***It is recommended that the macro-level AYII option is adopted under which the GoC would identify its target audience of cotton farmers and would then assume the role of the Insured and be responsible for the payment of premium***. The PRODAF project with 600 cotton farmers has been identified as the target audience for the AYII program. Two options for the distribution of premiums have been identified (1) where cotton farmers are receiving seasonal crop loans, the payouts would be settled directly to the lending institution and any balance over and above the loan amount with then be paid to the individual farmer. or (2) where no credit is involved, payouts would be made directly to the cotton grower registered with PRODAF. A voluntary individual farmer AYII cotton scheme in Chaco Province is unlikely to achieve rapid scale-up and sustainability and it is very unlikely that the Insurance Companies would be willing to consider a voluntary individual grower scheme given their poor experience with individual grower MPCI in recent years.

5.21. ***The major outstanding challenge for the operation of an AYII program for cotton will be to formalize the procedures for measuring actual production and yields of cotton in each department and to ensure this system remains independent and impartial under the introduction of an insurance program***. Finally, it is recommended that there is a need to consider an alternative back-up system of in-field cotton-yield sampling in each insured department to establish the average yields for AYII payout purposes.

Bibliography

AgriRisk Services Pty Ltd, Agricultural Risk Management Consulting Inc. and Cazenave & Associates (1999) 'Risk analysis and development of agricultural and livestock insurance in Argentina. Part B. Modelling and Evaluation of Alternatives'

Arza, V., L. Goldberg and C. Vasquez (2012). Argentina: Dissemination of genetically modified cotton and its impact on the profitability of small-scale fames in the Chaco Province. CEPAL Review 107, August 2012. http://www.eclac.org/publicaciones/xml/0/48670/RVI107Arzaetal.pdf

Elena de Bianconi, G., (2010). Costo de producción por hectárea de algodón – 2009/10, INTA. http://inta.gob.ar/documentos/costo-de-produccion-por-hectarea-de-algodon-2009-10-para-surcos-estrechos-0-52m-1/

Cámara Algodonera Argentina (2011). 'Nuevas señales en la lucha contra el picudo algodonero', *Campana 2010/2011*, pp. 38 – 40.

CONES (2012). Cooperativas Algodoneras Chaqueñas. Análisis económico, social y organizacional de sus factores internos y externos. Consejo Económico y Social de la Provincia del Chaco, Junio 2012.

Gentile, E. (ND) 'El Nino no tiene la culpa: Vulnerabilidad en el Noreste Argentino', *Universidad de Buenos Aires*. [Online] Available at: http://desastres.usac.edu.gt/documentos/pdf/spa/doc6575/doc6575.pdf

International Fund for Agricultural Development and World Food Programme (2010).

Potential for scale and sustainability in weather index insurance for agriculture and rural livelihoods, by P. Hazell, J. Anderson, N. Balzer, A. Hastrup Clemmensen, U. Hess and F. Rispoli. Rome.INTA (2010). Algodón. Manual de Campo. INTA Red de Información Agropecuario Nacional (RIAN). INTA EEA Sáenz Peña Chaco.

Lases, R., Gómez, I. and García, G (2006) 'Manejo de Riesgos climáticos en el sector rural de América Latina. Estudio inicial de viabilidad para la introducción de seguros por índice climáticos. Paises beneficiarios: Argentina & Belice', *Inter-American Development Bank*,

Mahul, O., and C.J. Stutley 2010. Government Support for Agricultural Insurance. Challenges and Opportunities for Developing Countries. Volume 1, Main Report and Volume 2, Annex E, International Experiences with Agricultural Insurance: Findings from a World Bank Survey of 65 countries. The World Bank, Washington DC

MPCh (2012) Estadísticas Algodoneras. Dirección de Algodón, Ministerio de Producción, Provincia del Chaco Marzo 2012

Ministerio de Producción, Provincia del Chaco (2013). Programa de Desarrollo Rural y Agricultura y Familiar (PRODAF) Skees, J.R., R Black and B.J.Barnett (1997). *"Designing and Rating and Area Yield Crop Insurance Contract"*. American Journal of Agricultural Economics 79 (May 1997).

Annex 1. Cotton Production and Yields (Sown Area basis) in Argentina by Province 2006/07 to 2010/11

This annex presents the results of the World Bank Teams' analysis of time series cotton production and yield data drawing on two sets of data (a) cotton data collected by the Federal authorities and (b) cotton data collected by the Ministry of Production in Chaco Province.

Argentina: National Cotton Production and Yield Statistics

Annex Table A1.1 presents a summary for the past 5 years (2006/07 to 2010/11) of the sown area of cotton by province and the total production and finally average yields on a sown area basis. Over the past 5 years, Chaco has recorded an average annual Yield of 1,280 MT/Ha sown area basis.

Table A1.1. Cotton Production and Yields (Sown Area basis) in Argentina by Province 2006/07 to 2010/11

Sown Area of Cotton (Ha)

Province	2006/07	2007/08	2008/09	2009/10*	2010/11*	Average	% of Total Average
Chaco	270,000	190,000	195,290	336,300	403,600	279,038	66%
Formosa	32,000	17,440	15,400	18,030	20,000	20,574	5%
Santa Fe	15,500	10,500	31,100	45,000	80,200	36,460	9%
Sgo. Del Estero	75,250	77,030	43,445	80,600	102,700	75,805	18%
Salta	6,175	8,500	8,100	6,240	9,280	7,659	2%
Other Provinces	7,583	6,962	5,280	3,430	2,450	5,141	1%
Total Argentina	406,508	310,432	298,615	489,600	618,230	424,677	100%

Production Raw Cotton (MT)

Province	2006/07	2007/08	2008/09	2009/10*	2010/11*	Average	% of Total Average
Chaco	325,000	277,527	226,798	434,080	517,215	356,124	55%
Formosa	38,130	19,690	18,480	12,150	24,000	22,490	3%
Santa Fe	23,850	13,252	27,600	120,000	171,860	71,312	11%
Sgo. Del Estero	132,013	147,820	80,513	165,998	285,950	162,459	25%
Salta	20,902	22,100	24,300	13,728	23,650	20,936	3%
Other Provinces	10,057	13,212	10,837	7,568	6,060	9,547	1%
Total Argentina	549,952	493,601	388,528	753,524	1,028,735	642,868	100%

Average Yields Raw Cotton Sown Area basis (Kg/Ha)

Province	2006/07	2007/08	2008/09	2009/10*	2010/11*	Average
Chaco	1,204	1,461	1,161	1,291	1,282	1,280
Formosa	1,192	1,129	1,200	674	1,200	1,079
Santa Fe	1,539	1,262	887	2,667	2,143	1,700
Sgo. Del Estero	1,754	1,919	1,853	2,060	2,784	2,074
Salta	3,385	2,600	3,000	2,200	2,548	2,747
Other Provinces	1,326	1,898	2,052	2,206	2,473	1,991
Total Argentina	**1,353**	**1,590**	**1,301**	**1,539**	**1,664**	**1,489**

Source: Dirección de Algodón-Ministerio de Producción, Provincia del Chaco 2012
Notes:
*Provisional, subject to readjustments

Table A1.2 presents a summary for the past 5 years (2006/07 to 2010/11) of the harvested area of cotton by province and the total production and finally average yields on a harvested area basis. Over the past 5 years, Chaco has recorded an average annual Yield of raw cotton of 1,334 Kg/Ha on a harvested area basis. This 4.2% higher than the average yield calculated on a sown area basis.**Annex 1.x. Cotton Production and Yields (Harvested Area basis) in Argentina by Province 2006/07 to 2010/11**

Harvested Area of Cotton (Ha)

Province	2006/07	2007/08	2008/09	2009/10*	2010/11*	Average	% of Total Average
Chaco	260,000	184,994	190,300	297,050	392,995	265,068	65%
Formosa	31,000	17,440	15,400	14,030	20,000	19,574	5%
Santa Fe	15,000	10,444	30,200	45,000	79,900	36,109	9%
Sgo. Del Estero	73,750	75,164	40,795	75,465	102,550	73,545	18%
Salta	6,175	8,500	8,100	6,240	9,280	7,659	2%
Other Provinces	6,428	6,845	4,990	3,430	2,300	4,799	1%
Total Argentina	392,353	303,387	289,785	441,215	607,025	406,753	100%

Production Raw Cotton (MT)

Province	2006/07	2007/08	2008/09	2009/10*	2010/11*	Average	% of Total Average
Chaco	325,000	277,527	226,798	434,080	517,215	356,124	55%
Formosa	38,130	19,690	18,480	12,150	24,000	22,490	3%
Santa Fe	23,850	13,252	27,600	120,000	171,860	71,312	11%
Sgo. Del Estero	132,013	147,820	80,513	165,998	285,950	162,459	25%
Salta	20,902	22,100	24,300	13,728	23,650	20,936	3%
Other Provinces	10,057	13,212	10,837	7,568	6,060	9,547	1%
Total Argentina	549,952	493,601	388,528	753,524	1,028,735	642,868	100%

Average Yields Raw Cotton Harvested Area basis (Kg/Ha)

Province	2006/07	2007/08	2008/09	2009/10*	2010/11*	Average
Chaco	1,250	1,500	1,192	1,461	1,316	1,344
Formosa	1,230	1,129	1,200	866	1,200	1,125
Santa Fe	1,590	1,269	914	2,667	2,151	1,718
Sgo. Del Estero	1,790	1,967	1,974	2,200	2,788	2,144
Salta	3,385	2,600	3,000	2,200	2,548	2,747
Other Provinces	1,565	1,930	2,172	2,206	2,635	2,102
Total	**1,402**	**1,627**	**1,341**	**1,708**	**1,695**	**1,554**

Source: Dirección de Algodón-Ministerio de Producción, Provincia del Chaco 2012
Notes:
*Provisional, subject to readjustments

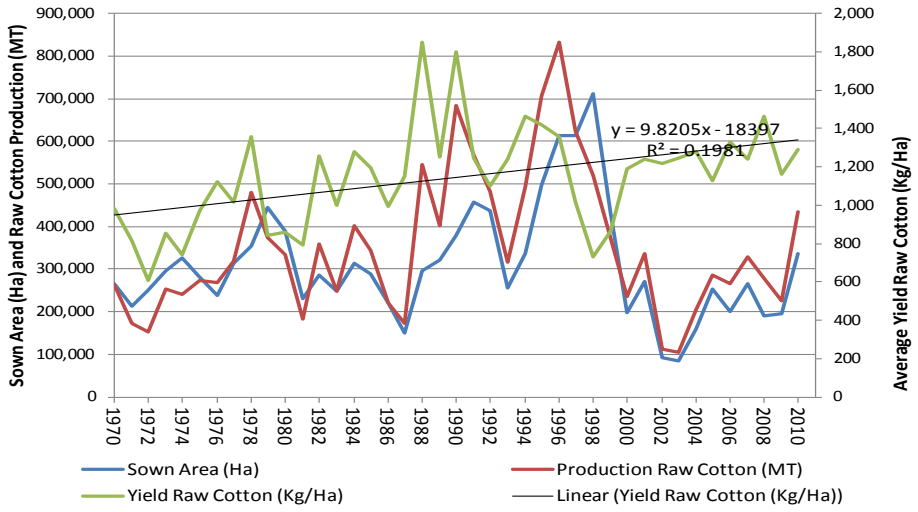
Cotton Production and Yield Data for Chaco Province (Federal Government Collected Data)

Table A1.3 presents a summary for Chaco Province of the total annual sown area and harvested area of cotton, percentage lost area and total production of raw cotton and finally the average yield per hectare of

raw cotton for the 40 year period 1969/70 to 2009/10. The data are also shown graphically in Figure A1.1. and Figure A1.2 below.

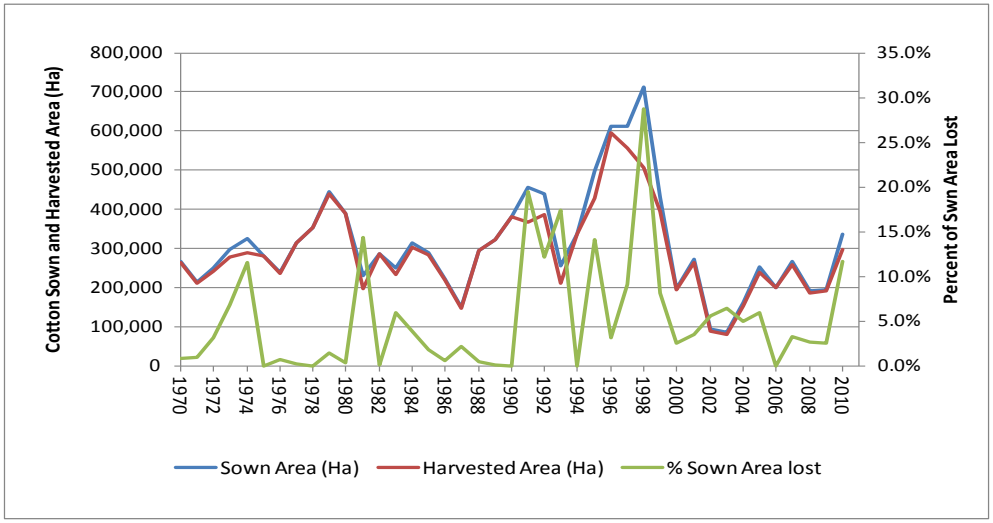
These data are based on cotton production data collected by the Federal Authorities each year.

Figure A1.1. Chaco Province: Annual Sown Area Cotton, Raw Cotton Production and average yields raw cotton, sown area basis, 1969/70 to 2009/10



Source: ORA-MAGyP, November 2011, based on Federal Government Production and Yield estimates

Figure A1.2. Chaco Province: Annual Sown Area and Harvested Area of Cotton, and percentage of area unharvested (lost) 1969/70 to 2009/10



Source: ORA-MAGyP, November 2011, based on Federal Government Production and Yield estimates

Table A1.3. Chaco Province: Sown Area, Harvested Area, Production and Average Yields of Raw Cotton 1969/70 to 2009/10

Cropping Year	Sown Area (Ha)	Harvested Area (Ha)	% Sown Area lost	Production Raw Cotton (MT)	Yield Raw Cotton (Kg/Ha)
1969/70	267,000	264,800	0.8%	263,000	985
1970/71	213,000	210,950	1.0%	173,000	812
1971/72	250,300	242,400	3.2%	152,600	610
1972/73	296,100	276,200	6.7%	253,000	854
1973/74	325,200	287,800	11.5%	241,000	741
1974/75	281,000	281,000	0.0%	273,000	972
1975/76	238,650	236,950	0.7%	268,200	1,124
1976/77	313,600	313,100	0.2%	319,000	1,017
1977/78	353,000	353,000	0.0%	479,200	1,358
1978/79	444,500	438,300	1.4%	374,000	841
1979/80	390,000	389,000	0.3%	335,000	859
1980/81	231,000	197,750	14.4%	182,950	792
1981/82	286,300	285,940	0.1%	360,000	1,257
1982/83	248,800	234,200	5.9%	249,000	1,001
1983/84	315,000	303,000	3.8%	402,500	1,278
1984/85	287,900	282,750	1.8%	344,700	1,197
1985/86	221,350	220,250	0.5%	219,800	993
1986/87	150,200	147,050	2.1%	173,100	1,152
1987/88	295,200	293,900	0.4%	546,000	1,850
1988/89	321,100	321,000	0.0%	402,000	1,252
1989/90	380,200	380,200	0.0%	684,200	1,800
1990/91	456,000	367,000	19.5%	568,850	1,247
1991/92	438,000	385,000	12.1%	481,750	1,100
1992/93	255,800	211,200	17.4%	316,800	1,238
1993/94	335,500	335,500	0.0%	491,600	1,465
1994/95	498,000	428,000	14.1%	705,300	1,416
1995/96	613,500	594,300	3.1%	832,010	1,356
1996/97	612,000	556,500	9.1%	622,700	1,017
1997/98	712,000	507,000	28.8%	518,928	729
1998/99	430,000	395,000	8.1%	371,844	865
1999/00	198,000	193,000	2.5%	235,878	1,191
2000/01	272,000	262,450	3.5%	337,670	1,241
2001/02	93,000	87,850	5.5%	113,330	1,219
2002/03	85,000	79,500	6.5%	105,735	1,244
2003/04	160,000	152,000	5.0%	204,950	1,281
2004/05	252,500	237,500	5.9%	285,200	1,130
2005/06	200,000	200,000	0.0%	266,000	1,330
2006/07	265,640	257,120	3.2%	329,417	1,240
2007/08	190,000	184,994	2.6%	277,527	1,461
2008/09	195,290	190,300	2.6%	226,798	1,161
2009/10	336,300	297,050	11.7%	434,080	1,291
Ann. Average	309,950	289,776	5.3%	351,747	1,146

Source: ORA-MAGyP, November 2011, based on Federal Government Production and Yield estimates

Comparison of Federal Government and Provincial Government Cotton Yield Data by Department for Chaco Province

Cotton is grown in 25 Departments located throughout Chaco Province.

This section presents a comparative analysis by Department of the annual average departmental yields drawing on 1) the Federal Government 40-year cotton production and yield statistics and 2) the Provincial Government of Chaco's own cotton production and yield statistics which cover the 22 year period 1989/90 to 2010/11 and which are collected by the Ministry of Production MPCh using its network of cotton extensionists. These comparative data were provided to the team by ORA-MAGyP in November 2011 and May 2012 respectively. It is important to note that the Departmental average raw yields of cotton have been calculated on a harvested area basis (and not on a sown area basis which is preferred by the World Bank team).

For each Department a summary is presented graphically in Figures A1.3 to A1.25 by year for the 2 sources of the average raw yields of cotton in Kg/Ha and then average yields over the past 5 years, 10 years and 20 years are compared in the Tables (Table A.4 to Table A.26), below each Figure.

It is noted that there are inconsistencies (errors) in both sets of Departmental average yield data in that in some years yields are at least 3 to 5 times higher[36] than the average and these must be errors. There are considerably more errors in the Provincial-level data and also there is a considerably higher percentage of missing yield data in several Departments. There is a further disadvantage of the Provincial data in that the available data in digitized format is only readily available since 1989/90, while the Federal Data set stretches back all the way to 1969/70 and there is much less missing data in the Federal data set. For these reasons the Federal Cotton data set were used under this study for the purposes designing and rating the Area-Yield Index Insurance (AYII) Cover described in Chapter 4. The AYII study, however, calculates the average raw cotton yields on a sown area basis.

[36] In the extreme case, in San Fernando the 2003-04 Provincial Yield is stated as 20,000 Kg/Ha against a 21 year average yield of only 1,045 Kg/Ha. This figure is clearly an error.

Figure A1.3. 1ero de Mayo Department Annual Average Yield Raw Cotton (Kg/Ha)

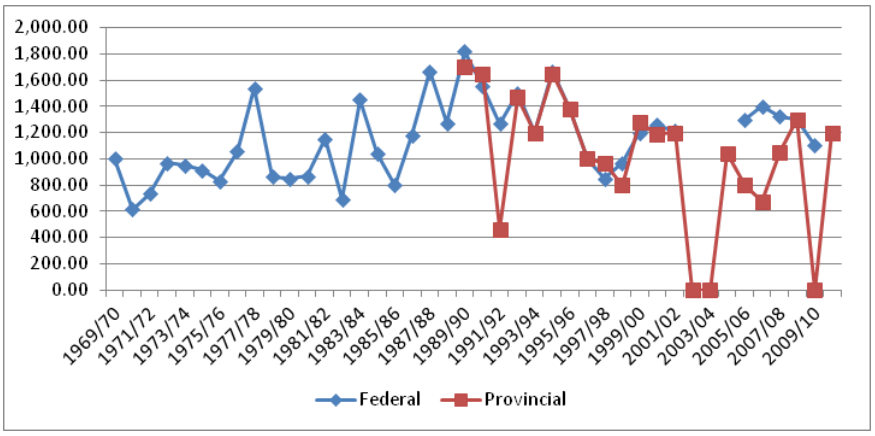


Table A1.4. 1ero de Mayo Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,284.00	765.00	60%
10 years	1,270.00	725.45	57%
20 years	1,263.14	955.70	76%

Source: ORA-MAGyP

Figure A1.4. 12 de Octubre Department Annual Average Yield Raw Cotton (Kg/Ha)

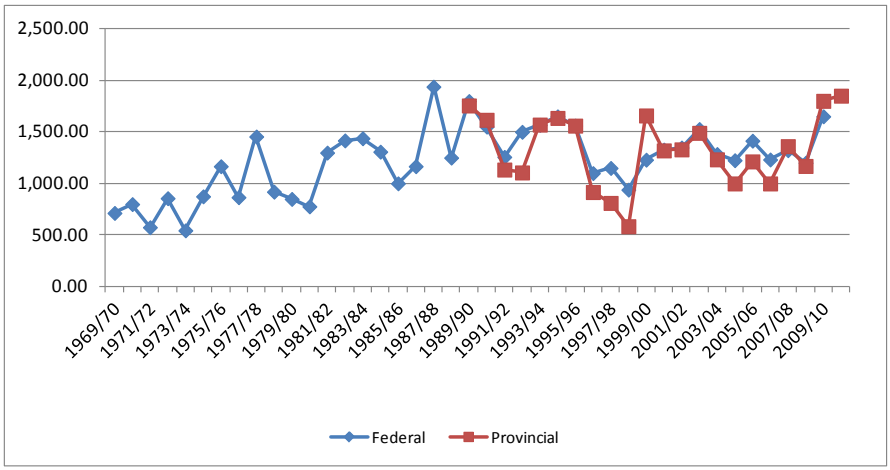


Table A1.5. 12 de Octubre Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,363.60	1,308.79	96%
10 years	1,353.10	1,291.73	95%
20 years	1,351.78	1,275.56	94%

Source: ORA-MAGyP **Figure A1.5. 2 de Abril Department Annual Average Yield Raw Cotton (Kg/Ha)**

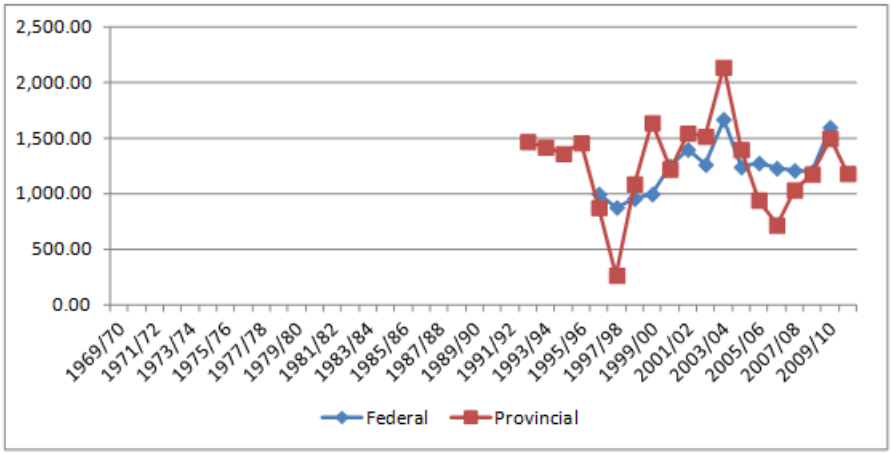


Table A1.6. 2 de Abril Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,304.60	1,076.25	82%
10 years	1,335.70	1,321.04	99%
20 years	1,228.36	1,266.97	103%

Source: ORA-MAGyP

Figure A1.6. 25 de Mayo Department Annual Average Yield Raw Cotton (Kg/Ha)

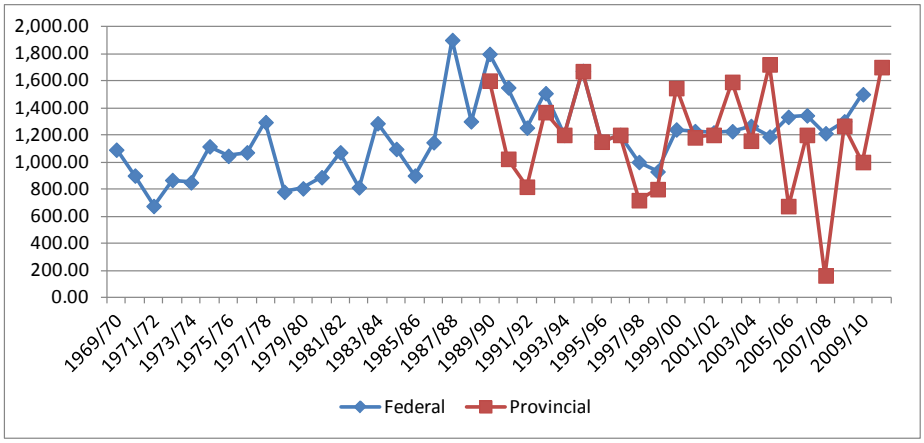


Table A1.7. 25 de Mayo Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,337.80	861.06	64%
10 years	1,281.60	1,115.52	87%
20 years	1,275.94	1,132.42	89%

Source: ORA-MAGyP

Figure A1.7. 9 de Julio Department Annual Average Yield Raw Cotton (Kg/Ha)

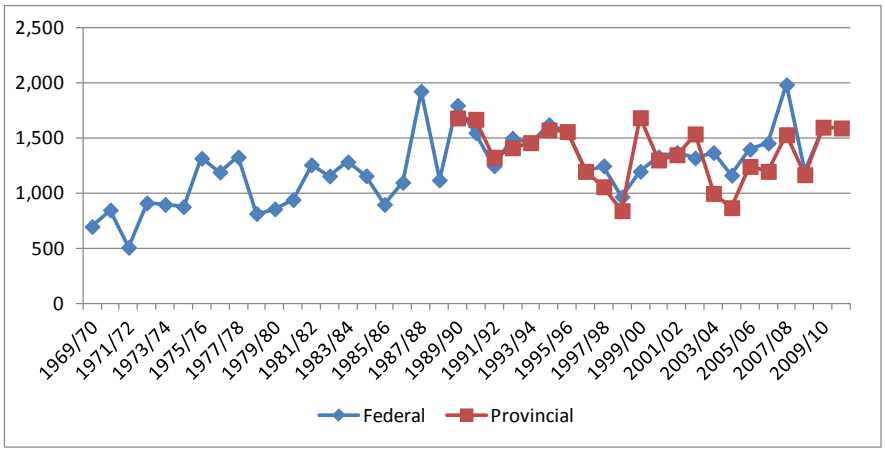


Table A1.8. 9 de Julio Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,528.20	1,349.12	88%
10 years	1,419.80	1,280.80	90%
20 years	1,388.04	1,330.29	96%

Source: ORA-MAGyP

Figure A1.8. Bermejo Department Annual Average Yield Raw Cotton (Kg/Ha)

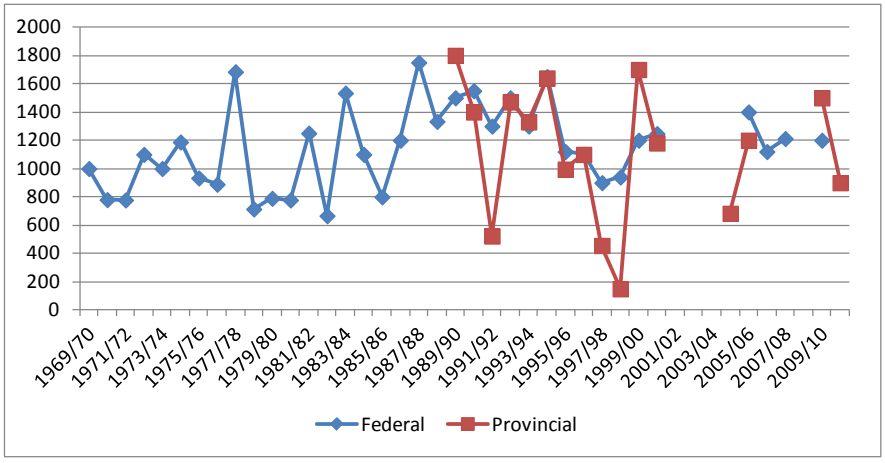


Table A1.9. Bermejo Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,233.00	1,350.00	109%
10 years	1,235.80	1,141.05	92%
20 years	1,249.27	1,094.99	88%

Source: ORA-MAGyP

Figure A1.9. Chacabuco Department Annual Average Yield Raw Cotton (Kg/Ha)

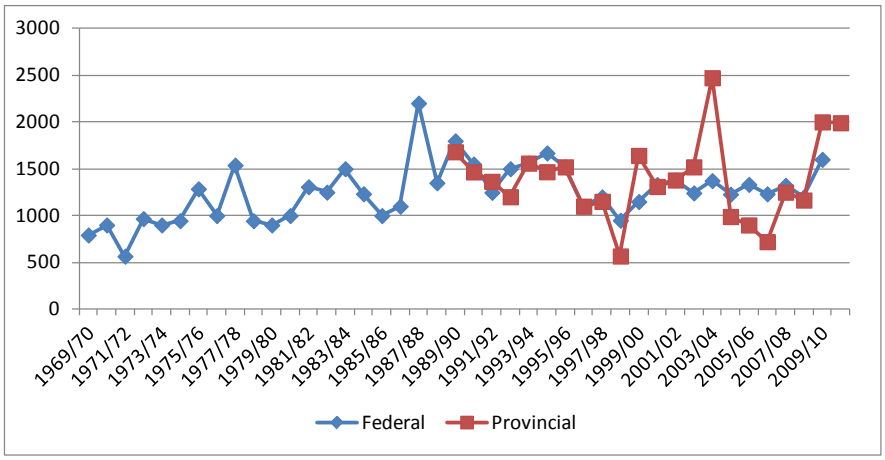


Table A1.10. Chacabuco Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,337.60	1,207.54	90%
10 years	1,324.20	1,370.97	104%
20 years	1,334.49	1,337.68	100%

Source: ORA-MAGyP

Figure A1.10. Com. Fernandez Department Annual Average Yield Raw Cotton (Kg/Ha)

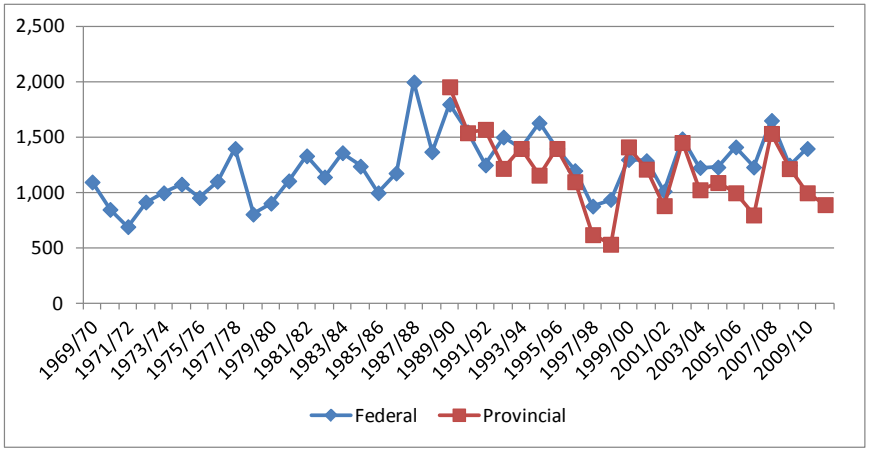


Table A1.11. Com. Fernandez Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,389.80	1,110.78	80%
10 years	1,320.10	1,122.45	85%
20 years	1,312.83	1,159.53	88%

Source: ORA-MAGyP

Figure A1.11. Com. Luis Fontano Department Annual Average Yield Raw Cotton (Kg/Ha)

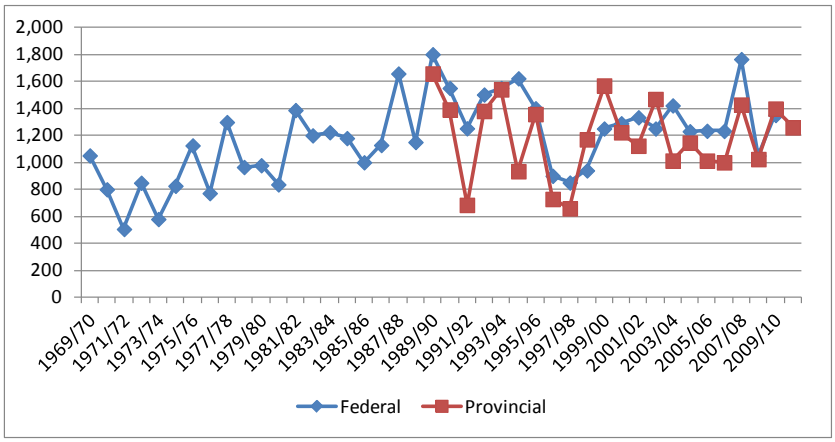


Table A1.12. Com. Luis Fontano Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,325.80	1,171.99	88%
10 years	1,315.20	1,183.12	90%
20 years	1,298.32	1,162.20	90%

Source: ORA-MAGyP

Figure A1.12. Gral. Donovan Department Annual Average Yield Raw Cotton (Kg/Ha)

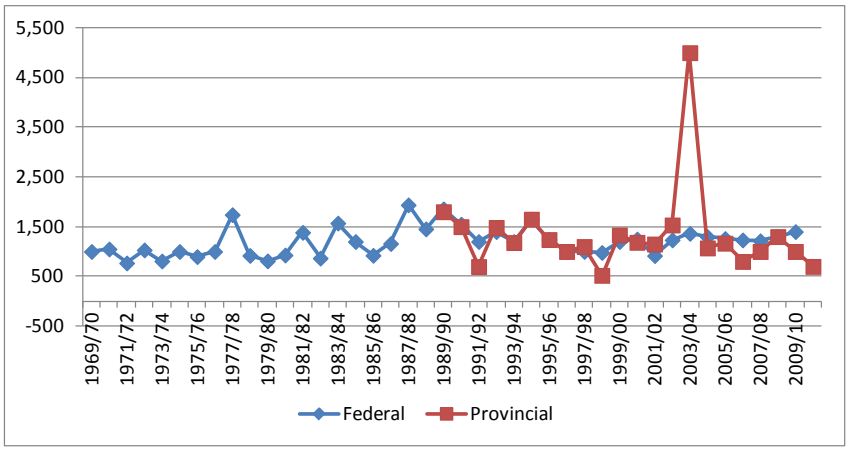


Table A1.13. Gral. Donovan Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,281.40	1,053.33	82%
10 years	1,246.70	1,520.56	122%
20 years	1,244.35	1,345.47	108%

Source: ORA-MAGyP

Figure A1.13. Fray Justo Department Annual Average Yield Raw Cotton (Kg/Ha)

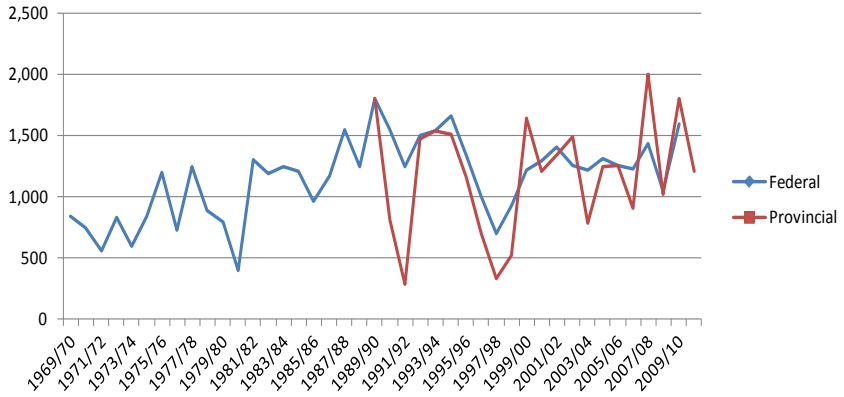


Table A1.14. Fray Justo Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,315.00	1,398.34	106%
10 years	1,305.60	1,306.20	100%
20 years	1,287.28	1,152.99	90%

Source: ORA-MAGyP (Fray Justo-Sta. Maria de Oro)

Figure A1.14. General Belgrano Department Annual Average Yield Raw Cotton (Kg/Ha)

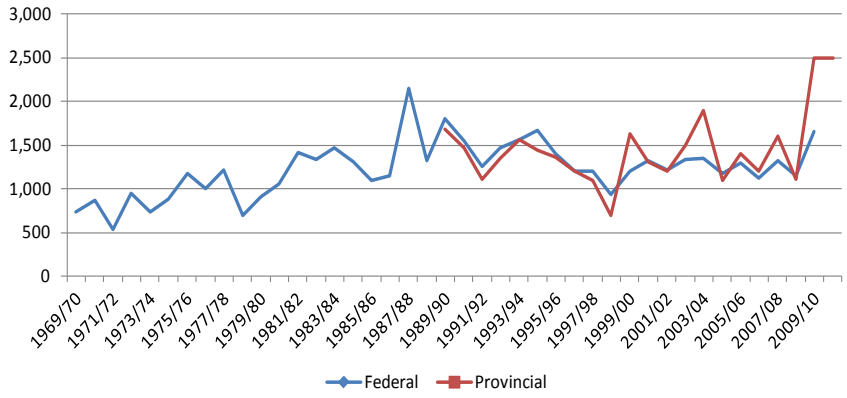


Table A1.15. General Belgrano Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,308	1,562	119%
10 years	1,294	1,480	114%
20 years	1,319	1,386	105%

Source: ORA-MAGyP

Figure A1.15. General Guemes Department Annual Average Yield Raw Cotton (Kg/Ha)

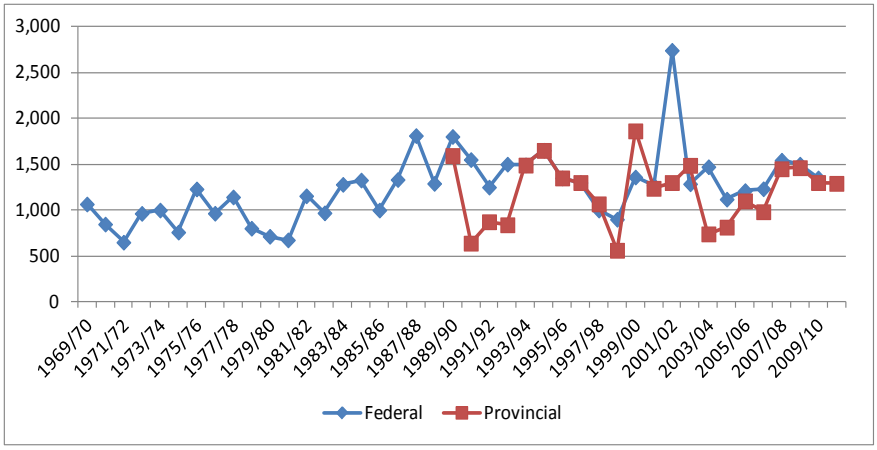


Table A1.16. General Guemes Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,367.40	1,258.78	92%
10 years	1,472.50	1,187.35	81%
20 years	1,403.94	1,175.46	84%

Source: ORA-MAGyP

Figure A1.16. General San Martin Department Annual Average Yield Raw Cotton (Kg/Ha)

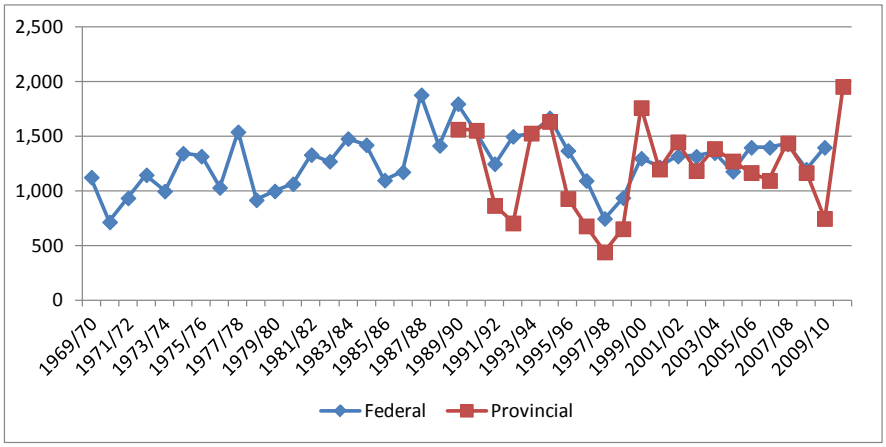


Table A1.17. General San Martin Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,366	1,125	82%
10 years	1,322	1,213	92%
20 years	1,309	1,145	88%

Source: ORA-MAGyP

Figure A1.17. Independencia Department Annual Average Yield Raw Cotton (Kg/Ha)

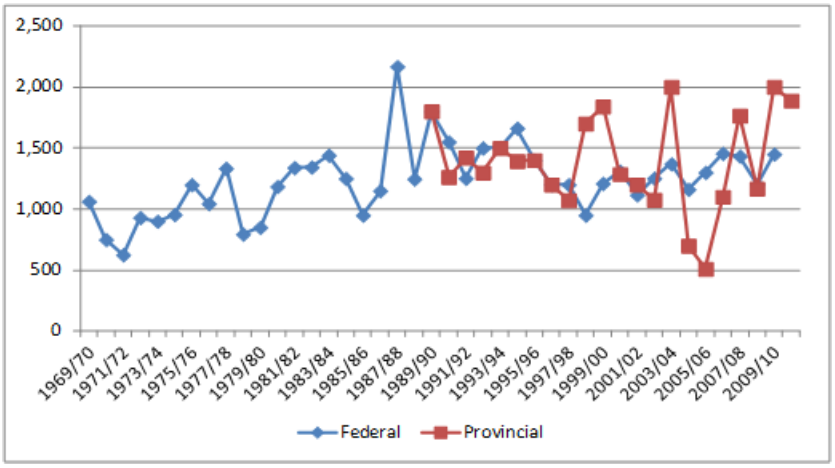


Table A1.18. Independencia Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,368	1,308	96%
10 years	1,305	1,280	98%
20 years	1,324	1,344	102%

Source: ORA-MAGyP

Figure A1.18. Libertad Department Annual Average Yield Raw Cotton (Kg/Ha)

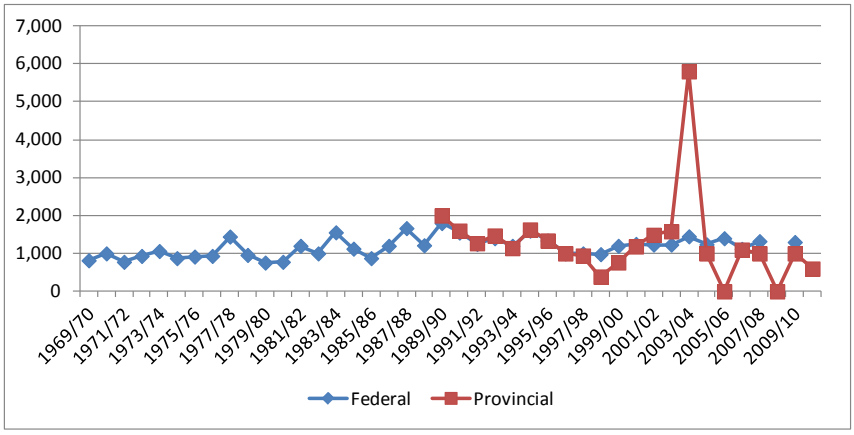


Table A1.19. Libertad Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,286	620	48%
10 years	1,283	1,416	110%
20 years	1,267	1,285	101%

Source: ORA-MAGyP

Figure A1.19. Maipu Department Annual Average Yield Raw Cotton (Kg/Ha)

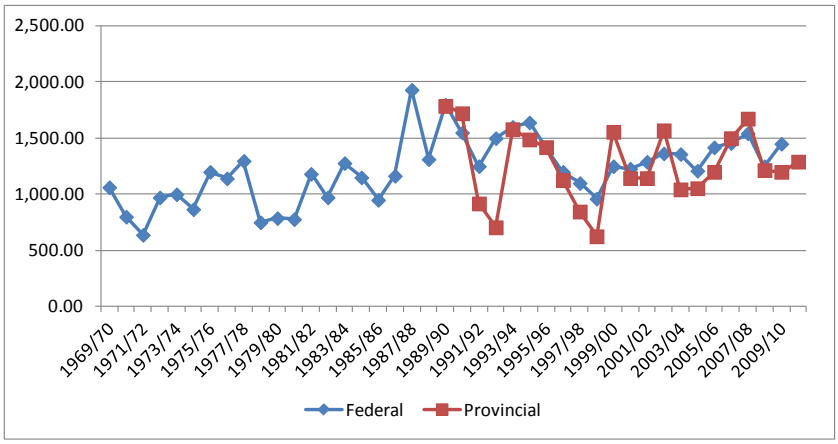


Table A1.20. Maipu Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,423.40	1,357.90	95%
10 years	1,356.60	1,274.53	94%
20 years	1,351.79	1,236.77	91%

Source: ORA-MAGyP

Figure A1.20. O'Higgins Department Annual Average Yield Raw Cotton (Kg/Ha)

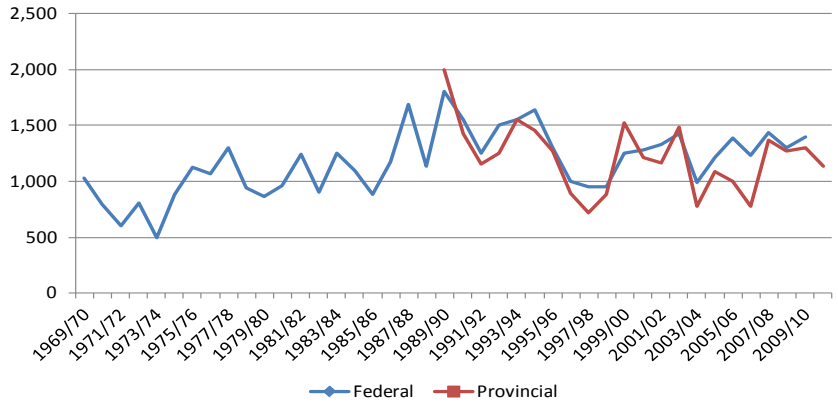


Table A1.21. O'Higgins Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,351	1,141	84%
10 years	1,300	1,144	88%
20 years	1,297	1,178	91%

Source: ORA-MAGyP

Figure A1.21. Pte. de la Plaza Department Annual Average Yield Raw Cotton (Kg/Ha)

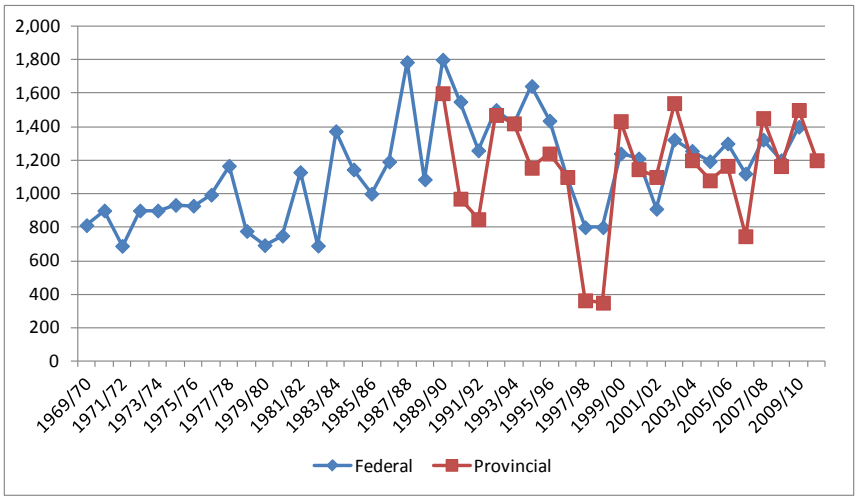


Table A1.22. Pte. de la Plaza Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,269	1,206	95%
10 years	1,224	1,210	99%
20 years	1,249	1,122	90%

Source: ORA-MAGyP

Figure A1.22. Quitilipi Department Annual Average Yield Raw Cotton (Kg/Ha)

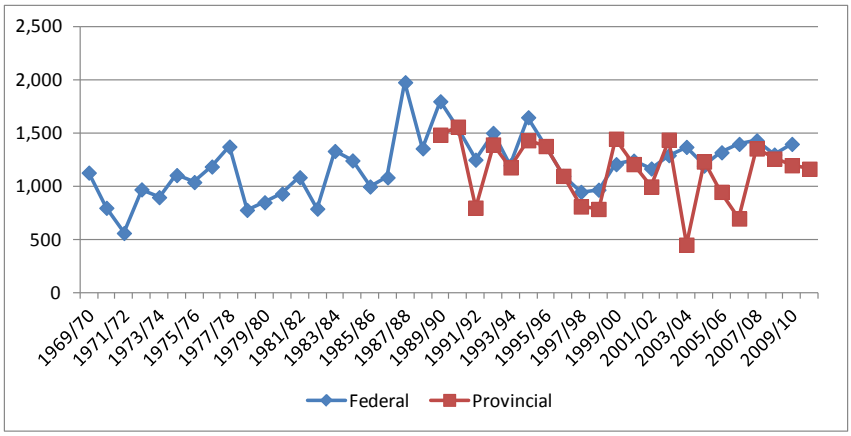


Table A1.23. Quitilipi Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,371	1,094	80%
10 years	1,313	1,081	82%
20 years	1,295	1,136	88%

Source: ORA-MAGyP

Figure A1.23. San Fernando Department Annual Average Yield Raw Cotton (Kg/Ha)

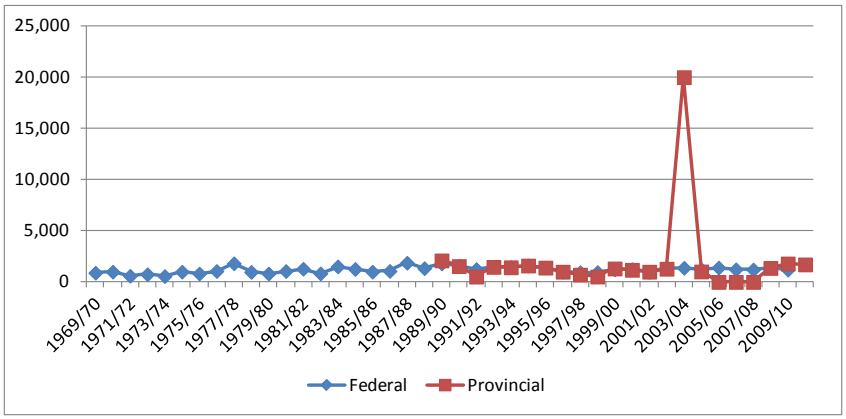


Table A1.24. San Fernando Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,289	633	49%
10 years	1,261	2,766	219%
20 years	1,273	1,959	154%

Source: ORA-MAGyP

Figure A1.24. Quitilipi Department Annual Average Yield Raw Cotton (Kg/Ha)

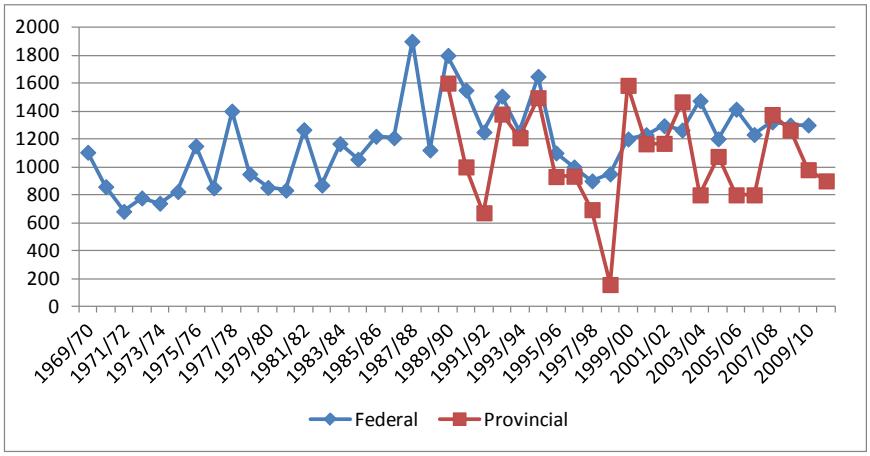


Table A1.25. Quitilipi Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1313	1044	79%
10 years	1303	1089	84%
20 years	1269	1047	83%

Source: ORA-MAGyP

Figure A1.25. Sargento Cabral Department Annual Average Yield Raw Cotton (Kg/Ha)

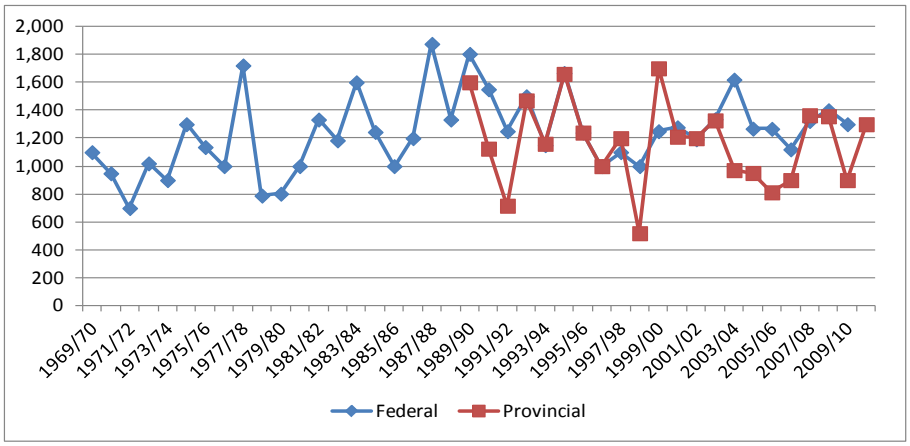


Table A1.26. Sargento Cabral Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,282	1,067	83%
10 years	1,310	1,099	84%
20 years	1,290	1,139	88%

Source: ORA-MAGyP

Figure A1.26. Tapenaga Department Annual Average Yield Raw Cotton (Kg/Ha)

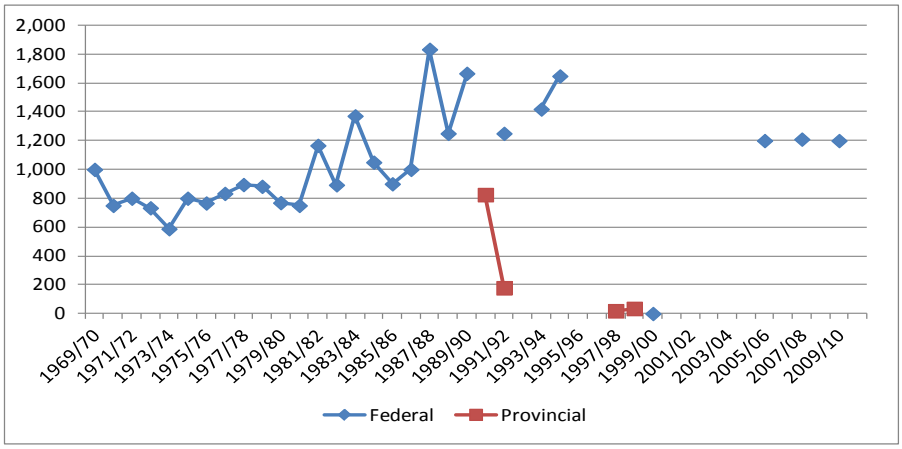


Table A1.27. Tapenaga Department Annual Average Yield Raw Cotton (Kg/Ha)

Period	Federal Average Yield Raw Cotton (Kg/Ha)	Provincial Average Yield Raw Cotton (Kg/Ha)	Difference (Provincial as % of Federal Yield)
5 years	1,203	#DIV/0!	#DIV/0!
10 years	1,203	#DIV/0!	#DIV/0!
20 years	1,132	264	23%

Source: ORA-MAGyP

Annex 2: Rainfall Analysis in Chaco Province

This annex presents the results of the rainfall analysis performed for twenty five selected weather stations. The annex aims to provide a broad estimation of the frequency and severity of extreme annual rainfall values, and to identify if there is any trend registered in the precipitation regime between the decades of the 1980s, the 1990s and the 2000s. As explained in Chapter 2 and shown in Tables A2.1, A2.2 and A2.3, a graduated classification of precipitation was used to compare the actual annual rainfall recorded at each station to the 10a year average or normal rainfall for that station. A color code has been used to show the percentage deviations of annual rainfall from the average where "normal" is shown in white, "below normal rainfall" is shown in light red to dark red and finally above normal rainfall years are highlighted in light blue to dark blue.

Table A2.1. Estimation of Moderate to Severe Drought (Excess of rainfall) events, 1980 -1989.

Weather Station	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AviaTerai	7.11%	16.70%	2.06%	53.45%	-1.07%	-2.48%	50.02%	-8.54%	1.66%	8.93%
CampoLargo	3.15%	16.25%	14.86%	45.52%	13.37%	-5.49%	32.51%	0.36%	-5.59%	7.98%
Charata	9.56%	33.13%	13.34%	-2.86%	47.44%	19.13%	64.81%	6.08%	-40.43%	4.29%
Chorotis	-22.15%	-2.20%	-2.68%	-5.46%	12.31%	59.45%	45.79%	-42.70%	-81.87%	-41.49%
CniasUnidas	-8.83%	-19.48%	-0.49%	-1.15%	13.47%	12.56%	50.22%	4.14%	-33.11%	34.53%
CniaElisa	-14.50%	-0.09%	-6.17%	8.58%	-1.17%	9.91%	33.16%	5.83%	-31.09%	14.25%
CnelDuGraty	-12.16%	28.57%	2.72%	-12.83%	6.25%	-2.43%	25.51%	-12.97%	-38.39%	-12.16%
Corzuela	-5.59%	26.30%	-0.16%	23.99%	-6.29%	2.84%	83.73%	-28.82%	-38.53%	16.59%
Gancedo	35.75%	55.85%	3.23%	-32.69%	-8.83%	74.68%	4.61%	-3.43%	-35.83%	3.98%
GralPinedo	32.32%	57.57%	10.30%	6.74%	9.98%	56.92%	76.67%	1.99%	-29.52%	22.71%
GralSanMartin	-6.54%	12.98%	8.34%	19.72%	5.10%	-18.70%	33.28%	15.80%	-20.89%	14.29%
Hcampo	26.53%	55.73%	6.19%	-16.34%	-9.45%	56.28%	62.84%	8.49%	-39.85%	-14.70%
LaClotilde	-0.62%	4.56%	1.68%	-24.23%	27.11%	59.50%	23.61%	-48.18%	-58.92%	-41.84%
LaTigra	4.02%	15.54%	8.24%	-17.08%	18.09%	45.00%	85.10%	1.83%	-19.89%	2.79%
LasBreñas	7.47%	10.62%	0.81%	-2.66%	13.98%	34.99%	55.55%	-21.26%	-39.34%	8.04%
LasPalmas	-9.17%	12.52%	-35.39%	-7.04%	-0.31%	6.58%	27.88%	45.30%	-27.31%	-6.72%
LagunaLimpia	-5.95%	15.11%	8.12%	6.24%	10.34%	26.62%	43.00%	8.38%	-37.33%	42.14%
Machagai	-36.17%	8.50%	-3.41%	-8.09%	5.06%	-7.21%	30.66%	-11.63%	-20.81%	-0.59%
PdelIndio	28.99%	23.82%	8.31%	15.40%	-11.17%	1.82%	56.98%	4.45%	-16.44%	-1.02%
PciadelaPlaza	3.73%	-16.60%	-12.45%	-8.38%	-0.43%	3.38%	15.93%	-2.76%	-21.79%	0.53%
PRSaenzPeña	-6.09%	14.58%	8.85%	0.84%	11.13%	-3.54%	47.77%	-15.44%	-18.05%	1.30%
Resistencia	-11.17%	-7.89%	14.42%	5.30%	9.01%	3.46%	55.60%	1.13%	-34.18%	6.15%
SantaSylvina	4.05%	52.33%	5.64%	-7.31%	1.44%	34.27%	44.26%	-4.47%	-41.84%	11.89%
TresIsletas	20.48%	56.97%	-1.29%	-21.07%	-13.32%	12.33%	52.69%	-8.35%	-1.69%	24.06%
VaAngela	0.24%	-12.38%	-44.95%	-24.90%	30.33%	14.81%	45.59%	0.27%	-24.48%	5.01%
>=Mod. Drought	**1.0**	**-**	**2.0**	**1.0**	**-**	**-**	**-**	**2.0**	**13.0**	**2.0**
>=Mod. Excess rai	**2.0**	**6.0**	**-**	**2.0**	**2.0**	**8.0**	**20.0**	**1.0**	**-**	**2.0**

Severe Excess	45.000%	To	<
Mod. Excess	30.000%	To	44.999%
Excess	15.000%	To	29.999%
Normal	-14.999%	To	14.999%
Drought	-29.999%	To	-15.000%
Mod. Drought	-44.999%	To	-30.000%
Severe Drought	<	To	-45.000%

Source: Authors' analysis of APA rainfall data

Table A2.2 Estimation of Moderate to Severe Drought (Excess of rainfall) events, 1990 - 1999.

Weather Station	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AviaTerai	43.76%	8.32%	46.38%	-23.58%	38.21%	-6.92%	23.97%	-7.51%	-0.76%	-58.81%
CampoLargo	31.21%	28.05%	25.54%	-13.11%	21.36%	-26.31%	13.74%	-30.40%	11.60%	-34.77%
Charata	11.45%	14.61%	-8.55%	-17.49%	-2.44%	-39.28%	40.92%	-11.18%	6.50%	-14.97%
Chorotis	-12.96%	22.34%	18.96%	-24.32%	-12.96%	-3.89%	42.89%	-24.56%	67.55%	-10.18%
CniasUnidas	7.60%	34.53%	4.30%	-54.58%	28.25%	-19.15%	59.55%	7.36%	32.13%	-19.48%
CniaElisa	32.41%	-11.84%	3.08%	-33.42%	10.50%	-30.92%	61.00%	-9.00%	45.25%	-11.00%
CnelDuGraty	-2.05%	42.49%	6.06%	-15.59%	-11.97%	7.11%	22.46%	-25.32%	55.94%	-15.78%
Corzuela	14.51%	8.39%	18.56%	-10.68%	-1.78%	-21.31%	28.96%	-35.41%	12.66%	-3.63%
Gancedo	23.32%	-32.31%	1.22%	-17.74%	16.92%	-22.01%	-3.18%	-10.77%	14.97%	-11.47%
GralPinedo	-6.75%	-6.54%	10.95%	-26.18%	6.41%	-17.98%	23.14%	-13.08%	-6.26%	-28.77%
GralSanMartin	16.92%	9.21%	25.67%	-24.83%	18.14%	-19.49%	26.28%	-30.25%	35.38%	-38.13%
Hcampo	67.98%	3.89%	8.38%	-17.65%	11.99%	-25.85%	17.35%	-35.86%	24.50%	-5.29%
LaClotilde	-2.30%	34.55%	47.32%	-32.92%	-6.81%	-20.92%	47.22%	-1.73%	34.26%	4.03%
LaTigra	25.74%	24.16%	29.88%	-30.53%	2.97%	-22.97%	18.62%	-21.48%	15.03%	-31.76%
LasBreñas	10.68%	34.88%	9.83%	-21.03%	-19.36%	-12.30%	13.54%	-35.18%	-9.69%	-16.13%
LasPalmas	26.14%	-0.07%	-0.94%	-12.34%	20.20%	-3.16%	60.90%	-14.24%	20.20%	-4.50%
LagunaLimpia	24.41%	12.81%	20.48%	-13.88%	31.48%	-4.67%	45.30%	-16.27%	41.55%	-11.92%
Machagai	14.07%	24.40%	41.52%	-14.27%	68.45%	-17.19%	38.70%	8.15%	35.50%	-28.84%
PdelIndio	5.16%	13.07%	64.69%	-31.14%	13.78%	-6.91%	21.29%	-16.95%	11.25%	-30.74%
PciadelaPlaza	37.21%	7.19%	-5.10%	-40.91%	19.56%	-36.59%	51.14%	-16.33%	39.46%	-3.28%
PRSaenzPeña	25.67%	15.28%	22.73%	-22.71%	18.18%	-24.53%	35.38%	-19.97%	23.31%	-31.97%
Resistencia	35.10%	-7.68%	-6.37%	-21.26%	17.39%	-15.66%	41.45%	15.28%	22.67%	-22.34%
SantaSylvina	19.39%	21.89%	-12.87%	-25.94%	-19.24%	-16.17%	21.32%	-59.33%	48.35%	-13.67%
TresIsletas	11.93%	5.07%	38.48%	-20.37%	-2.08%	-41.95%	70.98%	9.05%	-14.75%	-29.52%
VaAngela	16.94%	118.77%	35.80%	-25.56%	16.32%	-2.89%	39.80%	-26.95%	15.13%	-37.84%
>=Mod. Drought	-	**1.0**	-	**6.0**	-	**4.0**	-	**6.0**	-	**7.0**
>=Mod. Excess rai	**6.0**	**5.0**	**6.0**	-	**3.0**	-	**13.0**	-	**10.0**	-

Severe Excess	45.000%	To	<
Mod. Excess	30.000%	To	44.999%
Excess	15.000%	To	29.999%
Normal	-14.999%	To	14.999%
Drought	-29.999%	To	-15.000%
Mod. Drought	-44.999%	To	-30.000%
Severe Drought	<	To	-45.000%

Source: Authors' analysis of APA rainfall data

Table A2.3. Estimation of Moderate to Severe Drought (Excess of rainfall) events, 2000 - 2011.

Weather Station	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AviaTerai	-8.54%	-45.28%	75.05%	-42.15%	-23.28%	-52.15%	-37.71%	-0.76%	-24.18%	-31.91%	-23.07%	-7.83%
CampoLargo	-28.73%	-17.48%	54.91%	-11.63%	-8.84%	-46.20%	-35.32%	-4.01%	-30.96%	-21.57%	-6.24%	-34.02%
Charata	-5.49%	-4.76%	16.71%	-30.65%	-4.23%	-35.38%	-20.86%	-8.76%	-37.38%	-3.28%	-18.33%	4.40%
Chorotis	56.79%	-16.83%	48.82%	16.30%	0.10%	13.39%	-5.71%	-18.64%	-61.32%	-14.77%	-0.02%	-27.95%
CniasUnidas	26.76%	-16.84%	34.77%	-9.82%	-33.69%	-31.87%	-25.59%	-23.61%	-35.50%	-16.97%	-35.67%	35.02%
CniaElisa	25.41%	-12.92%	77.58%	-23.09%	-8.34%	-17.75%	-18.50%	-31.17%	-49.25%	-16.75%	-4.59%	46.41%
CnelDuGraty	26.56%	35.43%	18.08%	-4.53%	1.38%	-22.36%	-23.22%	2.53%	-57.27%	-12.06%	-22.94%	-24.75%
Corzuela	12.43%	-14.61%	38.66%	-24.66%	23.30%	-37.02%	-25.35%	3.88%	-33.79%	-27.20%	-6.63%	-25.47%
Gancedo	19.30%	4.61%	30.86%	-31.18%	-43.99%	0.84%	-24.15%	-21.14%	-8.20%	16.79%	-18.50%	5.61%
GralPinedo	-2.76%	-28.34%	24.55%	-30.82%	-15.17%	-41.07%	-31.04%	-18.62%	-54.46%	17.10%	-7.72%	36.20%
GralSanMartin	-4.96%	-9.86%	20.24%	-8.11%	-8.81%	-23.08%	5.54%	-26.49%	-20.89%	-5.84%	-26.58%	40.81%
Hcampo	14.83%	-21.70%	10.35%	-39.41%	-30.23%	-19.18%	-37.23%	-22.57%	-45.43%	5.42%	-5.62%	-20.17%
LaClotilde	5.47%	-6.72%	47.32%	-22.26%	14.40%	-17.08%	-11.61%	21.50%	-47.31%	-29.08%	7.68%	-6.91%
LaTigra	-25.70%	-29.30%	41.04%	-29.21%	13.43%	-33.35%	-37.83%	13.26%	-39.85%	-25.79%	-0.99%	-27.54%
LasBreñas	8.21%	-6.76%	45.07%	-10.84%	36.87%	-15.53%	-23.61%	3.61%	-48.83%	-11.62%	-13.78%	-1.19%
LasPalmas	21.39%	-16.38%	21.63%	-12.50%	-18.99%	-28.65%	10.54%	-29.37%	-41.01%	-5.22%	9.64%	-10.36%
LagunaLimpia	17.84%	-30.76%	11.62%	-21.98%	-14.48%	-23.26%	-23.26%	-49.44%	-43.64%	-68.62%	-76.38%	-44.32%
Machagai	16.36%	-39.08%	53.00%	-14.63%	-10.74%	-26.46%	-27.69%	5.06%	-34.62%	-48.00%	-30.61%	-2.00%
PdelIndio	10.84%	-41.49%	42.89%	-14.41%	-28.10%	-14.71%	0.09%	-30.53%	-52.64%	-26.58%	-15.42%	-16.44%
PciadelaPlaza	4.25%	-18.42%	106.85%	5.54%	21.38%	-14.09%	-30.88%	-8.64%	-41.84%	-37.63%	-33.13%	-8.47%
PRSaenzPeña	6.89%	-20.57%	53.24%	-17.35%	2.44%	-32.41%	-24.64%	7.66%	-28.56%	-29.39%	2.67%	-15.38%
Resistencia	16.48%	-9.38%	43.93%	-22.96%	-22.03%	-13.82%	-30.57%	-13.20%	-45.77%	-3.08%	-9.24%	-12.84%
SantaSylvina	22.34%	-1.29%	19.95%	25.07%	-12.65%	-12.87%	-40.93%	-27.41%	-45.48%	9.28%	18.93%	-1.40%
TresIsletas	21.18%	-49.70%	25.25%	-40.45%	-2.48%	-44.03%	0.40%	-19.58%	-31.81%	-6.46%	-30.22%	12.63%
VaAngela	-27.97%	-7.69%	3.07%	4.14%	-16.58%	-24.59%	-36.41%	10.90%	-43.44%	-0.49%	11.07%	9.47%
>=Mod. Drought	-	**5.0**	-	**6.0**	**3.0**	**9.0**	**9.0**	**3.0**	**21.0**	**4.0**	**5.0**	**2.0**
>=Mod. Excess rai	**1.0**	**1.0**	**15.0**	-	**1.0**	-	-	-	-	-	-	**4.0**

Severe Excess	45.000%	To	<
Mod. Excess	30.000%	To	44.999%
Excess	15.000%	To	29.999%
Normal	-14.999%	To	14.999%
Drought	-29.999%	To	-15.000%
Mod. Drought	-44.999%	To	-30.000%
Severe Drought	<	To	-45.000%

Source: Authors' analysis of APA rainfall data

Annex 3: Weather (Rainfall) Index Insurance for Cotton: Analysis and Results

This annex presents the historical losses of three different rainfall index prototype contracts. The three contracts considered under the WII feasibility study were: Cumulative rainfall contracts during four cotton vegetative growth stages to protect against (i) Extreme Rainfall Deficit (drought) events (See Table A3.1) and (ii) extreme Excess Rainfall events as a proxy for flooding (See Table A3.2); and (iii) Number of consecutive days Rainfall Deficit (drought) cover (See Table A3.3). The historical losses shown on the Tables below are expressed as a percentage of the Sum Insured valuated at AR$2,200 per hectare or in other words, the annual burning costs or loss costs. This information was subsequently used to calculate for each Weather Station (WS) the pure rates, but most importantly, the historical losses data was used to determine whether the rain indexes mentioned could work as a proxy of cotton yields in Chaco Province (See the results of the rainfall and yield correlation analyses in Table A3.1.1, Table A.3.2.1 and Table A3.3.1).

The key results of these analyses are summarized below.

Cumulative Rainfall Deficit WII Cover for Chaco Cotton (Table A3.1. and Table A3.1.1.)

There are very high drought losses across all 25 weather stations in 2008-09 as shown by the high loss costs (payouts divided by sums insured and expressed as a percentage) for cotton and other severe drought loss years in Chaco include 1985/86 and 1986/87. (Table A3.1).

There is an extremely poor correlation for all weather stations between the cumulative rainfall deficit index and the departmental annual average yields of raw cotton over the 31 year reference period (1979/80 to 2009/10). The correlation coefficients range from +12.6% at La Clotilde WS through to a high of -31.7% Corzuela WS, General Belgrano Department. The inverse relationship at many stations implies that as rainfall decreases, raw yields of cotton actually increase. The very low correlations indicate that there are many other factors which explain yield variability at a departmental level other than cumulative rainfall deficit (drought) in each of the 4 vegetative growth stages.

The model produced extremely high pure loss cost rates at each station with range from a low of 9.4% (VaAngela, Com Luis Fontana Department) through to a high of 21.1% (CniaEliza, Sergento Cabral Department). (Table A3.1.1). With loadings to derive firstly average technical premium rates and then illustrative commercial premium rates of at least 20% to 25% at each station, the Cumulative Rainfall Index Cover would in any case be uneconomic to buy even if the correlations were better.

Cumulative Excess Rainfall WII Cover for Chaco Cotton (Table A3.2. and Table A3.2.1.)

Table A3.1. shows that 1980/81 was a very wet year with excess rain losses recorded at nearly all the 25 weather stations and as high as 100% loss costs at several stations (implying a full payout on the excess rainfall index policy across the 4 vegetative growth stages. Other years when high excess rainfall losses were produced by the excess rainfall index model include 2009/10, in 1985/86 some weather stations recorded high excess rain losses and this also applied to 2007/08. In general the patter of excess rainfall losses is not as clear as for cumulative rainfall deficit.

The Cumulative Excess Rainfall Index showed more consistent correlations with raw cotton yields than the cumulative drought index. in nearly all weather stations the correlation between excess rain and yields was inverse which is to be expected namely excess rainfall particularly at boll burst and ripening of the cotton crop can be very damaging and lead to significant yield reduction. The correlation coefficients were, however, still very low, typically between -15% and -30% at each WS, with a maximum of -40% at Pciadela Plaza WS, Presidente de la Plata Department. These correlations are far too low to recommend offering a cumulative excess rainfall index contract for cotton grown in each department (Table A2.2.1)

The average pure loss cost rates for the Excess Rainfall index contract for cotton ranged between 2.2% (Resistencia WS, San Fernando Department) to a high of 7.5% (at both La Tigra WS, O'Higgins Department and at Va Angela WS in Comandante Luis Fontano Department).

Cumulative Number of Days with Rainfall Deficit (Dry Days) WII Contract for Cotton Grown in Chaco Province (table A3.3. and Table A3.3.1)

The cumulative Number of Rainfall Deficit Days Contract as defined produced the highest payout frequencies by year across the 25 weather stations. Particularly dry day years leading to high loss costs in cotton across nearly all stations included 2008/09, 1985/86, 1986/87, and also 2003/04 and 2005/06. This index produced payouts in practically every year at every station, or a 100% payout frequency (Table A3.3 and Table 3.3.1.).

There was a very mixed picture in the correlation of cumulative number of rainfall deficit days and cotton yields at a Departmental level. At 12 weather stations the correlations between increasing number of dry days and cotton yields were positive indicating the longer the dry period in each vegetative stage, the higher the departmental yield of cotton: however, in 8 other weather stations the correlation was negative implying that cumulative drought days with no rain lead to reduced yields in cotton. The correlations were in all cases extremely low.

The dry day contract produced extremely high modeled pure risk premium rates of a minimum of 21.6% at PRSaenz Pena WS to a high of 39.3% at Gancedo WS, 12 Octubre. With such high pure loss cost rates, the final commercial premium rates on such a cover would obviously be prohibitively expensive.

In conclusion the modeling exercise shows than none of the 3 WII excess rainfall and or Rainfall Deficit WII contracts designed for cotton in Chaco Province produced a sufficiently high response to cotton yields at a departmental level to be able to recommend the use of these WII products for a cotton rainfall (excess rain and or rainfall deficit) index insurance program which would be marketed to GoC in Chaco Province.

A3.1. Cumulative Rainfall Deficit (Drought cover), historical loss costs by Weather Station (1979/80 - 2009/10)

ID	WS Name	Department	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	CniaElisa	Sgnto. Cabral	0.0%	100.0%	0.0%	0.0%	30.0%	21.3%	13.0%	0.0%	100.0%	0.0%	0.0%	88.5%	70.0%	0.0%	0.0%	0.0%	0.0%	70.0%	5.0%	0.0%	30.0%	0.0%	0.0%	0.0%	30.0%	0.0%	30.0%	1.3%	19.1%	45.8%	0.0%
2	CniasUnidas	Sgnto. Cabral	29.4%	0.0%	4.1%	0.0%	0.0%	0.0%	70.0%	0.0%	2.7%	0.0%	0.0%	0.0%	0.0%	16.2%	0.0%	0.0%	0.0%	11.8%	50.0%	0.0%	30.0%	0.0%	0.0%	0.0%	70.0%	0.0%	31.0%	0.0%	4.7%	44.6%	0.0%
3	GralSanMartin	L. Gnral. Sn Martín	18.3%	0.0%	0.0%	0.0%	0.4%	0.0%	70.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.6%	0.0%	0.0%	0.0%	10.6%	0.0%	30.0%	45.6%	10.6%	0.0%	59.7%	64.9%	21.0%	21.0%	0.0%	54.2%	0.0%
4	LagunaLimpia	L. Gnral. Sn Martín	0.0%	0.0%	0.0%	59.1%	5.2%	0.0%	70.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	17.9%	28.4%	0.0%	30.0%	19.8%	0.0%	0.0%	70.0%	26.5%	31.9%	0.0%	39.0%	50.0%	50.0%
5	LasPalmas	Bermejo	0.0%	23.1%	0.0%	30.0%	53.8%	0.0%	25.2%	0.0%	0.0%	0.0%	0.0%	0.0%	25.2%	51.7%	0.0%	0.0%	0.0%	70.0%	42.1%	0.0%	30.0%	0.0%	0.0%	0.0%	70.0%	0.0%	0.0%	0.0%	18.2%	30.0%	0.0%
6	Machagai	25 Mayo	28.1%	50.0%	0.0%	0.0%	7.2%	42.5%	83.8%	6.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	83.2%	0.0%	0.0%	66.3%	13.7%	9.6%	0.0%	30.0%	100.0%	0.0%
7	PciadelaPlaza	Presidente de la Plaza	20.1%	44.9%	0.0%	0.0%	61.7%	5.1%	70.0%	0.0%	13.6%	0.0%	0.0%	61.1%	70.0%	0.0%	0.0%	0.0%	0.0%	70.0%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	55.2%	0.0%	33.3%	0.0%	28.0%	38.1%	0.0%
8	PdelIndio	L. Gnral. Sn Martín	21.8%	77.2%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%	23.9%	0.0%	0.0%	0.0%	0.0%	0.0%	50.7%	0.0%	0.0%	0.0%	0.0%	5.4%	30.0%	31.6%	29.3%	0.0%	0.0%	81.0%	100.0%	15.9%	3.9%	30.0%	62.3%
9	Resistencia	San Fernando	0.0%	0.0%	0.0%	0.0%	56.9%	6.7%	24.7%	0.0%	28.1%	0.0%	0.0%	0.0%	0.0%	0.0%	13.3%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	49.5%	1.3%	0.0%	70.0%	0.9%	0.0%	0.0%	53.6%	30.0%	0.0%
10	Charata	Chacabuco	0.0%	0.0%	3.7%	0.0%	30.0%	30.0%	50.0%	53.3%	3.8%	0.0%	26.7%	0.0%	34.1%	16.1%	14.8%	0.0%	0.0%	0.0%	0.0%	15.0%	5.6%	0.0%	0.0%	22.6%	0.0%	75.6%	11.2%	0.0%	0.0%	91.1%	0.0%
11	Chorotis	F. Sta. María Oro	36.5%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%	100.0%	50.0%	50.0%	0.0%	23.6%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	0.0%	4.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%
12	Corzuela	Gnral. Belgrano	100.0%	30.0%	0.0%	0.0%	0.0%	30.0%	46.8%	70.0%	0.0%	0.0%	0.0%	7.2%	19.9%	3.2%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%	27.2%	0.9%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	30.0%	0.0%
13	Gancedo	12 Octubre	51.7%	0.0%	41.3%	28.6%	1.6%	30.0%	0.0%	88.1%	1.6%	0.0%	0.0%	0.0%	30.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	43.1%	1.0%	0.0%	0.0%	0.0%	30.0%	0.0%
14	GralPinedo	12 Octubre	0.0%	0.0%	0.0%	0.0%	30.0%	30.0%	31.9%	85.6%	0.0%	0.0%	0.0%	24.1%	70.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	30.0%	6.5%	15.5%	2.8%	53.7%	0.0%	13.8%	26.4%	0.0%	0.0%	30.0%	0.0%
15	Hcampo	2 Abril	30.7%	0.0%	6.8%	11.3%	0.0%	30.0%	9.8%	68.6%	0.0%	38.1%	0.0%	0.0%	45.8%	0.0%	38.1%	0.0%	0.0%	0.0%	0.0%	24.2%	0.0%	0.0%	74.5%	3.5%	18.3%	16.0%	0.0%	0.0%	0.0%	90.0%	0.0%
16	LasBreñas	9 Julio	0.0%	0.0%	0.0%	0.0%	0.0%	7.6%	18.8%	64.5%	2.8%	1.2%	0.0%	0.0%	22.3%	56.9%	0.0%	8.9%	0.0%	13.5%	14.4%	0.0%	2.1%	35.6%	0.0%	0.0%	0.0%	22.6%	0.0%	0.0%	0.0%	100.0%	0.0%
17	SantaSylvina	F. Sta. María Oro	0.0%	0.0%	7.0%	0.0%	0.0%	30.0%	31.3%	62.7%	0.0%	42.2%	0.0%	5.1%	85.6%	0.0%	0.0%	0.0%	0.0%	5.4%	30.0%	7.7%	0.0%	0.0%	5.4%	0.0%	23.5%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
18	AviaTerai	Independencia	0.0%	0.0%	22.9%	0.0%	0.0%	0.0%	22.9%	0.0%	0.0%	0.0%	0.0%	0.0%	49.1%	70.0%	0.0%	0.0%	12.9%	15.2%	0.0%	0.0%	17.5%	0.0%	30.0%	0.0%	50.0%	40.9%	30.0%	0.0%	0.0%	76.8%	0.0%
19	CampoLargo	Independencia	0.0%	0.0%	0.0%	0.0%	5.6%	0.0%	9.9%	63.6%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	3.6%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	17.0%	0.0%	0.0%	70.0%	30.0%	21.9%	22.7%	66.6%	0.0%
20	CnelDuGraty	M. Fontana	0.0%	0.0%	0.0%	14.5%	0.0%	20.3%	1.1%	0.0%	0.0%	66.4%	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	93.1%	0.0%	0.0%	0.0%	0.0%	30.0%	14.5%	0.0%	0.0%	0.0%	1.2%	94.7%	57.5%	0.0%
21	LaClotilde	O´Higgins	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	30.0%	0.0%	50.0%	24.6%	0.0%	0.0%	7.6%	3.7%	0.0%	0.0%	14.7%	0.0%	0.0%	0.0%	0.0%	30.0%	61.1%	5.3%	0.0%	30.0%	0.0%	100.0%	85.7%	0.0%
22	LaTigra	O´Higgins	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	36.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	23.9%	0.0%	0.0%	89.1%	0.0%	0.0%	0.0%	6.3%	30.0%	29.2%	0.0%	15.6%	36.1%	12.3%	100.0%	30.0%	0.0%
23	PRSaenzPeña	Cnte. Fernández	0.0%	0.0%	0.0%	0.0%	17.6%	17.1%	0.0%	33.1%	0.0%	35.9%	0.0%	0.0%	0.0%	20.7%	1.9%	1.8%	0.0%	76.4%	0.0%	0.0%	6.6%	0.0%	0.0%	0.0%	9.3%	8.3%	49.1%	0.0%	0.0%	54.8%	0.0%
24	TresIsletas	Maipu	70.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	32.0%	0.0%	0.0%	0.0%	21.9%	0.0%	0.0%	30.0%	30.0%	0.0%	6.5%	4.6%	0.0%	0.0%	0.0%	21.6%	4.8%	15.3%	54.2%	30.0%	0.0%	71.7%	70.0%	0.0%
25	VaAngela	M. Fontana	0.0%	43.4%	30.0%	0.0%	0.0%	0.0%	18.9%	55.1%	0.0%	19.3%	0.0%	0.0%	0.0%	7.9%	54.0%	0.0%	0.0%	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%	25.1%	0.0%	0.0%	30.0%	0.0%	0.0%	6.5%	0.0%

Source: Authors' analysis of APA rainfall data

Table A3.1.1. Calculated correlation coefficients and pure rates by weather station based on the Cumulative Rainfall Deficit (Drought cover) parameters.

ID	WS Name	Department	Corr.Coef. *	Freq.**	Intensity	Pure Rate	Stdev. [1]
1	CniaElisa	Sgnto. Cabral	8.5%	48.4%	43.6%	21.1%	31.9%
2	CniasUnidas	Sgnto. Cabral	-8.9%	38.7%	30.4%	11.8%	21.0%
3	GralSanMartin	L. Gnral. Sn Martín	-2.5%	41.9%	32.8%	13.8%	22.0%
4	LagunaLimpia	L. Gnral. Sn Martín	-19.1%	41.9%	38.3%	16.1%	23.1%
5	LasPalmas	Bermejo	ND	38.7%	39.1%	15.1%	22.3%
6	Machagai	25 Mayo	-15.3%	45.2%	39.4%	17.8%	29.3%
7	PciadelaPlaza	Presidente de la Plaza	1.8%	45.2%	42.9%	19.4%	26.1%
8	PdelIndio	L. Gnral. Sn Martín	-2.0%	48.4%	39.5%	19.1%	28.0%
9	Resistencia	San Fernando	ND	38.7%	30.4%	11.8%	20.5%
10	Charata	Chacabuco	-13.3%	51.6%	30.2%	15.6%	23.7%
11	Chorotis	F. Sta. Maria Oro	ND	32.3%	40.3%	13.0%	24.8%
12	Corzuela	Gnral. Belgrano	-31.7%	41.9%	34.2%	14.4%	24.5%
13	Gancedo	12 Octubre	-8.8%	41.9%	27.1%	11.4%	21.2%
14	GralPinedo	12 Octubre	-21.2%	48.4%	30.1%	14.6%	22.3%
15	Hcampo	2 Abril	ND	48.4%	33.7%	16.3%	24.8%
16	LasBreñas	9 Julio	-25.0%	45.2%	26.5%	12.0%	23.2%
17	SantaSylvina	F. Sta. Maria Oro	ND	41.9%	33.5%	14.1%	26.1%
18	AviaTerai	Independencia	-17.9%	38.7%	36.5%	14.1%	22.2%
19	CampoLargo	Independencia	-21.6%	38.7%	34.2%	13.3%	22.6%
20	CnelDuGraty	M. Fontana	-0.5%	35.5%	40.3%	14.3%	27.8%
21	LaClotilde	O´Higgins	12.6%	41.9%	37.9%	15.9%	27.0%
22	LaTigra	O´Higgins	-1.2%	38.7%	34.1%	13.2%	25.0%
23	PRSaenzPeña	Cnte. Fernández	-2.7%	41.9%	25.6%	10.7%	19.4%
24	TresIsletas	Maipu	-7.8%	48.4%	34.2%	16.5%	23.7%
25	VaAngela	M. Fontana	3.8%	35.5%	26.6%	9.4%	16.7%

Source: Authors' analysis of APA rainfall data
Notes:
ND means No Data available.
.- *Corr.Coef means correlation coefficients and is the correlation between the annual rainfall index and the department annual mean yield of raw cotton .
.- ** Freq. means frequency of payouts.
.- [1] Stdev means standard deviation around the calculated annual average pure loss cost rate.

Table A3.2. Cumulative Excess Rainfall Cover, historical loss costs by Weather Station (1979/80 to 2009/10)

ID	WS Name	Department	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	CniaElisa	Sgnto. Cabral	0.0%	29.0%	0.0%	7.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	47.6%	26.6%	2.0%	0.0%	0.0%	9.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%
2	CniasUnidas	Sgnto. Cabral	0.0%	59.4%	0.0%	21.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.0%	0.0%	1.6%	0.3%	4.1%	0.0%	0.0%	0.0%	0.0%	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	GralSanMartin	L. Gnral. Sn Martín	0.0%	35.0%	5.8%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.9%	15.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.7%	0.0%	0.0%	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4	LagunaLimpia	L. Gnral. Sn Martín	0.0%	19.6%	1.0%	0.0%	0.0%	0.0%	4.5%	62.5%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	LasPalmas	Bermejo	0.0%	56.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.6%	6.2%	0.0%	2.7%	21.4%	0.0%	73.0%	0.0%	0.0%	0.0%	5.1%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%
6	Machagai	25 Mayo	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.8%	0.0%	0.0%	41.7%	6.2%	30.0%	20.5%	1.8%	23.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7	PciadelaPlaza	Presidente de la Plaza	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.7%	0.0%	13.8%	0.0%	30.0%	19.5%	0.0%	47.8%	0.0%	0.0%	0.0%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.3%
8	PdelIndio	L. Gnral. Sn Martín	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	41.5%	0.0%	0.0%	0.0%	0.0%	35.7%	36.2%	0.0%	4.2%	0.0%	0.0%	0.0%	0.0%	27.4%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.0%	0.0%	0.0%	0.0%
9	Resistencia	San Fernando	0.0%	0.0%	0.0%	18.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.9%	0.7%	0.0%	0.0%	4.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%
10	Charata	Chacabuco	0.0%	2.1%	0.0%	0.0%	8.8%	0.0%	7.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	0.0%	0.0%	39.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.8%
11	Chorotis	F. Sta. María Oro	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	47.2%	0.0%	23.2%	100.0%	3.8%	24.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.7%
12	Corzuela	Gnral. Belgrano	0.0%	24.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.4%	0.0%	7.7%	0.0%	0.0%	0.0%	7.6%	0.0%	13.8%	55.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.3%	0.0%	0.0%	0.0%	0.0%	7.7%
13	Gancedo	12 Octubre	15.6%	29.6%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	0.0%	11.3%	0.0%	0.0%	30.0%	0.0%	6.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	GralPinedo	12 Octubre	0.0%	95.3%	0.0%	5.9%	0.0%	7.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.6%	0.0%	0.0%	5.9%
15	Hcampo	2 Abril	0.0%	43.9%	0.0%	0.0%	0.0%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	17.5%	0.0%	0.0%	0.0%	0.0%	0.0%	30.6%	0.0%	12.3%	0.0%	0.0%	10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%
16	LasBreñas	9 Julio	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	19.3%	0.0%	18.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%	24.3%
17	SantaSylvina	F. Sta. María Oro	0.0%	70.0%	0.0%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.8%	0.0%	0.0%	0.0%	0.0%	3.2%	3.6%	0.0%	0.0%	0.0%	0.0%	0.0%	87.4%
18	AviaTerai	Independencia	0.0%	13.1%	0.0%	100.0%	0.0%	0.0%	7.9%	0.0%	0.0%	9.7%	0.0%	0.0%	0.0%	3.4%	0.0%	0.0%	23.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
19	CampoLargo	Independencia	0.0%	16.9%	0.0%	66.8%	0.0%	0.0%	10.0%	0.0%	0.0%	2.5%	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	36.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	16.8%
20	CnelDuGraty	M. Fontana	0.0%	70.0%	0.0%	0.3%	0.0%	0.0%	33.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	50.0%	1.0%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
21	LaClotilde	O´Higgins	0.0%	0.0%	0.0%	0.0%	8.1%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	45.0%	0.0%	13.4%	28.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%
22	LaTigra	O´Higgins	0.0%	16.2%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	16.8%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	8.6%	0.0%	0.0%	18.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.0%
23	PRSaenzPeña	Cnte. Fernández	6.7%	52.8%	0.0%	0.0%	0.0%	0.0%	37.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	75.9%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%
24	TresIsletas	Maipu	0.0%	23.1%	0.0%	0.0%	0.0%	0.0%	64.3%	12.4%	0.0%	21.6%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	11.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
25	VaAngela	M. Fontana	2.7%	60.3%	0.0%	0.0%	0.0%	36.3%	52.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	55.7%	0.0%	0.0%	25.7%

Source: Authors' analysis of APA rainfall data

Table A3.2.1. Calculated correlation coefficients and pure rates by weather station based on the Cumulative Excess Rainfall Cover parameters.

ID	WS Name	Department	Corr.Coef. *	Freq.**	Intensity	Pure Rate	Stdev. [1]
1	CniaElisa	Sgnto. Cabral	-35.0%	22.6%	17.8%	4.0%	10.8%
2	CniasUnidas	Sgnto. Cabral	-20.5%	22.6%	13.3%	3.0%	11.2%
3	GralSanMartin	L. Gnral. Sn Martín	-27.3%	22.6%	14.3%	3.2%	8.4%
4	LagunaLimpia	L. Gnral. Sn Martín	-10.9%	19.4%	17.0%	3.3%	11.8%
5	LasPalmas	Bermejo	ND	25.8%	26.1%	6.7%	17.1%
6	Machagai	25 Mayo	2.4%	22.6%	18.2%	4.1%	10.2%
7	PciadelaPlaza	Presidente de la Plaza	-40.7%	22.6%	19.0%	4.3%	10.6%
8	PdelIndio	L. Gnral. Sn Martín	-28.4%	22.6%	25.2%	5.7%	12.9%
9	Resistencia	San Fernando	ND	16.1%	13.9%	2.2%	6.7%
10	Charata	Chacabuco	12.4%	22.6%	11.4%	2.6%	7.4%
11	Chorotis	F. Sta. Maria Oro	ND	22.6%	30.8%	7.0%	20.1%
12	Corzuela	Gnral. Belgrano	-33.2%	25.8%	16.7%	4.3%	10.9%
13	Gancedo	12 Octubre	-5.3%	22.6%	28.9%	6.5%	19.1%
14	GralPinedo	12 Octubre	-30.9%	19.4%	21.9%	4.2%	17.2%
15	Hcampo	2 Abril	ND	22.6%	17.1%	3.9%	10.0%
16	LasBreñas	9 Julio	-3.1%	19.4%	15.7%	3.0%	8.0%
17	SantaSylvina	F. Sta. Maria Oro	ND	22.6%	25.9%	5.8%	19.7%
18	AviaTerai	Independencia	14.1%	19.4%	26.3%	5.1%	18.3%
19	CampoLargo	Independencia	-4.8%	22.6%	21.7%	4.9%	13.8%
20	CnelDuGraty	M. Fontana	-19.5%	22.6%	22.3%	5.0%	16.0%
21	LaClotilde	O´Higgins	-25.8%	19.4%	39.0%	7.5%	20.7%
22	LaTigra	O´Higgins	-24.6%	22.6%	25.2%	5.7%	18.4%
23	PRSaenzPeña	Cnte. Fernández	-25.5%	22.6%	25.5%	5.8%	17.3%
24	TresIsletas	Maipu	-21.3%	19.4%	22.2%	4.3%	12.7%
25	VaAngela	M. Fontana	-20.0%	22.6%	33.3%	7.5%	18.0%

Source: Authors' analysis of APA rainfall data

Notes:

ND means No Data available.

.- *Corr.Coef means correlation coefficients and is the correlation between the annual rainfall index and the department annual mean yield of raw cotton .

.- ** Freq. means frequency of payouts.

.- [1] Stdev means standard deviation around the calculated annual average pure loss cost rate

A3.3. Number of Consecutive Days Rainfall Deficit (Drought) Cover, historical loss costs by weather station (1979/80 - 2009/10)

ID	WS Name	Department	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	CniaElisa	Sgnto. Cabral	46.0%	35.0%	26.0%	36.0%	48.0%	38.0%	61.0%	58.0%	40.0%	40.0%	46.0%	22.0%	47.0%	36.0%	13.0%	28.0%	29.0%	37.0%	33.0%	19.0%	33.0%	42.0%	24.0%	15.0%	62.0%	40.0%	42.0%	36.0%	21.0%	54.0%	34.0%
2	CniasUnidas	Sgnto. Cabral	50.0%	36.0%	23.0%	33.0%	49.0%	27.0%	64.0%	55.0%	37.0%	40.0%	42.0%	22.0%	25.0%	33.0%	34.0%	28.0%	28.0%	20.0%	31.0%	19.0%	19.0%	37.0%	24.0%	20.0%	48.0%	48.0%	42.0%	27.0%	34.0%	54.0%	44.0%
3	GralSanMartin	L. Gnral. Sn Martín	45.0%	41.0%	20.0%	44.0%	41.0%	14.0%	59.0%	50.0%	29.0%	31.0%	18.0%	36.0%	25.0%	0.0%	48.0%	25.0%	13.0%	51.0%	7.0%	26.0%	48.0%	25.0%	37.0%	32.0%	46.0%	34.0%	36.0%	25.0%	43.0%	34.0%	32.0%
4	LagunaLimpia	L. Gnral. Sn Martín	10.0%	34.0%	14.0%	33.0%	43.0%	27.0%	63.0%	50.0%	32.0%	40.0%	42.0%	35.0%	25.0%	17.0%	45.0%	28.0%	13.0%	31.0%	17.0%	22.0%	35.0%	42.0%	25.0%	54.0%	48.0%	16.0%	41.0%	44.0%	45.0%	84.0%	77.0%
5	LasPalmas	Bermejo	33.0%	27.0%	24.0%	69.0%	40.0%	18.0%	59.0%	32.0%	20.0%	29.0%	30.0%	36.0%	25.0%	17.0%	38.0%	16.0%	12.0%	38.0%	29.0%	26.0%	19.0%	37.0%	25.0%	33.0%	62.0%	27.0%	36.0%	6.0%	30.0%	28.0%	28.0%
6	Machagai	25 Mayo	46.0%	25.0%	29.0%	52.0%	45.0%	38.0%	56.0%	42.0%	28.0%	49.0%	17.0%	36.0%	25.0%	31.0%	13.0%	28.0%	36.0%	17.0%	14.0%	39.0%	18.0%	31.0%	29.0%	15.0%	39.0%	35.0%	34.0%	18.0%	29.0%	53.0%	33.0%
7	PciadelaPlaza	Presidente de la Plaza	26.0%	10.0%	24.0%	32.0%	39.0%	24.0%	64.0%	62.0%	24.0%	48.0%	48.0%	36.0%	41.0%	20.0%	25.0%	28.0%	0.0%	46.0%	9.0%	46.0%	20.0%	35.0%	24.0%	15.0%	41.0%	39.0%	34.0%	18.0%	37.0%	62.0%	33.0%
8	PdelIndio	L. Gnral. Sn Martín	14.0%	50.0%	16.0%	39.0%	30.0%	51.0%	72.0%	61.0%	28.0%	31.0%	31.0%	57.0%	5.0%	42.0%	41.0%	18.0%	13.0%	35.0%	11.0%	7.0%	37.0%	44.0%	37.0%	34.0%	49.0%	44.0%	55.0%	19.0%	43.0%	76.0%	56.0%
9	Resistencia	San Fernando	10.0%	6.0%	14.0%	12.0%	23.0%	0.0%	53.0%	29.0%	24.0%	32.0%	28.0%	26.0%	25.0%	17.0%	35.0%	16.0%	0.0%	13.0%	7.0%	27.0%	18.0%	10.0%	18.0%	15.0%	15.0%	40.0%	18.0%	22.0%	44.0%	16.0%	0.0%
10	Charata	Chacabuco	0.0%	11.0%	29.0%	51.0%	20.0%	16.0%	56.0%	42.0%	29.0%	49.0%	51.0%	47.0%	22.0%	23.0%	29.0%	37.0%	0.0%	32.0%	10.0%	19.0%	37.0%	23.0%	30.0%	24.0%	28.0%	34.0%	51.0%	8.0%	47.0%	29.0%	29.0%
11	Chorotis	F. Sta. María Oro	23.0%	43.0%	20.0%	55.0%	13.0%	16.0%	32.0%	66.0%	82.0%	40.0%	38.0%	13.0%	33.0%	34.0%	48.0%	37.0%	22.0%	38.0%	22.0%	19.0%	18.0%	44.0%	50.0%	25.0%	33.0%	33.0%	54.0%	9.0%	74.0%	70.0%	38.0%
12	Corzuela	Gnral. Belgrano	35.0%	42.0%	29.0%	37.0%	22.0%	16.0%	21.0%	66.0%	30.0%	34.0%	50.0%	30.0%	21.0%	56.0%	33.0%	19.0%	16.0%	41.0%	27.0%	21.0%	15.0%	29.0%	28.0%	27.0%	35.0%	40.0%	54.0%	5.0%	32.0%	48.0%	30.0%
13	Gancedo	12 Octubre	49.0%	18.0%	44.0%	20.0%	22.0%	53.0%	46.0%	54.0%	29.0%	41.0%	34.0%	49.0%	72.0%	23.0%	41.0%	31.0%	19.0%	49.0%	7.0%	19.0%	33.0%	34.0%	63.0%	66.0%	49.0%	36.0%	53.0%	16.0%	45.0%	61.0%	43.0%
14	GralPinedo	12 Octubre	26.0%	12.0%	20.0%	19.0%	37.0%	29.0%	34.0%	33.0%	16.0%	41.0%	51.0%	32.0%	39.0%	35.0%	31.0%	37.0%	22.0%	19.0%	9.0%	19.0%	36.0%	18.0%	44.0%	24.0%	29.0%	33.0%	47.0%	8.0%	45.0%	42.0%	30.0%
15	Hcampo	2 Abril	36.0%	12.0%	20.0%	43.0%	43.0%	27.0%	22.0%	53.0%	5.0%	17.0%	30.0%	47.0%	44.0%	41.0%	29.0%	30.0%	36.0%	39.0%	21.0%	19.0%	36.0%	37.0%	56.0%	63.0%	44.0%	38.0%	46.0%	19.0%	53.0%	42.0%	29.0%
16	LasBreñas	9 Julio	20.0%	6.0%	27.0%	24.0%	17.0%	15.0%	15.0%	10.0%	5.0%	13.0%	35.0%	19.0%	0.0%	39.0%	27.0%	33.0%	5.0%	31.0%	25.0%	7.0%	22.0%	21.0%	15.0%	9.0%	33.0%	19.0%	30.0%	8.0%	42.0%	44.0%	15.0%
17	SantaSylvina	F. Sta. María Oro	48.0%	12.0%	29.0%	51.0%	8.0%	33.0%	22.0%	45.0%	28.0%	28.0%	20.0%	30.0%	59.0%	43.0%	32.0%	33.0%	11.0%	50.0%	25.0%	18.0%	30.0%	38.0%	58.0%	25.0%	33.0%	34.0%	54.0%	13.0%	54.0%	57.0%	23.0%
18	AviaTerai	Independencia	42.0%	15.0%	38.0%	48.0%	31.0%	27.0%	47.0%	49.0%	38.0%	31.0%	31.0%	22.0%	24.0%	68.0%	25.0%	29.0%	22.0%	56.0%	22.0%	35.0%	9.0%	36.0%	43.0%	41.0%	77.0%	42.0%	45.0%	10.0%	34.0%	59.0%	60.0%
19	CampoLargo	Independencia	35.0%	14.0%	41.0%	28.0%	25.0%	27.0%	52.0%	61.0%	50.0%	36.0%	33.0%	22.0%	38.0%	48.0%	25.0%	29.0%	18.0%	40.0%	13.0%	20.0%	22.0%	34.0%	40.0%	41.0%	62.0%	56.0%	44.0%	25.0%	31.0%	49.0%	21.0%
20	CnelDuGraty	M. Fontana	39.0%	17.0%	16.0%	25.0%	28.0%	17.0%	26.0%	54.0%	35.0%	43.0%	36.0%	45.0%	25.0%	50.0%	35.0%	10.0%	6.0%	47.0%	36.0%	23.0%	9.0%	8.0%	25.0%	34.0%	51.0%	48.0%	34.0%	10.0%	34.0%	47.0%	39.0%
21	LaClotilde	O´Higgins	36.0%	0.0%	41.0%	45.0%	9.0%	24.0%	73.0%	63.0%	20.0%	81.0%	43.0%	27.0%	39.0%	46.0%	45.0%	19.0%	7.0%	26.0%	28.0%	20.0%	9.0%	26.0%	42.0%	30.0%	63.0%	42.0%	35.0%	10.0%	43.0%	56.0%	21.0%
22	LaTigra	O´Higgins	31.0%	19.0%	17.0%	30.0%	8.0%	18.0%	46.0%	35.0%	7.0%	21.0%	33.0%	18.0%	41.0%	48.0%	11.0%	21.0%	17.0%	43.0%	18.0%	21.0%	23.0%	27.0%	43.0%	42.0%	53.0%	53.0%	37.0%	10.0%	43.0%	48.0%	28.0%
23	PRSaenzPeña	Cnte. Fernández	33.0%	13.0%	15.0%	16.0%	7.0%	15.0%	19.0%	25.0%	19.0%	27.0%	23.0%	17.0%	24.0%	45.0%	21.0%	7.0%	5.0%	23.0%	20.0%	23.0%	9.0%	8.0%	17.0%	27.0%	55.0%	41.0%	34.0%	10.0%	19.0%	27.0%	25.0%
24	TresIsletas	Maipu	47.0%	25.0%	38.0%	28.0%	25.0%	31.0%	59.0%	57.0%	19.0%	15.0%	22.0%	22.0%	25.0%	39.0%	34.0%	51.0%	13.0%	27.0%	20.0%	23.0%	8.0%	21.0%	39.0%	27.0%	59.0%	42.0%	46.0%	33.0%	36.0%	74.0%	59.0%
25	VaAngela	M. Fontana	32.0%	6.0%	48.0%	30.0%	43.0%	17.0%	47.0%	49.0%	19.0%	25.0%	48.0%	19.0%	25.0%	53.0%	39.0%	19.0%	7.0%	29.0%	19.0%	33.0%	8.0%	8.0%	38.0%	33.0%	29.0%	43.0%	35.0%	11.0%	32.0%	50.0%	18.0%

Source: Authors' analysis of APA rainfall data

Table 3.1.3. Calculated correlation coefficients and pure rates per weather station based on the Number of Consecutive Days Rainfall Deficit) Drought contract parameters.

ID	WS Name	Department	Corr.Coef. *	Freq.**	Intensity	Pure Rate	Stdev. [1]
1	CniaElisa	Sgnto. Cabral	18.4%	100.0%	36.8%	36.8%	12.6%
2	CniasUnidas	Sgnto. Cabral	8.3%	100.0%	35.3%	35.3%	12.0%
3	GralSanMartin	L. Gnral. Sn Martin	10.2%	96.8%	33.8%	32.7%	13.8%
4	LagunaLimpia	L. Gnral. Sn Martin	20.8%	100.0%	36.5%	36.5%	17.5%
5	LasPalmas	Bermejo	ND	100.0%	30.6%	30.6%	13.5%
6	Machagai	25 Mayo	-12.8%	100.0%	32.3%	32.3%	12.0%
7	PciadelaPlaza	Presidente de la Plaza	9.9%	96.8%	33.7%	32.6%	15.5%
8	PdelIndio	L. Gnral. Sn Martin	3.8%	100.0%	37.0%	37.0%	18.4%
9	Resistencia	San Fernando	ND	90.3%	21.9%	19.8%	12.6%
10	Charata	Chacabuco	19.4%	93.5%	31.5%	29.5%	15.1%
11	Chorotis	F. Sta. Maria Oro	ND	100.0%	36.8%	36.8%	18.7%
12	Corzuela	Gnral. Belgrano	6.7%	100.0%	31.9%	31.9%	13.4%
13	Gancedo	12 Octubre	-7.5%	100.0%	39.3%	39.3%	16.3%
14	GralPinedo	12 Octubre	15.1%	100.0%	29.6%	29.6%	11.3%
15	Hcampo	2 Abril	ND	100.0%	34.7%	34.7%	13.6%
16	LasBreñas	9 Julio	18.2%	96.8%	21.0%	20.4%	11.7%
17	SantaSylvina	F. Sta. Maria Oro	ND	100.0%	33.7%	33.7%	14.9%
18	AviaTerai	Independencia	-9.1%	100.0%	37.3%	37.3%	16.1%
19	CampoLargo	Independencia	5.4%	100.0%	34.8%	34.8%	13.4%
20	CnelDuGraty	M. Fontana	-3.1%	100.0%	30.7%	30.7%	14.2%
21	LaClotilde	O´Higgins	-5.4%	96.8%	35.6%	34.5%	19.6%
22	LaTigra	O´Higgins	-25.2%	100.0%	29.4%	29.4%	13.9%
23	PRSaenzPeña	Cnte. Fernández	-21.0%	100.0%	21.6%	21.6%	11.4%
24	TresIsletas	Maipu	-15.8%	100.0%	34.3%	34.3%	15.9%
25	VaAngela	M. Fontana	22.0%	100.0%	29.4%	29.4%	14.2%

Source: Authors' analysis of APA rainfall data
Notes:
.- ND means No Data available.
.- *Corr.Coef means correlation coefficients and is the correlation between the annual rainfall index and the department annual mean yield of raw cotton .
.- ** Freq. means frequency of payouts.
.- [1] Stdev means standard deviation around the calculated annual average pure loss cost rate.

Annex 4: Cotton Area-Yield Index Rating Analysis for Chaco Province

4.1. Introduction

This annex describe the methodology followed in the design and rating of the "Area Yield Index Insurance for Cotton" in Chaco Province Argentina, as well as the calculation of the Probable Maximum Loss (PML).

The main objective of crop risk modeling is to estimate a yield probability density function that reflects the stochastic nature of yield outcomes. The yield model relies on two basic parameters: (a) a crop yield probability density function which in the case of Chaco cotton is derived from 41-years of departmental annual average yields (sown area basis) and (b) a correlation matrix of departmental-level average cotton yields which reflects the covariate risk under the cotton portfolio. The probability density functions were inferred from the technology adjusted annual average yields from the Federal Government of Argentina's annual average yield series 1969/70 to 2009/10 that were fitted to a Gamma probability distribution.

Section A4.2 describes (i) the methodology followed to calculate the historical yields in each department, (ii) the criteria that should be met by the cotton production related data in a department in order to be included in the AYII, (iii) the trend analysis carried out to get a de-trended time series data which is used to study the deviations in each year, (iv) the calculation of the expected yield and its valuation, and finally (v) the correlation analysis of the historical yields.

Section A4.3 gives the details regarding the methodology followed for rating and probable maximum loss estimation developed through Monte Carlo Simulation. The historical yields of each department and its correlations were used to fit parametric distribution function and to then simulate 5,000 yields (years) to calculate risk premiums, smoothed risk premiums, probable maximum loss (PML), technical premiums and indicative commercial premiums.

4.2. Yield Data Analysis

The Chaco cotton AYII product is based on the analysis of variation in Departmental-level of cotton yields for the period 1969/70 to 2009/10. The Departmental time-series of sown area, harvested area and cotton raw production and yield data was provided by ORA-MAGyP. This data set was used for the risk assessment and the cotton AYII design and rating purposes.

4.2.1. Yield Calculation

The yield of cotton was calculated on a sown area basis. MPCh and MAGyP report yields according to a harvested area basis; however, this methodology would reduce the loss in production in case some sown areas were totally lost, as they would be excluded from the calculation. For this reason, for the purpose of design and rating of the AYII product raw cotton yields in each department were calculated on a sown area basis and not on a harvested area basis.

Let $AS_{t;d}$ be the sown area of cotton (in hectares) and let $P_{t;d}$ be the production (in metric tons), both measured in year "t" and in department "d". The yield of raw cotton expressed in kilograms per hectare in year "t" in department "d", $Y_{t;d}$, is calculated as:

$$Y_{t;d} = \frac{P_{t;d}}{AS_{t;d}}$$

4.2.2. Inclusion Criteria for Departments

In the design and rating and risk analysis of the AYII for cotton production in Chaco only those departments were considered where (i) the sown area of cotton was greater than a pre-specified minimum and (ii) the missing cotton production and yield data was less than a pre-specified percentage of total historical time-series.

The AYII is aimed to give protection to the departments where cotton is a traditional crop and consequently those departments that have a small sown area, in which sowing is speculative in years with high prices, should be excluded. In this report, the departments in which the average sown area in the last three years was less than 2,000 Ha were excluded from the AYII rating analysis. However, the Excel-based rating tool is flexible and allows the user to choose the minimum departmental sown area needed for the inclusion in the AYII program.

Additionally, the rating and risk analysis require if possible an uninterrupted historical data series to perform the statistical analysis and produce reliable results. In this report, a maximum of 10% or 4 years of missing data is permitted, or a minimum of 31 years of data is required in a department in order to be included in the AYII program. However, the Excel-based rating tool allows the user to change the maximum percentage of missing data permitted, and the insurer and or the GoC could select a more or less strict cutoff.

A total of 18 out of the 25 departments in Chaco met these two criteria and were included in the final rating and risk analysis of the AYII for cotton.

It is worth mentioning that in the 18 departments included there were no missing data at all. In case in future a more comprehensive analysis is accomplished and departments with missing data are included, an interpolation procedure should be considered to in fill the missing data.

4.2.3. Expected Yield and Valuation

The expected yield in next year in each department for insurance purpose is calculated as the simple average of the last five years. Formally, the expected yield for year “t” and department “t” is calculated as follows:

$$E\left(Y_{t;d}\right) = \frac{1}{5}\sum_{i=1}^{5} Y_{t-i;d}$$

Beyond that there is a long-run trend, the objective in setting the expected yield as a simple average is to avoid an overestimation of it, which ultimately would trigger the insurance, not because there is an event that damages the production but because the expected yield was set in a too high level.

The rating tool allows the user to choose the value per kilogram of raw cotton. In this report a value of AR$ 2/kg was set on the basis of discussions carried out in the meetings in Chaco. The team is aware that there is a high volatility in cotton prices, but at this stage of the design the cotton price is kept fixed in the policy, because the objective of the AYII is to cover the “production risk”, and not the “price risk” that should be hedged using other kind of financial

tools, such as futures, forward and options contracts. In future, the latter contracts could be used in combination with the AYII, but the analysis of this alternative is beyond the scope of this study.

4.2.4. Trend Analysis

For AYII rating purposes it is necessary to adjust the time series departmental average cotton yields to remove the effects of improved technology and management practices on cotton yields. A simplified method was adopted for determining the central tendency for the departmental average annual cotton yields. The trend in yields in each department was calculated as a simple average of (i) the linear trend, (ii) the logarithm trend, and (iii) the five year moving average. Formally, each one of these components of the trend is calculated as follows:

- Linear-trend: $TY_{t;d}^{(1)} = \hat{\alpha}_1 + \hat{\beta}_1 \times t$; where $\hat{\alpha}_1$ and $\hat{\beta}_1$ are the estimates of the intercept and slope of a linear regression of yield versus time.
- Log-trend: $TY_{t;d}^{(2)} = \exp\left[\hat{\alpha}_2 + \hat{\beta}_2 \ln(t)\right]$; where $\hat{\alpha}_2$ and $\hat{\beta}_2$ are the estimates of the intercept and slope of a linear regression of Log-yield versus Log-time.
- 5-year Moving Average: $TY_{t;d}^{(3)} = \frac{1}{5}\sum_{i=1}^{5} Y_{t-i;d}$.

Thereupon, the trend yield is calculated as:

$$TY_{t;d} = \frac{1}{3}\sum_{i=1}^{3} TY_{t;d}^{(i)}$$

Figure A4.1 shows the yields in each year in Com. Luis Fontana Department, along with each one of the components of the trend as well as the final trend calculated as the simple average of the components.

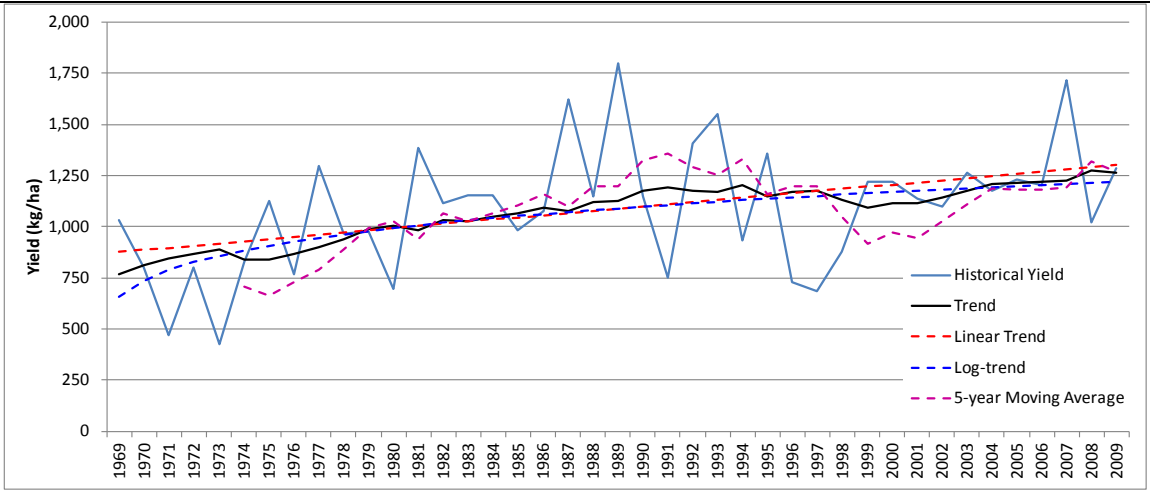


Figure A4.1

The second part of this analysis was to estimate the expected annual average yield volatility of the annual average yield. The method used for this purpose was to measure the percentage deviations between the historic actual annual average yields for each year of the series in respect to the corresponding annual average trended yield. Then, these deviations were applied to the expected yield to obtain an adjusted and detrended annual average yield series. More formally, the detrended yield in year "t" in department "d", $DY_{t;d}$, was calculated by applying to the expected yield in next year, $E(Y_d)$, the percentage deviation of the historic actual average yield, $Y_{t;d}$, from the trended average yield, $TY_{t;d}$; namely[37]:

$$DY_{t;d} = E(Y_d) \times \left(1 + \frac{Y_{t;d} - TY_{t;d}}{TY_{t;d}}\right)$$

Figure A4.2 shows the detrended average yields in each year in Com. Luis Fontana Department, calculated from the trended average yields and the historic actual average yield.

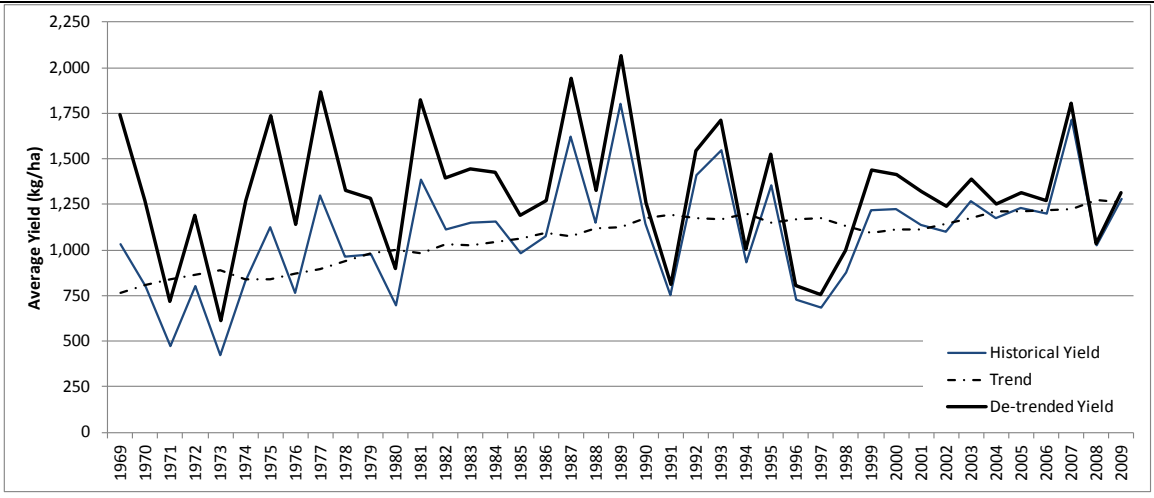


Figure A4.2

An example of the process of detrending the 41-year cotton yields is presented in Figure A4.2 for cotton grown in Com. Luis Fontana Department.

4.2.5. Yield Correlation

The detrended historical cotton yields in the 18 departments were correlated in order to reflect the systemic risk and the diversification effect as well. If a perfect correlation between the departmental yields is assumed (i.e. all the departmental yields vary proportionally), the losses

[37] Note that the subscript of the year was intentionally avoided in $E(Y_d)$, because it is the expected yield in the next policy year, and all the detrended historical yields are calculated as deviations from this expectation.

would be overestimated because a low yield in one department would imply low yields in all of them. In the other extreme, if no correlation at all is considered, the losses would be underestimated: the losses in yields one department would have nothing to do with losses in the remaining of them. Neither of those extremes is a reasonable assumption: there is some level of correlation, but it is not perfect. The correlation matrix between the historical detrended yields was then calculated to reflect the imperfect (but probably positive) covariation in the departmental yields.

In Table A4.1, which shows the correlation matrix between the yields, it is appreciated that the correlations are all positives and almost all greater than 0.5, with the only exception being Almirante Brown department, which has a correlation lower than 0.5 with 4 of the 17 remaining departments. The high level of correlation shows the exposition to systemic risk in Chaco.

	12 de Octubre	25 de Mayo	9 de julio	almirante brown	Chacabuco	Com Fernandez	Com Luis Fontana	Fray Justo	General Belgrano	General Guemes	General San Martin	Independencia	Maipu	O Higgins	Pres de la Plaza	Quililipi	San Lorenzo	Sargento Cabral
12 de Octubre	1.0000	0.6636	0.7792	0.6646	0.8832	0.6243	0.7778	0.7886	0.8169	0.6715	0.7056	0.7088	0.7316	0.7761	0.5942	0.6311	0.6842	0.7063
25 de Mayo	0.6636	1.0000	0.7225	0.5793	0.7775	0.7612	0.6084	0.6815	0.7088	0.7676	0.7642	0.7703	0.7929	0.8220	0.8309	0.9072	0.8425	0.8364
9 de julio	0.7792	0.7225	1.0000	0.7930	0.8791	0.7015	0.7240	0.6454	0.8480	0.7272	0.6195	0.8334	0.7943	0.7524	0.6777	0.7481	0.6536	0.6979
almirante brown	0.6646	0.5793	0.7930	1.0000	0.7832	0.5644	0.4577	0.3848	0.7935	0.5616	0.4479	0.6684	0.5385	0.5233	0.5804	0.5597	0.4848	0.7277
Chacabuco	0.8832	0.7775	0.8791	0.7832	1.0000	0.7230	0.7410	0.6849	0.9289	0.7412	0.7166	0.8616	0.8016	0.7842	0.7159	0.7601	0.7417	0.7953
Com Fernandez	0.6243	0.7612	0.7015	0.5644	0.7230	1.0000	0.6821	0.5477	0.6911	0.6998	0.7200	0.7557	0.8245	0.7714	0.8053	0.8337	0.6802	0.6225
Com Luis Fontana	0.7778	0.6084	0.7240	0.4577	0.7410	0.6821	1.0000	0.8374	0.7040	0.5830	0.6104	0.7468	0.6439	0.8135	0.6403	0.6710	0.7502	0.6047
Fray Justo	0.7886	0.6815	0.6454	0.3848	0.6849	0.5477	0.8374	1.0000	0.6273	0.6142	0.6818	0.6054	0.6307	0.7629	0.6284	0.6013	0.7438	0.6054
General Belgrano	0.8169	0.7088	0.8480	0.7935	0.9289	0.6911	0.7040	0.6273	1.0000	0.6738	0.6119	0.8822	0.7129	0.7185	0.6643	0.6998	0.6628	0.7266
General Guemes	0.6715	0.7676	0.7272	0.5616	0.7412	0.6998	0.5830	0.6142	0.6738	1.0000	0.7624	0.7091	0.9154	0.6678	0.7134	0.7442	0.6791	0.6750
General San Martin	0.7056	0.7642	0.6195	0.4479	0.7166	0.7200	0.6104	0.6818	0.6119	0.7624	1.0000	0.6283	0.8279	0.7156	0.6596	0.7466	0.7145	0.6905
Independencia	0.7088	0.7703	0.8334	0.6684	0.8616	0.7557	0.7468	0.6054	0.8822	0.7091	0.6283	1.0000	0.7599	0.7463	0.6540	0.8159	0.6962	0.7430
Maipu	0.7316	0.7929	0.7943	0.5385	0.8016	0.8245	0.6439	0.6307	0.7129	0.9154	0.8279	0.7599	1.0000	0.7511	0.7446	0.8134	0.6955	0.6658
O Higgins	0.7761	0.8220	0.7524	0.5233	0.7842	0.7714	0.8135	0.7629	0.7185	0.6678	0.7156	0.7463	0.7511	1.0000	0.7283	0.7591	0.8612	0.6772
Pres de la Plaza	0.5942	0.8309	0.6777	0.5804	0.7159	0.8053	0.6403	0.6284	0.6643	0.7134	0.6596	0.6540	0.7446	0.7283	1.0000	0.8267	0.7197	0.7053
Quililipi	0.6311	0.9072	0.7481	0.5597	0.7601	0.8337	0.6710	0.6013	0.6998	0.7442	0.7466	0.8159	0.8134	0.7591	0.8267	1.0000	0.7735	0.7664
San Lorenzo	0.6842	0.8425	0.6536	0.4848	0.7417	0.6802	0.7502	0.7438	0.6628	0.6791	0.7145	0.6962	0.6955	0.8612	0.7197	0.7735	1.0000	0.7464
Sargento Cabral	0.7063	0.8364	0.6979	0.7277	0.7953	0.6225	0.6047	0.6054	0.7266	0.6750	0.6905	0.7430	0.6658	0.6772	0.7053	0.7664	0.7464	1.0000

Table A4.1

4.3. Rating and Risk Analysis

Once the Historical Detrended Yields was calculated and the Expected Yield for next year was established, the rating and risk assessment can be carried out. Specifically, Monte Carlo Simulation is used to generate a simulated sample of 5,000 years and all the risk analysis is based in this simulated sample.

4.3.1. Fitting and Simulation

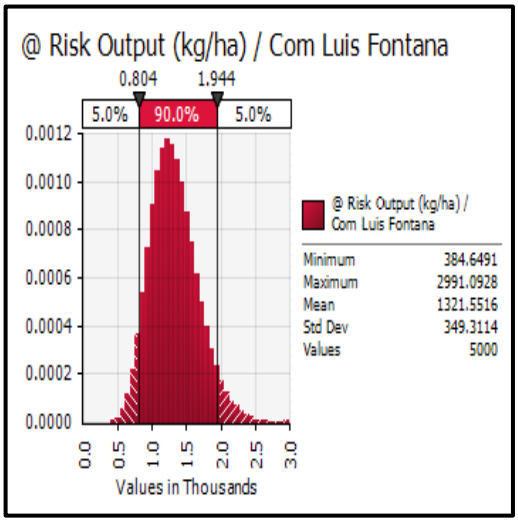
While a pure historical exercise could be conducted to calculate the burning cost, best practices in crop insurance and reinsurance industry are based on the risk assessment and rating in risk modeling executed through Monte Carlo Simulation. This improves the confidence levels of the average loss cost as well as the risk loadings added to derive technical rates.

For the "AYII for Cotton" in Chaco Province, “At Risk” software was used to fit the detrended yield data in each one of the 18 departments to a Gamma distribution. The fitting was conducted in an individual basis (i.e. different parameters for the Gamma distribution were estimated in each department) and the correlation structure of the historical data was considered in the risk model.

Cotton yields in the 18 departments were correlated in order to reflect the covariance in yields and the exposition to systemic risk.

The fitted distributions in conjunction with the correlation matrix have been used to simulate 5,000 annual yields (years) in each one of the departments, and the simulated sample was then used for risk analysis and rating.

An example of the @Risk Output is given in Figure A4.3 below for Cotton Yield in Com. Luis Fontana Department.



Summary Statistics for @ Risk Output (kg/ha) / Com Luis Fontana			
Statistics		**Percentile**	
Minimum	384.65	**5%**	803.94
Maximum	2,991.09	**10%**	898.23
Mean	1,321.55	**15%**	965.94
Std Dev	349.31	**20%**	1,022.12
Variance	122018.4806	**25%**	1,072.07
Skewness	0.526884627	**30%**	1,118.54
Kurtosis	3.403996019	**35%**	1,162.59
Median	1,290.89	**40%**	1,205.57
Mode	1,218.34	**45%**	1,248.06
Left X	803.94	**50%**	1,290.89
Left P	5%	**55%**	1,334.63
Right X	1,943.66	**60%**	1,380.12
Right P	95%	**65%**	1,428.13
Diff X	1,139.72	**70%**	1,480.08
Diff P	90%	**75%**	1,537.30
#Errors	0	**80%**	1,602.93
Filter Min	Off	**85%**	1,681.58
Filter Max	Off	**90%**	1,783.99
#Filtered	0	**95%**	1,943.66

Figure A4.3.

4.3.2. Loss Cost

The loss in each year and in each department is calculated on the basis of the deviation of the actual yield from a pre-specified trigger yield: if the actual yield is lower than the trigger, then there is a loss proportional to the level in which the trigger was crossed. Formally, the percentage loss cost in year "t" and in department "d" is calculated as follows:

$$L_{t;d} = \max\left(\frac{T_d - Y_{t;d}}{T_{t;d}};0\right) \qquad \text{(A4.1)}$$

where $Y_{t,d}$ is the actual average yield in year "t" in department "d" (see Section 2.1 of this annex) and T_d is the Trigger Yield in department "d", which is set as a percentage of the expected yield according to the desired coverage level, $T_d = \alpha \times E\left(Y_{t;d}\right)$. Figure A4.4 shows a graph of the percentage loss cost as a function of the actual average departmental yield.

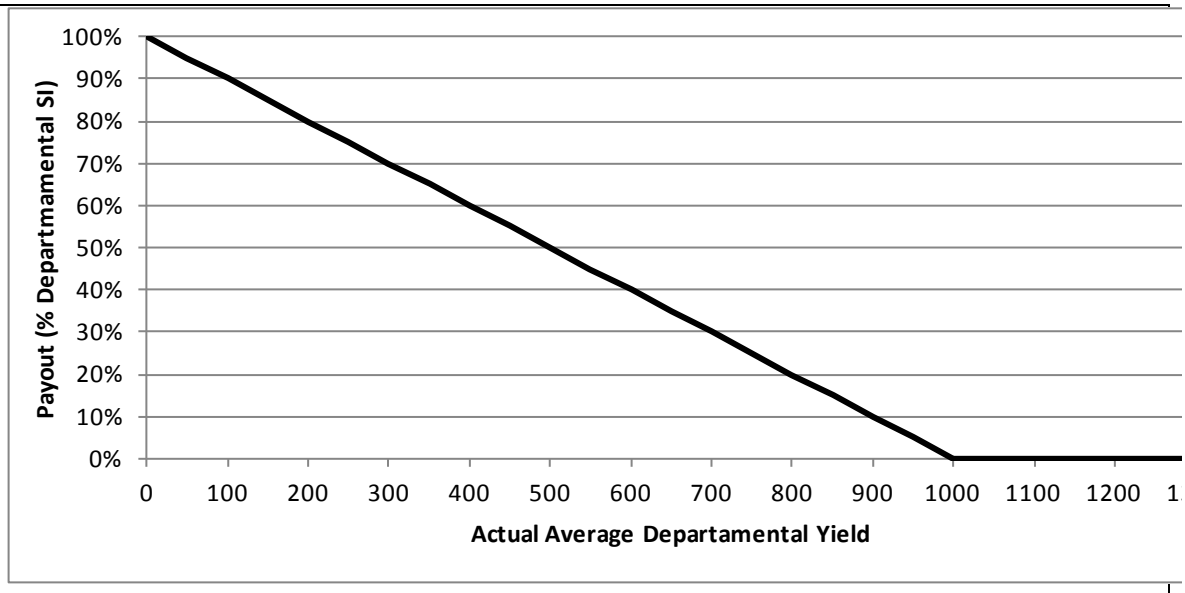


Figure A4.4

Formula (A4.1) is also used to calculate the simulated loss costs using the simulated average yields (see Section 3.1 of this annex) instead of the actual average yield. Specifically, the simulated percentage loss cost is:

$$SL_{i;d} = \max\left(\frac{T_d - Y_{i;d}}{T_{i;d}};0\right) \qquad \text{(A4.2)}$$

where $Y_{i;d}$ is the average yield in department "d" in simulation number "i", where $i = 1,2,\ldots,5{,}000$. The monetary loss cost is calculated by multiplying the percentage loss cost in each department by the Departmental Sum Insured, and the Total Loss Cost (in money) is the sum of the monetary loss cost in each department.

4.3.3. Risk Premium and Smoothed Risk Premium

The Risk Premium Rate per department is calculated as the simple average of percentage loss costs over the 5,000 simulated yields as described in Section 3.1 of this annex. Formally, the Risk Premium Rate in department "d", RP_d, is calculated as follows:

$$RP_d = \frac{1}{5{,}000}\sum_{i=1}^{5000} SL_{i;d}$$

where $SL_{i;d}$ was defined in Formula A4.2.

The insurance industry usually smoothes the rates of the AYII to avoid the influence of outliers in a single department. In risk analysis of the AYII for Cotton in Chaco Province the smoothing of

the Risk Premium Rates was performed using the neighboring Departments. The final smooth rate in each department was calculated as a weighted average of the target department rate and the rates in the neighboring Departments, where the target department weight is pre-specified and the neighboring department rates is assigned according to the area of each one of them. Formally, the Smooth Risk Premium Rate in department "d" (target), SRP_d, is calculated as follows:

$$SRP_d = \omega RP_d + \sum_{i=1}^{n} w_i RP_i; \qquad \sum_{i=1}^{n} w_i = 1 - \omega$$

where RP_k is the Risk Premium in department "k", ω is the pre-specified weight assigned to the target department, n is the number of neighboring departments that has the target department and w_i is the weight assigned to each one of the neighboring departments according to their area, which is calculated as:

$$w_i = (1-\omega)\frac{H_i}{\sum_{i=1}^{n} H_i}$$

where H_i is the area in hectares of the department "i".

4.3.4. Probable Maximum Loss (PML)

The Probable Maximum Loss is a key measure used by insurers to establish the appropriate level of risk retention. PML estimates the worst loss that could occur in, for instance, 1 in 100 years.

The estimation of the PML is based on the Loss Distribution, which is a byproduct of the distribution functions of the average yield in each department, the correlation between these average yields and the level of coverage set in the AYII. The PML is a percentile of the Loss Distribution, calculated according to the recurrence of the catastrophic event in which is focused the estimation. For example, the PML for a 1 in 100 years event, is the value of the Loss Distribution that accumulates 99% of probability, i.e. the 99th percentile; the PML for a 1 in 50 years event, is the percentile 98th; and so on.

Formally, let PML_R be the Probable Maximum Loss associated to a recurrence period R, and let TL be the total loss cost for the whole Chaco Province, then the PML is implicitly defined in the following formula:

$$P(TL < PML_R) = 1 - \frac{1}{R}$$

Figure A4.5 shows the pattern of the PML as a function of the recurrence period. Actual PML curves of the AYII for Cotton in Chaco Province were shown in Chapter 4 of the main report.

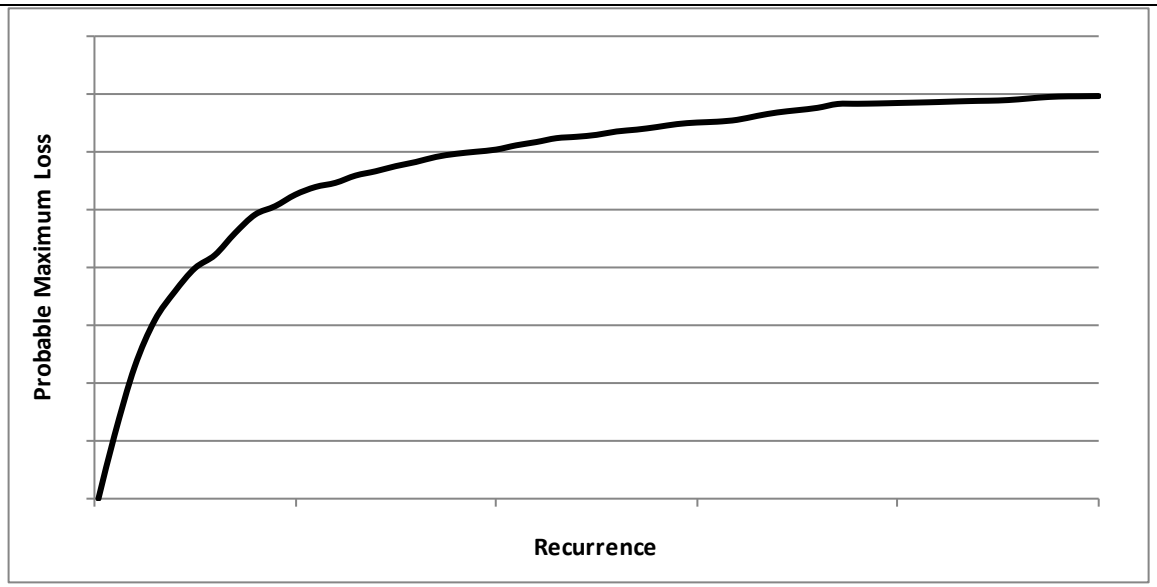


Figure A4.5

4.3.5. Technical Premium

The Technical Premium is calculated by charging a risk loading to the Risk Premium. In this report, the Risk Loading is calculated under the assumption that insurers would constitute a reserve to afford catastrophic events as measured by the PML.

Formally, the Technical Premium, TR, is calculated as follows:

$$TP = RP + \gamma \times PML_R$$

where γ is a factor related to the number of years in which the PML should be reserved. For instance, if PML should be reserved in twenty years, $\gamma = 1/20$. This latter value of γ and a 1 in 100 years PML was used in this report to load the Pure Premium and get the Technical Premium, namely:

$$TP = RP + \frac{1}{20} PML_{100}$$

4.3.6. Commercial Premium

Commercial Premiums, CP, was derived on the basis of a pre-defined target long-run Loss Ratio[38]. Formally:

$$CP = \frac{TP}{TLR}$$

[38] Loss Ratio is the ratio of Total Loss Cost to Total Commercial Premium.

where TLR is the above mentioned Target Loss Ratio and is the Technical Premium as defined in previous section.

4.3.7.Rating Tool

A Rating Tool was developed by the World Bank team and was shared with the main stakeholders. The tool is very flexible and allows the users to modify the following parameters:

- Sown Area (Has) in each Department.
- Expected Yield (Kg/Ha) in each Department.
- Price of raw cotton (AR$/Kg).
- Guaranteed Yield (% of Expected Yield).
- Weight assigned to Target Department in order to smooth the Risk Premiums
- Target Loss Ratio used to derive the Commercial Premiums.