# Uruguay

## NDVI Pasture index-based insurance for Livestock Producers in Uruguay

## Feasibility Study: Final Report

**29 May 2013**

**The World Bank**

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**Disclaimer:**

# ACKNOWLEDGEMENTS

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[1] *Oficina de Programación y Política Agropecuaria* (OPYPA)

[2] The Insurance Companies met included, Banco de Seguro del Estado (BSE), Surco Seguros, Sancor, Mapfre and Berkley International Seguros.

# MEASURES

**1 hectare (Ha)** **= 10,000 $m^2$**

**Exchange Rate** Average 2012 exchange rate of Uruguay Pesos (UYU) 20 = US$ 1.00

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **AFSC** | Agriculture Financial Services Corporation of Alberta, Canada |
| **AGROSEGURO** | Spanish Group of Insurers of the Combined Agrarian Insurance program **(***Agrupación Española de Entidades Aseguradores de los Seguros Agrarios Combinados, S.A.*) |
| **DICOSE** | Division of Livestock Control (*División Contralor de Semovientes)***.** |
| **FAE** | Fund for Agricultural Emergencies (*Fondo Agropecuario de Emergencias)* |
| **FMD** | Foot and Mouth Disease |
| **GDP** | Gross Domestic Product |
| **GNPI** | Gross Net Premium Income |
| **GoU** | Government of Uruguay |
| **IDB** | Inter-American Development Bank |
| **INALE** | National Milk Institute *(Instituto Nacional de la Leche)* |
| **INIA** | National Institute of Agricultural Research (*Instituto Nacional de Investigación Agropecuaria*) |
| **LART-FAUBA** | Laboratory for Regional Analysis and Remote Sensing, Faculty of Agronomy, University of Buenos Aires |
| **MGAP** | Ministry of Livestock, Agriculture, and Fisheries (*Ministerio de Ganadería, Agricultura y Pesca)* |
| **MPCI** | Multiple Peril Crop Insurance |
| **MODIS** | Moderate Resolution Imaging Spectroradiometer |
| **NDVI** | Normalized Difference Vegetation Index (also referred to as Normalized Differential Vegetative Index) |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **OPYPA** | Office of Programming and Policy for Agriculture and Livestock **(***Oficina de Programación y Política Agropecuaria)* |
| **PML** | Probable Maximum Loss |

| | |
|---|---|
| **PPP** | Public Private Partnership |
| **PPR** | Responsible Production Program (*Programa Producción Responsable*) |
| **PUR** | Uruguay Rural Project (*Proyecto Uruguaya Rural*) |
| **SFS** | Superintendent of Financial Services of the Central Bank of Uruguay |
| **SNIG** | National System for Cattle Information (*Sistema Nacional de Información Ganadería*) |
| **SP** | Police Section (*Sección Policial*) |
| **SSA** | Southeastern South American region |
| **TSI** | Total Sum Insured |
| **USGS-EROS** | United States Geological Service, Earth Resources Observation and Science |
| **VAT** | Value Added Taxes (*Impuesto al Valor Agregado-IVA*) |
| **WII** | Weather Index Insurance |
| **XOL** | Excess of Loss Reinsurance |

# EXECUTIVE SUMMARY

i. ***In 2011, the Government of Uruguay through the Office of Programming and Policy for Agriculture and Livestock (OPYPA) of the Ministry of Livestock, Agriculture and Fisheries (MGAP), requested the World Bank to conduct a Feasibility study for the development of a suitable index-based agricultural insurance product to protect cattle producers located throughout Uruguay against severe drought and other climatic losses in their pasture and natural grazing***.

ii. ***This report presents the findings and recommendations of the Feasibility study for a macro-level NDVI index insurance program for the Government of Uruguay (GoU) as part of its natural-disaster risk management strategies for cattle producers in Uruguay.*** NDVI Index insurance for pasture is a very flexible instrument which can be designed to protect the insured interest of individual livestock producers (termed micro-level insurance) through to the interests of regional authorities or national governments (termed macro-level insurance) for example, as part of a national natural and climatic disaster risk management program. The NDVI-index insurance Feasibility study is based on the design of a macro-level product whose main objective consist on making timely payouts to livestock producers in the event of severe drought induced losses in their pasture and natural grazing and enabling these producers to purchase necessary supplementary fodder to maintain their herds. The advantages and disadvantages of alternative micro-level individual farmer NDVI insurance are also reviewed in this report.

## Drought Exposure to Cattle Production in Uruguay

iii. ***Cattle production in Uruguay is an important economic sector and the largest source of export earnings***. The livestock sector employs about 5% of the population and it contributes about 20 percent of Gross Domestic Product and nearly 50% of the value of exports. Beef cattle production is a very important sub-sector which has about 38,000 registered livestock producers farming nearly 13.5 million hectares of predominantly natural pasture (>90% of total forage production) and with about 11.2 million head of cattle in 2011 (DICODE 2011 statistics).

iv. ***In Uruguay cattle production is based on extensive grazing of natural grassland which is grown under rain fed conditions***. Cattle rearing and fattening is therefore highly dependent on adequate rainfall during the spring and summer seasons to produce the pasture production and grazing required by the cattle. Rainfall is fairly evenly distributed throughout the year, and annual precipitation increases from southeast to northwest. Montevideo in the south averages 950 millimeters of rainfall annually, and Artigas on the northern border with Brazil receives 1,235 millimeters in an average year.

v. ***Beef cattle rearing in Uruguay is exposed to natural weather events and especially to droughts which impact severely on pasture/ grassland production.*** In the past 100 years beef production has been hit by severe droughts on at least seven occasions including 1916-17, 1942-43, 1964-65, 1988-89, 1999-2000, 2004-05 and 2008-09. It is notable that 4 of these droughts have occurred in the last 20 years of which the 1988-89 drought was the most severe event for the livestock sector of the last century, followed in second place by the 2008-09 drought and this may indicate a tendency towards increased frequency and severity of droughts related to climatic change.

vi. ***In Uruguay, prolonged spring/summer drought in pasture results in major direct losses to the beef cattle sector*** including reduced pregnancy and birth rates, forced sales of calves prior to weaning and in extreme cases starvation and death of the cattle while indirect effects include disruptions to the beef rearing and or fattening enterprise over the next two or three years. In the 2008-09 extreme droughts the value of direct and indirect economic losses to the beef cattle industry are estimated at between US$ 0.75 billion and US$ 1.00 billion.

*vii.* ***In view of the very high costs of drought to the livestock sector and to agricultural exports, GoU is keen to explore opportunities to develop a suitable pasture-drought insurance program,*** focussing initially on breeding cattle.

## Pasture Insurance using Satellite-based Remote Sensing Indexes

viii. ***Traditional indemnity-based crop insurance has not been successfully developed for pasture and natural grazing, but recent innovations in remote sensing indexes appears to offer a viable alternative for insuring pasture against climatic perils such as drought***. Traditional indemnity-based crop insurance programs have been widely developed for more than a century for a wide range of annual cereal, oil seed and horticultural crops, but to date indemnity based insurance has not been able to provide practical solutions for insuring extensive natural pasture and grazing lands against production and yield losses due to climatic and natural perils. Conversely the last decade has seen the development of new innovative parametric or index-based solutions to insure against production losses in pasture, all of which use satellite imagery to measure the Normalized Difference Vegetative Index (NDVI) in pasture.

ix. ***Remote sensing Normalized Difference Vegetative Indexes (NDVI) offer potential for insuring pasture and grazing lands against natural and climatic perils and several commercial schemes are now offering this insurance cover to livestock producers.*** The NDVI is a measure of the difference in reflectance between two wavelength ranges, the Red (R) and Near Infra Red (NIR) radiation. Healthy vegetation tends to absorb strongly the Red (R) wavelengths of sunlight and to reflect light in the Near Infra Red (NIR) wavelength and as such the NDVI index provides a very good indicator of the vegetative growth condition or plant vigor of any type of vegetation (e.g. annual crops, pasture, and forestry). By analyzing monthly NDVI values for pasture and rangelands over a series of 15 or more years, it is possible to construct an NDVI index for insurance purposes and which is calibrated according the frequency of extreme climate years (e.g. major droughts) and the required frequency and magnitude of payouts.

x. ***Since 2000, four major agricultural insurance markets including the USA, Canada, Spain and Mexico have developed commercial pasture insurance programs based on the design of NDVI triggers***. Three of the four programs in USA, Canada and Spain are designed as individual farmer (livestock producer) voluntary pasture NDVI index insurance programs, and are being promoted using high levels of premium subsidies: uptake rates are relatively low for this voluntary pasture index insurance product. Conversely, the Mexican index product is designed as a macro-level ex-ante contingency financing instrument for State Governments to compensate small livestock producers in the event that pasture and fodder supplies are impacted due to extreme climatic events. In Mexico the macro-level index insurance program has been massively scaled-up over the past five years and currently insures over 60 million hectares of pasture and grazing and more than 5 million head of cattle, with premiums fully paid by government.

## Objective of NDVI Index Insurance Program in Uruguay

xi. ***The purpose of the macro-level NDVI pasture index cover would be to protect the Federal and/or Provincial budgets in years of catastrophe (mainly drought) induced losses in the livestock sector in Uruguay and to ensure ex-ante timely payouts to livestock producers in areas where the quantity and quality of pasture and grazing is seriously reduced***. Under the proposed macro-level insurance program, all ± 38,000 beef cattle producers located in the qualifying pasture areas in 18 out of the 19 Departments of Uruguay would be automatically registered with the Insurer(s) along with their individual livestock holding details (the number of cattle in each eligible category of livestock) and where the NDVI cover is triggered they would be the recipients of the financial payouts**.**

xii. ***The alternative of offering micro-level or individual livestock producer voluntary pasture insurance was not considered technically or operationally feasible under the start-up phase of any new NDVI index insurance program in Uruguay***. With the current low spatial resolution of the available satellite imagery (pixel size of 5 km x 5 km or 2,500 Ha) it is not feasible to identify individual livestock producer's pasture fields or holdings, and their often very different forage management practices, in order to offer individual farmer insurance. An additional drawback for the implementation of a micro-level NDVI insurance program is that under an individual farmer scheme with such a low spatial resolution there is a potential for very high basis risk namely, that the difference between the pasture quantity and quality as determined by the NDVI index for that pixel and the actual pasture quantity and quality in individual livestock producer's fields may be so high as to invalidate an individual cover.

## NDVI Data-base construction and definition of Pasture and grazing areas

xiii. ***In 2011, the World Bank conducted a formal tender process to contract an international remote sensing specialist to develop a historical NDVI data-base and digitized pasture maps at a spatial resolution of 2,500 Ha for all natural and sown pasture and grazing areas of Uruguay[3].*** On the basis of this tender, the Remote Sensing and Regional Analysis Laboratory, Faculty of Agronomy, University of Buenos Aires (LART-FAUBA) was appointed in July 2011 under a twelve month contract to develop the pasture-NDVI database for Uruguay. The development of this NDVI database involved combining NOAA monthly imagery from 1981 to 1999 at a resolution of 5 km x 5 km (2,500 hectares) grids (or pixels) and MODIS 16-daily imagery from 2000 to 2011 at a resolution of 250 meters x 250 meters (6.25 hectares). The final spatial resolution of the combined 30-year NDVI data sets was 2,500 Ha per pixel with a monthly temporal resolution. LART-FAUBA was also responsible for the mapping and classification of the vegetation cover and land use in each of the pixels and specifically for identifying and distinguishing areas of natural pasture and grazing from other types of land use and ground cover. For the purposes of the NDVI index insurance program a decision was made to classify a forage pixel as having 60% or more of its area allocated to natural pasture and grazing. In the context of Uruguay, LART-FAUBA faced a specific challenge namely the changing land use patterns over the 30 years with conversion of former agricultural and grazing lands to commercial forestry (mainly eucalyptus and pine). LART-FAUBA conducted a detailed control analysis to check that the introduction of forestry had not affected the time-series pasture NDVI database levels.

## NDVI Pasture Insurance in Uruguay: Technical Contract Design and Rating

xiv. ***Under this study an Excel-based NDVI contract design and actuarial rating tool was developed for Uruguay.*** The Excel rating tool was designed to enable the local insurers and other key stakeholders in Government and in the livestock industry in Uruguay to estimate the pure rates and technical premium rates corresponding to a series of contract design options and parameters. This NDVI rating model is extremely flexible allowing users to select the Insured

[3] Under this tender process four international companies specializing in remote sensing and in NDVI applications to pasture insurance submitted proposals.

Departments and their sub-divisions termed Police Sections (*Seccion Policial*) they wish to insure, the classes of insured cattle, the basis of valuation and sum insured and the cover period (spring cover only, autumn cover only or combined spring and autumn cover) as well as to change the contract parameters including the NDVI threshold value or trigger which opens the policy for a payout, the exit trigger and the incremental payouts. A Manual of Instructions was also prepared to accompany the NDVI rating tool (Full details of the Rating tool are presented in Chapter 5 of this Report and a copy of the Instructions Manual is attached as Annex 3).

xv. ***The definition of the Insured Unit for this NDVI insurance program was based on the Police Section (Seccion Policial) equal to a county.*** It was not deemed feasible to operate an NDVI insurance program in Uruguay with the individual pixel as the Insured Unit given the very large number of pixels and the complications of (i) trying to establish a system of identifying and allocating livestock producers and their animals to these very small grids and (ii) the issue of basis risk of operating at this scale and (iii) the potentially high administrative costs of managing triggered payouts in the very large number of 3,845 forage resource pixels distributed across 18 of the 19 departments of Uruguay. The other reason for choosing the Police Section as the Insured Unit is that this is the smallest administrative area recognized in Uruguay and in most cases this represents a relatively homogeneous risk zone for the operation of the NDVI-pasture insurance program. There are a total of 252 Police Sections in the 18 out 19[4] Departments of Uruguay with livestock: a total of 195 Police Sections contain adequate pasture and grazing (more than 60% of the area of the pixels are classified being devoted to pasture and grazing) and were included in the final NDVI database constructed under this study.

xvi. ***On the basis of discussions with the livestock industry, a seven month cover period was selected for the NDVI pasture Index insurance program namely, September through to March the following year***. During the conduct of the study the cover period was refined on the basis of discussions with local livestock technicians and beef cattle breeders in Uruguay. The seven month cover period includes the spring and summer seasons and coincide with the main growth cycle in natural pasture and grazing in the country – in autumn and winter pasture growth is very much reduced. The cover period coincides with critical periods in the beef cattle rearing systems in Uruguay: calving occurs in early spring following which it is important that the cows receive adequate nutrition before being serviced in November and while the calves are being suckled up through to late summer, the cows again require high quality pasture and grazing. Droughts occurring in spring and summer can impact very severely on the cow-calf beef cattle production systems in Uruguay.

xvii. ***Under the proposed NDVI index insurance program, cattle producers and MGAP livestock specialists agreed that the primary objective of the insurance program should be to protect the breeding cows in the event of severe drought induced pasture and fodder shortages***. On the basis of the 2011 National System for Cattle Information (SNIG) figures this would imply up to a maximum of about 3.87 million insured breeding cows in the 195 qualifying Police Sections. The rationale of the livestock industry for insuring breeding cows only is that in periods of severe fodder scarcity and when it is necessary to reduce stocking densities, it is essential to maintain the breeding herd rather than lower value calves and bullocks and which are much cheaper and easier to replace than the breeding stock (cows). It was decided that heifers would not initially be insured under this program because it would add greatly to the number of insured cattle and therefore the total sum insured and premium costs of the program. By maintaining the

[4] Montevideo Department was excluded from the NDVI study as it is not a cattle producing department and is an urban capitol city area.

breeding cows, beef cattle producers are able to recover much more quickly after the end of a severe drought.

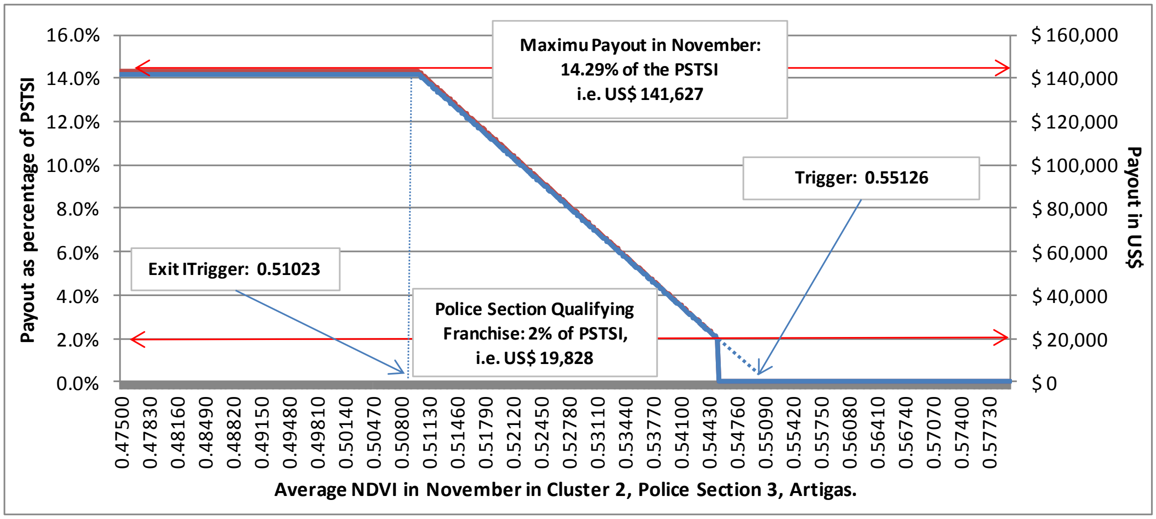
xviii. ***The basis of valuation and the sum insured was determined according to the nutritional requirements of the insured breeding cows during the insurance cover period.*** The sum insured was based on the supplementary cost of feeding of breeding cows which are equivalent to 1 Livestock Unit according to MGAP's classification. For the 7-month insurance cover period, the total cost of providing supplementary feed was estimated at about US$ 163 per breeding cow. It is not, however, the purpose of this NDVI insurance program to replace sound pasture grazing and fodder management practices by a cover which will meet the full nutritional requirements of the insured cattle. For this reason it is recommended that the NDVI insurance program should not insure more than 50% of the cost of feeding of the cattle giving a sum insured value of US$ 81.4 per breeding cow for the 7 month cover period.

xix. ***The total sum insured for the Macro-level NDVI insurance program for the national herd of 3.87 million breeding cows in Uruguay for a 7-month cover period was estimated at about US$ 315 million.*** The total sum insured was calculated on the basis of the number of insurable cattle (breeding cows) in each Insured Unit (Police Section) valued according to the monthly sum insured of 50% of the nutritional requirements for breeding cows for the 7-month cover period from September to December and January to March the following year. In practice GoU is likely to start with a pilot NDVI program in selected Police Sections and Departments and therefore the number of insured cattle and total sum insured would be very much lower than the national herd figures.

xx. ***The indemnity or payout system for the pasture index insurance program is based on the deviation of the actual NDVI value against the normal average NDVI value during a defined time period.*** It is very important in setting the NDVI indemnity parameters to reflect as closely as possible the impact of the insured event (e.g. drought) on the quality of pasture production and grazing in each Insured Unit and also to take into account the need by livestock producers for timely payouts. On the basis of discussions with the industry it was agreed that the policy would respond to loss on a monthly basis or in other words that if the actual average NDVI value in any month falls below the threshold trigger (see chapter 5), this would result in a payout being made to all livestock producers in the affected Police Section(s) in the following month. The NDVI threshold triggers opening the policy for a payout were set to reflect as closely as possible the extreme drought years identified by the livestock industry over the 30-year data series. The maximum payout anyone month was set at 100% of the monthly sum insured. The NDVI rating model is programmed to permit the user to adjust the threshold triggers according to a specified monthly payout frequency (e.g. 1 in 10 years; 1 in 15 years) and also to adjust the exit triggers and incremental payouts. Finally a qualifying franchise was built into the model to avoid very small payouts of a few dollars being made and which would cost more to settle to the individual livestock producers. The index parameters are illustrated for one Police Section (Insured Unit) No. 3 in Artigas Department in Figure 1 below.

xxi. ***The NDVI Pasture Index Insurance Product that has been designed by the World Bank-OPYPA team under this Feasibility study generates NDVI triggered payouts that approximate very closely months and years of severe drought-related losses in pasture and grazing in Uruguay.*** The NDVI Contract Design and Rating tool was tested and refined at group meetings with livestock producers and MGAP livestock technicians. The final NDVI index product shows a very close relationship to years of severe drought losses, with the highest payouts in most Police Sections in 1988-89, followed by 2008-09 and other severe drought years such as 1999/2000 and 2004-05. This evidence strongly suggests that the NDVI insurance product can operate as an effective pasture/grazing drought risk transfer product at a macro-level in Uruguay.

**Figure 1. Example of the NDVI Pasture Index Payout structure for Police Section No. 3 (SP3), Artigas Department for the month of November**




Source: Authors' analysis, NDVI Rating Tool

xxii. ***The NDVI Rating Model is programmed to calculate pure loss cost rates, technical rates and indicative commercial premium rates for each Police Section (Insured Unit)***. The pure loss cost rates are calculated on a historical burning cost basis. Once the sum insured for each month of the cover period, the recurrence period or payout frequency (which sets the Trigger Index of each cluster[5] for each month of coverage), and the parameter k (which determines the Exit Trigger of each cluster for each month of the cover period) have been set, the model proceeds to calculate the pure loss cost (payout amount divided by sum insured) that would have occurred in each month and in total for the 30 years of NDVI values analyzed in the database. The average loss cost rate for each Police Section is calculated as the simple average of the 30-year loss costs. The rating model is also programmed to generate a security or catastrophe loading which is added to the pure loss cost to derive the technical premium rate for each Police Section. Finally for illustrative purposes, indicative commercial premium rates are generated assuming loadings for acquisition costs, insurers administrative and operating costs and profit margin. It is stressed that the commercial premiums presented in this report are illustrative and that final rating decisions will be made by local insurers in conjunction with their lead reinsurers. (See Chapter 5 for full details). A summary of the average program pure rates, technical rates and indicative Commercial Premium rates and corresponding premium values in US dollars are shown in Table 1 for different monthly payout frequencies of 1 in 7 years up to 1 in 15 years and assuming that the full national breeding cattle herd of 3.87 million animals is insured with TSI of 315 million. .

xxiii. ***It is apparent that the financial payouts and therefore the pricing on this macro-level NDVI index policy are highly influenced by the payout frequency that is agreed by the Insurer and the Insured***: with a one in 7 year payout frequency any month(s) in the cover period there is a much higher frequency of payouts and higher payouts per triggered event than for a 1 in 15 year payout frequency. Great caution, must, however, be exercised in finalizing the payout parameters

[5] The cluster is a group of pixels in each Police Section which has a similar NDVI signature and on which basis an average NDVI value is calculated for that Police Section.

on this product because of issues relating to **basis risk** namely, the difference between the payouts triggered by the NDVI-pasture index and the actual losses in pasture and grazing experienced on the ground. While it might appear financially attractive to policy makers to purchase a cheaper priced NDVI cover which only responds to catastrophe events 1 in every 15 years, this may exclude moderately severe losses in pasture and grazing which are experienced by livestock producers in intervening years, thereby invalidating the objective of the NDVI cover.

**Table 1. Uruguay NDVI Insurance Program for Breeding Cattle: Average calculated Pure Loss Cost Rates, Technical Rates and Indicative Commercial Premium Rates***

| Payout Frequency (Years) | Pure Risk Rate (%) | Pure Risk Premium (US$) | Technical Rate (%)[1] | Technical Premium (US$)[1] | Indicative Commercial Rate (%)[2] | Indicative Commercial Premium (US$)[2] |
|---|---|---|---|---|---|---|
| **Assuming benefits from Diversification in reduced Technical and Commercial Premium Rates** | | | | | | |
| 1 in 7 | 7.59% | 23,813,877 | 9.32% | 28,525,588 | 11.33% | 35,656,985 |
| 1 in 10 | 5.59% | 17,605,714 | 6.84% | 21,528,294 | 8.55% | 26,910,367 |
| 1 in 12 | 4.89% | 15,390,096 | 6.02% | 18,947,976 | 7.52% | 23,684,971 |
| 1 in 15 | 4.12% | 12,974,799 | 5.13% | 16,156,834 | 6.42% | 20,196,042 |

Source: Authors' NDVI Rating Model

Notes:

[1] Technical rates in each Police Section calculated as pure loss cost rate + uncertainty load of 15% of the standard deviation of the pure loss cost rate

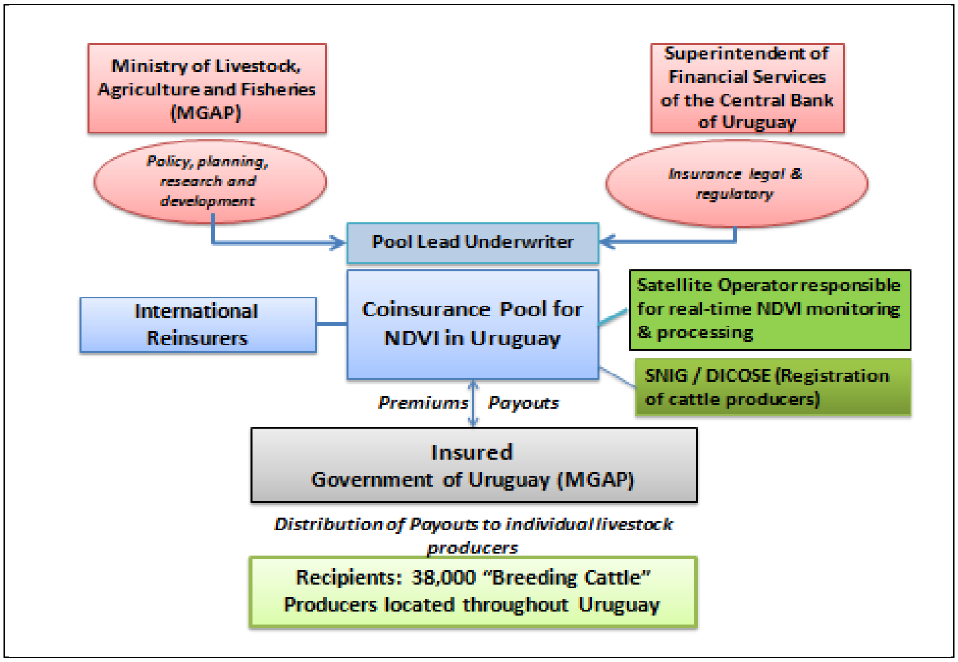
[2] Illustrative Commercial Premium Rates calculated as Technical Premium Rate + Simple Load of 25%

## Institutional Framework for the NDVI insurance program in Uruguay

xxiv. ***Under the proposed Macro-level national Livestock-pasture NDVI Index Insurance Program, Government of Uruguay would be the Insured.*** The recipients of the pasture NDVI index insurance policy would be the ± 38,000 breeding cattle producers located in the 195 qualifying Police Section in the 18 eligible Departments of Uruguay (See Figure 2).

xxv. ***The public and private agricultural insurance companies in Uruguay are considering whether to underwrite the Livestock Pasture NDVI insurance program either singly (one company would be appointed to underwrite the program), or collectively under some form of Coinsurance (Pool) agreement.*** There are two main options for underwriting this Macro-level NDVI program, either (i) one Insurer would be selected to underwrite the program or (ii) the group of five Uruguayan agricultural insurance companies which have been involved in this initiative from the outset could form of coinsurance Pool structure and collaborate in underwriting the program together. The advantages of a Pool include that the participating insurers could spread their administration and operating costs, the pool is likely to be able to retain a higher share of risk than if a single company were to underwrite this risk and all insurers would share in the learning process of this new class of agricultural index insurance. The Superintendent of Financial Services (SFS) has advised its agreement, in principle, to the Uruguay Program being coinsured under a Pool agreement (See Figure 2).

**Figure 2. Outline Institutional Framework for Macro-Level Livestock NDVI Insurance for Government in Uruguay (Coinsurance Pool option)**




Source: Authors

## NDVI Financial and Reinsurance Considerations

xxvi. ***Under the proposed macro-level option the NDVI policy would be issued to GoU (the Insured) which would be responsible for settling the due premium to the Pool Insurers***. Government will need to decide whether it will cover 100% of the NDVI program commercial premium by itself, or to seek a premium cost-sharing formula with the livestock industry and local associations and the 38,000 cattle producers (the beneficiaries who will be automatically registered under the macro-level NDVI policy. It would, however, potentially be very difficult to implement an automatic NDVI product if livestock producers in Uruguay are required to contribute to the costs of premiums and possibly this program would have to then revert to a voluntary insurance scheme and which would not currently be accepted by the commercial insurers.

xxvii. ***The probable maximum loss (PML) estimates on this scheme are high. This is a reflection both of the systemic nature of drought risk exposure in pasture grown in Uruguay and also the nature of a parametric index insurance cover which is designed to trigger payouts up to 100% of the total sum insured (liability).*** Under an automatic scheme for all breeding cattle producers in Uruguay there would, however, be considerable benefits from the pooling of risk across the 18 departments. For the 1 in 10 year payout frequency, and modelled log-normal distribution for expected losses, the 1 in 100 year PML for the whole breeding cattle portfolio of 3.87 million animals and TSI of US$315 million is calculated at 71% of the TSI or US$ 223 million. This would be equivalent to a 1 in a 100 year PML loss ratio of about 831%.

xxviii. ***The capacity requirements for this program are potentially very large under the scenario of a full-scale national scheme for all breeding cattle and inevitably the local insurers will need to seek the support of specialist international reinsurers of this class of agricultural***

***index-based insurance***. International reinsures will need to have access to the NDVI database and cover design and rating model in order to conduct their own analyses and to validate the threshold and exit triggers and payout scales and to then validate the technical rates and to determine the final commercial premium rates they require to support this program.

## *Next Steps – Moving Ahead*

xxix. ***Decisions will need to be taken at an early stage by the Government of Uruguay whether it wishes to purchase the proposed macro-level NDVI Index Insurance program for livestock producers in*** Uruguay. This report has clearly indicated that because of the limitations on the satellite spatial resolution used by the World Bank for the design of this insurance program, the NDVI cover is not suited to individual farmer insurance and furthermore that the insurance companies are currently not willing to underwrite a voluntary individual farmer scheme. As such the proposed NDVI program is designed as an ex-ante financial contingency product for government to use to provide timely payouts to small and medium livestock (cattle) producers located in Uruguay in years of extreme drought. The government will also need to decide whether to start with a pilot-program in selected Police Sections and Departments and to confirm the NDVI coverage terms it wishes to purchase including most importantly the monthly payout frequency, the coverage period (spring only or the full 7 month spring and summer period recommended in this report) and finally the percentage of the insured breeding cattle's daily nutritional requirements it is willing to insure and which in turn will determine the sum insured.

xxx. ***The new Macro-level NDVI insurance program should be seen as part of the Government's natural disaster risk management strategy and will need to be carefully coordinated with the existing national Fund for Agricultural Crop and Livestock Emergencies (FAE)*** which compensates farmers in the event of climatic disasters and which is administered by MGAP. If government elects to introduce NDVI pasture-drought cover for livestock (cattle) producers in Uruguay, it will be necessary to decide on the future role of the FAE system as it would not be logical to continue operating two natural and climatic disaster programs with overlapping objectives. If, however, Government elected only to purchase a very high level of catastrophe cover (for example the 1 in 15 year payout option) under the proposed NDVI Policy, it would have to consider how to address smaller loss events which are not triggered in intervening years: such losses might possibly continue to be compensated through the FAE system (see Chapter7).

xxxi. ***If GoU approves the implementation of a macro-level NDVI pasture insurance program, OPYPA-MGAP has indicated that it plans to start with a Pilot Program in seven selected Departments located in two regions, four departments in the Basalto region in northern Uruguay and three more in south eastern Uruguay.*** This pilot NDVI pasture insurance program would be linked to the Fund for Adaptation to Climate Change under the Kyoto Agreement[6] and would be implemented in 30 selected Police Sections located in Artigas, Salto, Paysandu and Tacuarembo Departments in the Basalto Region and Lavelleja, Rocha and Maldonado Departments in south-eastern Uruguay. OPYPA advised that the pilot project would be targeted at small and medium breeding cattle owners with less than 750 hectares of land and on this basis would insure a total of 326,427 breeding cattle (8.4% of the national herd) with TSI of US$ 26.6 million and illustrative commercial premium costs of US$ 2.2 million (1 in 10 year month by month payout frequency option).

[6] *Fondo de Adaptación de Protocolo de Kyoto (Proyecto del GoU).*

xxxii. ***The World Bank team fully endorses this prudent approach of starting with a pilot project*** as this will (i) reduce the insurance and reinsurance capacity requirements to a manageable level, (ii) reduce the costs to GoU of the premium to a more fundable level, (iii) permit all parties to test the cover design parameters of the NDVI product and the operating systems and procedures and to strengthen these if required over time and (iv) enable all parties to gain experience with the NDVI product and to evaluate its cost-effectiveness and on which basis to take decisions to scale the program up to full national coverage over time. The only drawback of starting with a pilot project is that there will be reduced benefits from pooling of risk and the PML as a percentage of TSI would be higher.

xxxiii. ***At the outset, the insurance companies will need to decide how they wish to underwrite the NDVI program and the option of forming a coinsurance pool has been identified as one strategy to follow***. Decisions will again have to be made by GoU (the Insured) and the insurance sector at an early stage whether to insure the NDVI program through a single insurance company or through some form of pool agreement with the leading public and private agricultural insurance companies in Uruguay.

xxxiv. ***From a technical viewpoint it is recommended that the appointed Insurer (Pool coinsurers) consider contracting a specialist firm to update the Uruguay NDVI Data-base from 2011 to 2013.*** The NDVI database study was conducted by LART-FAUBA in 2012 using NDVI remote sensing data for the period 1981/82 to 2010/11. If the NDVI Pilot project is approved, the first task will be to update the NDVI data-base to include the most recent years 2011/12 and 2012/13. Following this the World Bank NDVI-Rating Model will need to be updated to include the past two years NDVI data and the pure rates and technical rates recalculated. Sustainability of the NDVI index product will need to include building in a budget for ongoing technical assistance covering both the processing of the NDVI imagery and also for updating the NDVI Rating Model as experience is gained over time. LART-FAUBA has provided indicative cost estimates for the processing of the NDVI imagery and details are presented in this report.

xxxv. ***The insurance companies will need to obtain formal approval from the SFS to implement the new NDVI product / program.*** Throughout the conduct of this feasibility study the World Bank team has regularly briefed the SFS on the technical design characteristics and rating model for the proposed index-based Pasture NDVI insurance program for livestock producers in Uruguay. The SFS has been very supportive of the NDVI Feasibility study and has indicated that to date it has not identified any impediments to the implementation of the NDVI index insurance product in Uruguay. Now that the feasibility study has been completed and the NDVI Rating Manual and NDVI Rating Tools have been finalized, the insurance companies are in a position to prepare their Technical Note and formally to submit these documents and rating tools to the SFS for formal approval.

xxxvi. ***There will be a need to involve international reinsurers at an early stage in the negotiations over the final cover design and rating and sums insured for this NDVI program and also in the design of the risk financing and reinsurance program.*** The specialist international agricultural reinsurers are familiar with NDVI insurance and their support will be critical to the implementation of this new NDVI program in Uruguay. This report presents 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

xxxvii. ***A third party NDVI Operator will also need to be identified and approved by all stakeholders in the implementation planning phase***. It is essential that the third party operator is able to operate independently in monitoring the NDVI values for each pixel and Insured Unit during the Insurance Cover Period and for providing these data to the key stakeholders (including the Insured, the insurance companies and their reinsurers) on a regular monthly basis and where a claims payout is triggered in any Insured Unit that the claims are then settled to the intended recipients within the agreed period specified in the Master Policy which will be issued to Government or its representative. It is important to note that the third party NDVI operator's responsibility would stop at the point it transmits the updated monthly NDVI values to the Insurer and other key stakeholders as agreed: it will then be the Insurer's responsibility to input the NDVI values into the Excel NDVI data-base and rating tool in order to calculate whether any payouts have been triggered in any of the insured Police Sections during the reference month and the value of the payouts in each Police Section. At the World Bank's request LART-FAUBA has drawn up a costed technical specification for the requirements of such a third party NDVI operator for the insurance program in Uruguay and OPYPA has been provided with the full details.

xxxviii. ***The most critical operational aspect of the proposed NDVI pasture index insurance program is to ensure that in the event of losses being triggered livestock producers in the effected Insured Units (Police Section) receive their payouts in a timely fashion***. This report has shown that SNIG-DICOSE can provide accurate information for each and every livestock producer on their breeding cattle holdings by Police Section and by Department in Uruguay for the purposes of registering these producers as the recipients of the macro-level program and for the purposes of establishing the sums insured per livestock producer and by Police Section and Department and in total. The key outstanding issue which the insurers will need to discuss with government and with the livestock associations is the mechanism(s) for distributing timely payments to cattle owners in the event the policy triggers in any month of the cover period in any Insured Unit. There are potentially three main methods for distributing the payouts to individual livestock producers in the affected areas: (i) in the form of cash payments to their bank accounts, (ii) in the form of vouchers (coupons) which would be redeemable at local animal feed dealers or (iii) for government to organize payments in kind through deliveries of animal feed rations to the cattle producers in the triggered Police Sections. MGAP's preference is for GoU to use the NDVI payouts to make bulk purchases of animal feeds and to then distribute the livestock feed rations to breeding cow producers in the Police Sections which have been triggered under the NDVI cover. MGAP already has considerable experience in distributing animal feed rations to livestock producers under the Fund for Agricultural Emergencies (FAE) program which it administers. This option of making payments in the form of livestock feed rations will, however, potentially be very costly and time-consuming to operate and it is noted that these costs have not been contemplated in the illustrative commercial premium rates presented in this report. Decisions would therefore have to be taken on who would cover the costs of delivering the rations to the recipients.

xxxix. ***It is recommended that the key interested parties in this NDVI-pasture-drought insurance initiative consider forming a Working Group which would meet on a regular basis to review the key implementation planning tasks and issues which need to be resolved in order to launch the Pilot NDVI scheme***. The composition of the Working Group should include key stakeholders such as OPYPA-MGAP, the Ministry of Economy, INIA, the Superintendent of Financial Services and representatives of the livestock associations.

# 1. Introduction and Objectives of the Feasibility Study

## Background to Livestock Production and Drought Exposure in Uruguay

1.1. ***Livestock production in Uruguay is very important to the economy and to its exports.*** The livestock sector employs about 5% of the population and it contributes about 20% of Gross Domestic Product and nearly 50% of the value of exports. Beef cattle production is a very important sub-sector which has over 40,000 registered livestock producers farming nearly 13.5 million hectares of predominantly natural pasture (>90% of total forage production) and with about 11.2 million head of cattle and 7.7 million heads of sheep (DICOSE, 2011). Uruguay has very well developed animal health and veterinary services and it was the first country in the World to develop and to implement a national computerized animal registration and traceability database as part of its livestock epidemic disease management and control systems.

1.2. ***Cattle production is based on extensive grazing of mainly natural pasture and is distributed throughout 18 of the 19[7] departments of Uruguay.*** In the most productive livestock grazing areas situated in the centre and south of the country, beef cattle production is often performed in combination with crop production activities. In these areas both beef-cattle breeding and beef fattening are practiced and cattle are fed both on pasture and on sown fodder crops and cereal crop residues. Conversely, in the low productive grazing areas located in northern Uruguay comprising the Basalto Region (Artigas and Salto Departments)where low water holding capacity of soils is a limiting factor to crop production, most cattle producers are involved in cow-calf breeding operations and the animals are mainly fed on natural pasture.

1.3. ***Beef cattle rearing in Uruguay is exposed to natural weather events and especially to droughts which impact severely on pasture/ grassland production***. In the past 100 years beef production has been hit by severe droughts on at least seven occasions including 1916-17, 1942-43, 1964-65, 1988-89, 1999-2000, 2004-05 and 2008-09. It is notable that 4 of these droughts have occurred in the last 25 years including 1988-89 which was the most severe drought in the last century for the livestock sector and the second worst drought in 2008-09 and which may indicate a tendency towards increased frequency and severity of droughts related to climatic change. The impacts of spring drought in pasture results in major direct losses to the beef cattle sector including reduced pregnancy and birth rates, forced sales of calves prior to weaning and in extreme cases starvation and death of the cattle while indirect effects include disruptions to the beef rearing and or fattening enterprise over the next two or three years. In the 2008-09 extreme droughts the value of direct and indirect economic losses to the beef cattle industry are estimated at between US$ 0.75 billion and US$ 1.0 billion (Asociacion Rural del Uruguay 2009; Paulino et al 2010).

1.4. ***The tendency in the past twenty years for more frequent and severe droughts and increased economic value of losses in livestock has important implications both for the future management of the livestock sector in*** Uruguay ***and for any risk transfer / insurance program.*** Government of Uruguay (GoU) and the Ministry of Livestock, Agriculture and Fisheries (MGAP) are very conscious about the need to improve livestock husbandry and management practices in

[7] The exception is Montevideo Department (which includes the federal capital city of Montevideo) and this predominantly urban Department has very few registered farmers with livestock. Montevideo Department was therefore excluded from the scope of the livestock-pasture NDVI insurance feasibility study.

the more marginal natural grazing regions of Uruguay such as Basalto Region in the central and northern parts of the country and to introduce improved soil and water conservation measures and to ensure sustainable livestock stocking densities. The measures that MGAP has taken to promote improved livestock-range management since the 1988/89 very severe drought are reviewed in Chapter 2. From an insurance viewpoint, underwriters will be interested to assess whether the increasing drought trends and losses in the livestock sector are adequately dealt with in the rating of the NDVI pasture insurance program for livestock producers in Uruguay It is, therefore, very important to note here that the analysis presented in this report clearly indicates that there are no trends in the NDVI data values over the 30 year time-series, or in other words, even if rainfall is more variable, this has not been accompanied by a declining trend in the quality of pasture and grazing in Uruguay (see Chapter 5 for further discussion).

## Agricultural Insurance in Uruguay and lack of suitable pasture insurance covers for Livestock Producers

1.5. ***Uruguay has a well developed agricultural crop, livestock and forestry insurance market.*** Uruguay has more than 75 years experience with traditional indemnity-based crop hail insurance; and today 5 insurance companies (4 private plus one public, the Banco de Seguros del Estado, BSE) are actively involved in insuring named peril damage-based hail plus fire and additional perils cover in the main export cereals including rice, wheat, maize, oilseeds such as soya and sunflower, fruit, fibers and grape crops grown in Uruguay. Multiple-peril crop insurance (MPCI) which provides loss of yield-based protection against catastrophe perils including drought and flood and frost is only offered on a very restricted basis for soyabeans, maize, sunflower, wheat and barley. There is some limited accident and mortality cover for livestock. Uruguay also has a very well developed standing timber insurance market for commercial eucalyptus and pine plantations which are mostly located in the eastern part of the country. Agricultural insurance in Uruguay is voluntary and with the exception of tree fruit and horticulture does not attract government premium subsidy support. Since 2002 MGAP has been responsible for administering a program to rehabilitate the fruit and horticultural crops and also for pigs and poultry under the Fund for the Reconstruction and Development of the Farm (*Fondo de Reconstruccion y Fomento de la Granja, FRFG*). The FRFG includes allowances to provide premium subsidy support covering a minimum of 35% of the premium costs. The agricultural insurance market is controlled and regulated by the Superintendent of Financial Services (SFS).

1.6. ***There is, however, currently no commercial insurance product available in Uruguay for livestock producers to protect them against quantitative and qualitative losses in natural pasture or sown pasture***. No insurer is currently offering any insurance cover for losses in natural or sown pasture and grazing lands.

1.7. ***Since 2008, the GoU through MGAP has provided limited compensation to crop and livestock producers who have suffered climatic losses, under the Fund for Agricultural Emergency.*** The Agricultural Emergency Fund (*Fondo Agropecuario de Emergencias or* FAE) was created by law in October 2008 in response to the very severe drought losses. The objectives of the FAE are to provide ex-post financial assistance, productive infrastructure and inputs to enable effected crop and livestock producers to recover their losses resulting from climatic and natural disasters. The FAE currently has very limited funding and would not be able to respond to major loss events such as the 2008-09 droughts when the direct losses to crops and livestock were estimated at US$ 869 million (Asociacion Rural del Uruguay 2009). It is for this reason the Office of Programming and Policy for Agriculture and Livestock, OPYPA-MGAP is seeking to design a formal ex-ante risk transfer product to protect livestock producers against major drought induced shocks and to access capacity from the local insurance and major international reinsurance markets.

## Remote Sensing Applications to Pasture Insurance

1.8. ***In the past decade, several countries have developed remote sensing pasture index-based insurance programs and GoU is keen to develop a similar cover for livestock producers in Uruguay.*** In the past decade, several countries including the USA, Canada, Spain and Mexico have developed commercial index-based insurance programs to protect against mainly drought related losses in pasture. These programs use satellite-based remote sensors that measure the vegetative growth status of the pasture on a regular basis during the year. All these commercial insurance programs are based on Normalized Difference Vegetation Indexes (NDVI). The covers are designed (i) to provide timely payouts in the event of severe losses in pasture production and grazing quality; and (ii) to enable livestock producers in the affected zones to purchase supplementary feeds in order to maintain their herds rather than being forced to sell their animals. In addition, several other countries are exploring the potential to introduce livestock NDVI insurance including Argentina. In Argentina the World Bank has conducted a similar feasibility study to Uruguay for the introduction of NDVI insurance for cattle producers located in the South West of Buenos Aires Province (World Bank 2013).

## Government of Uruguay Request to World Bank and Scope of the Study

1.9. ***In 2011, the Government of Uruguay (GoU) through the Ministry of Livestock Agriculture and Fisheries (MGAP), requested the World Bank to conduct a feasibility study for the development of a suitable index-based agricultural insurance product to protect cattle producers located throughout the country against severe drought and other climatic losses in their pasture and natural grazing.*** The specific components of this study included: (i) to identify and contract an international remote sensing/NDVI specialist to develop an NDVI data-base for pasture and grazing lands in Uruguay, (ii) to assist the Office of Programming and Policy for Agriculture and Livestock (OPYPA-MGAP) in the design and rating and implementation planning of an NDVI index-based insurance for cattle producers located in Uruguay; (iii) to develop a policy framework based on a public-private partnership (PPP), for the implementation of NDVI index based agricultural insurance in Uruguay; (iv) to provide MGAP and the private commercial insurance sector with capacity building on NDVI index-based agricultural insurance; and finally (v) to provide the national insurance regulator with capacity building on NDVI index-based insurance. The NDVI pasture index insurance study was implemented under the World Bank's Non-Lending Technical Assistance to MGAP.

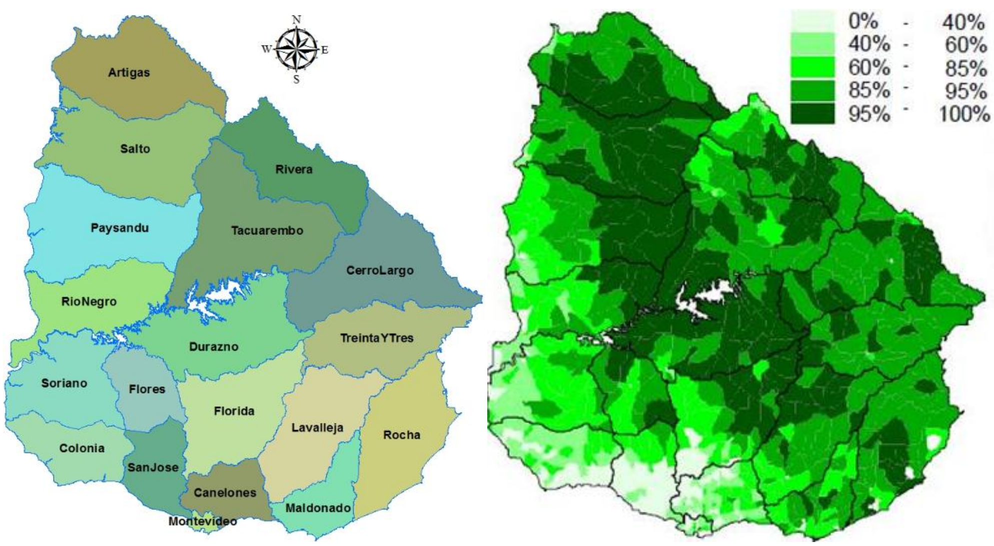
1.10. ***This report presents the findings and recommendations of the feasibility study for the introduction of a macro-level pasture NDVI index program which would be purchased by the Government of Uruguay (GoU) as part of its natural-disaster risk management strategy for cattle producers located throughout the country.*** The report consists of seven chapters starting with this introduction. Chapter 2 includes a review of cattle production systems in Uruguay and presents an assessment of the main climatic risk exposures associated with livestock grazing in the country. Chapter 3 deals with NDVI concepts and international experience with NDVI insurance for pasture and applications of this product to Uruguay. Chapter 4 deals with the development of the NDVI Database for Uruguay. Chapter 5 presents full details of the NDVI Pasture Insurance Policy Design and Rating Methodology used under this feasibility study. Chapter 6 deals with the legal, institutional, operational, financial, insurance and reinsurance requirements and challenges for introducing NDVI pasture insurance into Uruguay. Finally, Chapter 7 presents conclusions and recommendations. The report contains four technical annexes which are provided for reference purposes.

# 2. Livestock (Cattle) and Pasture Production Risk Assessment in Uruguay

## Climate and Livestock Production in Uruguay

2.1. ***The livestock sector in Uruguay is highly organized and is an important economic and social activity.*** The livestock sector employs about 5% of the population and it contributes about 20% of Gross Domestic Product and nearly 50% of the value of exports. Beef cattle production is a very important sub-sector which has over 40,000 registered livestock producers farming nearly 13.5 million hectares of predominantly natural pasture (>90% of total forage production) and with about 11.2 million head of cattle and 7.5 million heads of ovines (DICOSE 2011 statistics). Livestock (cattle) production is distributed throughout 18 of the 19 departments of Uruguay (see Maps in Figure 2.1).

**Figure 2.1. Location of Departments in Uruguay and Main Livestock Producing Areas**

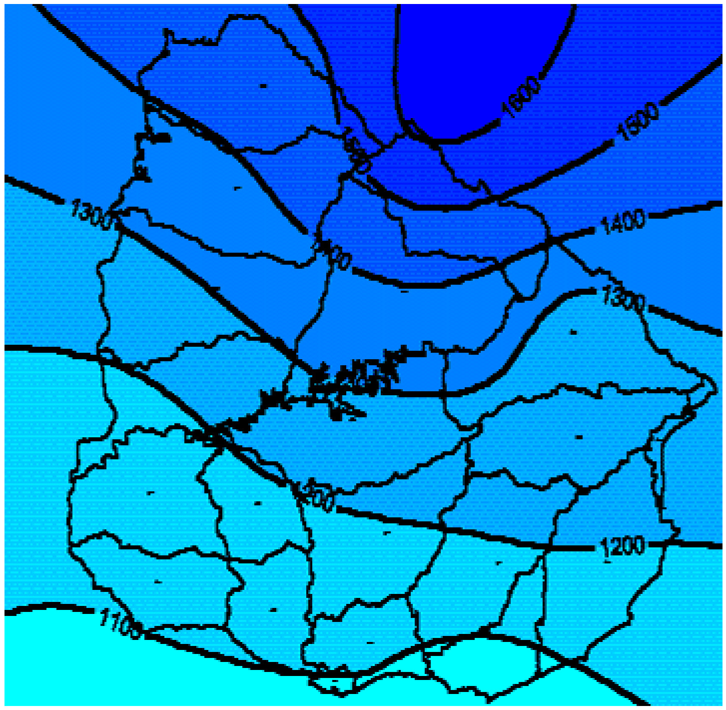



Source: IEA based on Agricultural Census 2000

2.2. ***Located entirely within the temperate zone, Uruguay has a climate that is fairly uniform nationwide***. Seasonal variations are pronounced, but extremes in temperature are rare. Seasons are fairly well defined, and in most of Uruguay spring is usually damp, cool, and windy; summers are warm; autumns are mild; and winters are chilly and uncomfortably damp. North-western Uruguay, however, is farther from large bodies of water and therefore has warmer summers and milder and drier winters than the rest of the country. Average high and low temperatures in summer (January) in Montevideo are 28° C and 17° C, respectively; comparable numbers for Artigas in the northwest are 33° C and 18° C. In winter (July) average high and low temperatures in Montevideo are 14° C and 6° C, respectively; the lowest temperature registered in Montevideo is -4° C. Averages temperatures in July of a high of 18° C and a low of 7° C in Artigas confirm the milder winters in north-western Uruguay, but even here minimum temperatures have dropped to a subfreezing -4° C. Rainfall is fairly evenly distributed throughout the year, and annual amounts increase from southeast to northwest. Montevideo averages 950 millimeters of rainfall annually, and Artigas receives 1,235 millimeters in an average year.

Figure 2.2. shows the Annual Average Precipitation Isohyets for Uruguay with increasing rainfall from south to north. Figures 2.3 (a) and (b) show the monthly average climograms (rainfall and temperature) for the weather stations of Paso de los Toros and Artigas, respectively and illustrates the fairly even distribution of rainfall throughout the year with peak rainfall in the spring/summer months and a low in winter.

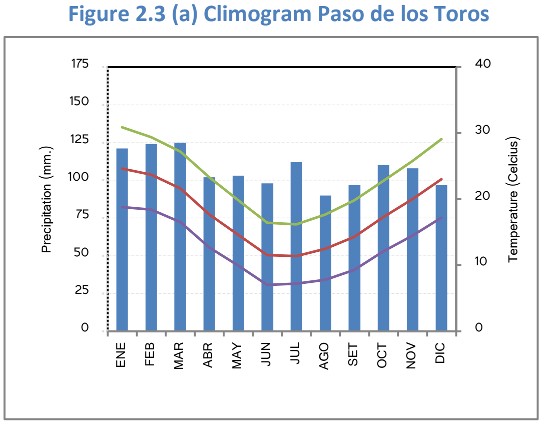
**Figure 2.2. Uruguay: Annual Average Precipitation Isohyets (1961-1990)**




Source: Dirección Nacional de Meteorología

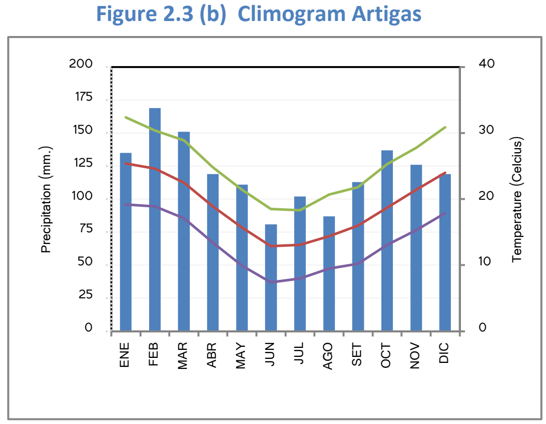
**Figure 2.3. Mean Monthly Rainfall and Temperature for selected Weather Stations**

Figure 2.3 (a) Climogram Paso de los Toros




Source: Direccion Nacional de Meteorologia

Figure 2.3 (b) Climogram Artigas



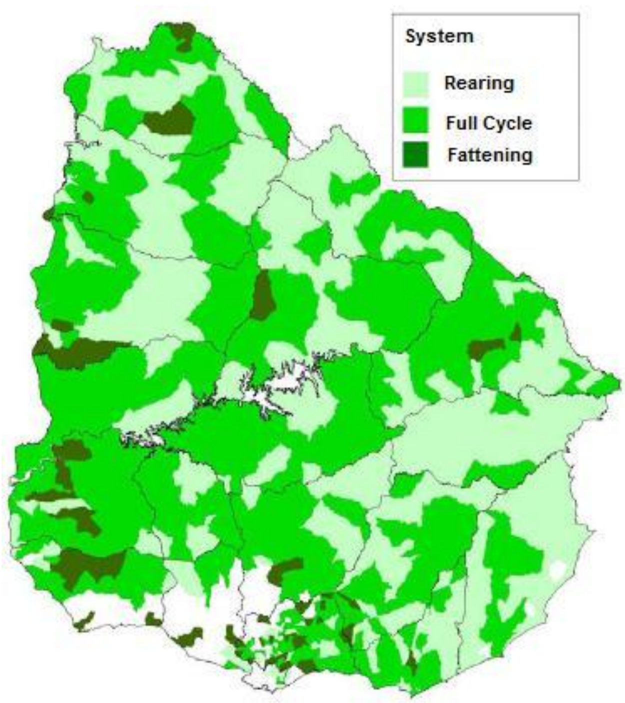

Source: Direccion Nacional de Meteorologia

Notes: The bars in Figure 2.3 represent mean monthly rainfall and the lines, monthly temperatures

## Livestock (Cattle) Production Systems in Uruguay

2.3. ***Livestock production systems in Uruguay are mainly based on extensive grazing.*** Livestock production activities may take place as a complement to crop production activities (mostly winter cereal crops) or can be the single activity of the farm. The most productive agricultural land in Uruguay is located in the western Departments of the country (Soriano, Colonia, Rio Negro, Paysandu, Salto, Artigas), and in these areas beef cattle production - mostly beef fattening- is performed in combination with crop activities. In the eastern most parts of the Departments of Cerro Largo, Treinta y Tres and Rocha, beef cattle production (mainly cattle breeding) takes place jointly with rice crop production. Cattle and sheep breeding activities, with or without rearing, are performed in low productivity areas of the country, mainly situated in the region known as Basalto. The Basalto region is situated in the central and north-western areas of Uruguay comprising the eastern sections of Artigas, Salto, and Paysandu Departments; and the western sections of Rivera and Tacuarembo Departments. Cattle fattening (brood cows, calves, replacement females, growing steers, and fattening animals) prevails in the Northeast, Centre and Southeast of Uruguay (East of Rivera, East of Tacuarembo, West of Cerro Largo and Treinta y Tres, Durazno, Florida, and Lavalleja). Dairy cattle production is mainly located in the southern Departments (San Jose, parts of Colonia, Florida, Canelones). The Map in Figure 2.4. presents the distribution of the beef cattle production systems throughout the Departments of Uruguay. Further information on beef cattle production systems in Uruguay is contained in Annex 1.

**Figure 2.4. Uruguay Distribution of Livestock (Cattle) Production systems.**




Source: Pereira et al. 2004, based on MGAP-DIEA General Agricultural Census, 2000

2.4. ***In 2011, there were 11.2 million head of cattle in Uruguay according to the National Service for Livestock (SNIG) / DICOSE statistics.*** SNIG/DICOSE livestock data are considered to be the most accurate information available on livestock holdings in Uruguay. Twice a year SNIG/DICOSE are involved in census exercises to update each livestock owners' animal numbers as part of the national Foot and Mouth Disease (FMD) control program. According to the SNIG/DICOSE statistics, the most important livestock producing departments by number of breeding cattle include Tacuarmebó with 1.03 million head of cattle (9.2% of total), followed by Cerro Largo (8.2% of total) and Salto (7.7%) all located in central and northern Uruguay (Table 2.1).

**Table 2.1. Number of Cattle by Category and by Department in Uruguay in 2011**

| Department | Bulls | Breeding Cows | Wintered Cows | Bullocks > 3 years | Bullocks 2-3 years | Bullocks 1-2 years | Heifers > 2 years | Heifers 1-2 years | Calves | Total Cattle |
|---|---|---|---|---|---|---|---|---|---|---|
| **Artigas** | 10,298 | 266,746 | 25,218 | 34,696 | 59,099 | 64,651 | 35,938 | 69,412 | 176,061 | 742,119 |
| **Canelones** | 3,497 | 81,768 | 9,175 | 15,668 | 25,550 | 32,380 | 15,939 | 24,732 | 62,006 | 270,715 |
| **Cerro Largo** | 13,653 | 345,170 | 31,459 | 56,550 | 69,113 | 70,181 | 57,909 | 83,167 | 197,782 | 924,984 |
| **Colonia** | 3,856 | 147,124 | 6,107 | 4,879 | 24,959 | 41,519 | 19,863 | 40,826 | 107,418 | 396,551 |
| **Durazno** | 11,509 | 267,227 | 36,644 | 46,105 | 71,999 | 56,585 | 33,712 | 68,931 | 188,405 | 781,117 |
| **Flores** | 4,906 | 119,986 | 12,913 | 11,688 | 26,334 | 30,977 | 18,133 | 37,077 | 87,250 | 349,264 |
| **Florida** | 10,445 | 288,477 | 30,788 | 33,217 | 52,026 | 53,347 | 40,412 | 75,436 | 204,051 | 788,199 |
| **Lavalleja** | 10,445 | 248,028 | 21,107 | 40,592 | 57,779 | 52,823 | 32,466 | 58,669 | 159,845 | 681,754 |
| **Maldonado** | 3,706 | 108,703 | 7,884 | 8,596 | 12,545 | 16,479 | 13,343 | 25,528 | 62,044 | 258,828 |
| **Montevideo** | 53 | 799 | 55 | 40 | 140 | 197 | 57 | 318 | 434 | 2,093 |
| **Paysandù** | 10,758 | 265,994 | 23,937 | 52,404 | 70,095 | 73,877 | 39,538 | 80,064 | 177,730 | 794,397 |
| **Río Negro** | 7,358 | 147,191 | 20,964 | 18,111 | 46,567 | 53,479 | 23,364 | 49,258 | 119,018 | 485,310 |
| **Rivera** | 10,327 | 247,005 | 23,017 | 37,017 | 45,044 | 44,716 | 37,425 | 62,280 | 130,494 | 637,325 |
| **Rocha** | 10,359 | 270,835 | 25,856 | 21,846 | 52,399 | 68,804 | 25,656 | 71,430 | 191,299 | 738,484 |
| **Salto** | 13,541 | 317,349 | 21,704 | 37,510 | 62,326 | 69,388 | 45,138 | 80,280 | 212,161 | 859,397 |
| **San José** | 5,171 | 140,605 | 11,622 | 9,058 | 22,336 | 28,294 | 18,300 | 34,939 | 94,650 | 364,975 |
| **Soriano** | 5,438 | 124,638 | 16,616 | 19,224 | 57,855 | 64,619 | 22,872 | 45,604 | 115,976 | 472,842 |
| **Tacuarembó** | 15,639 | 364,794 | 38,702 | 70,495 | 84,576 | 85,064 | 55,128 | 93,816 | 225,367 | 1,033,581 |
| **Treinta y Tres** | 9,666 | 252,143 | 22,316 | 26,729 | 36,327 | 47,318 | 28,719 | 62,820 | 151,265 | 637,303 |
| **Total** | **160,625** | **4,004,582** | **386,084** | **544,425** | **877,069** | **954,698** | **563,912** | **1,064,587** | **2,663,256** | **11,219,238** |

Source: DICOSE 2011

## Climatic Risk Exposures to Cattle and Pasture Production in Uruguay

2.5. ***The precipitation in Uruguay experiences large inter-annual variability.*** The analysis for selected weather stations shows that the variation in annual rainfall as shown by the coefficient of variation around mean annual rainfall ranges between 18% and 31% and the variability in monthly rainfall values is even higher at between 50% and 80% (Table 2.2). Given that a great proportion of agricultural activities are highly dependent on rainfall, such variability has been a topic of great interest among researchers[8], whose studies have agreed on the need to understand the causes of negative (positive) deviation of rainfall within Uruguay and the rest of the Southeastern South America[9] (SSA) region.

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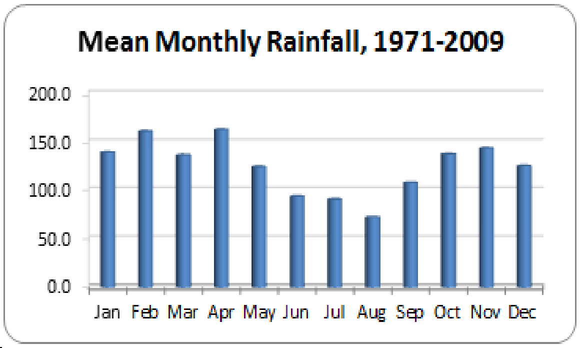
[8] Barros et al (2000); Barros, Doyle and Camilloni (2008)

[9] The Southeastern South American region includes geographical areas from Uruguay, Paraguay, and the subtropical part of Argentina and Brazil.

**Table 2.2. Inter-annual rainfall variability calculated for the period 1971-2009 for the weather Station No. 86330 (Artigas).**

| Month | Mean rainfall (mm) [1] | Desvest (mm) [2] | % [2/1] | Max (mm) | Min (mm) |
|---|---|---|---|---|---|
| Jan | 139.34 | 108.12 | 77.59% | 449.70 | 14.40 |
| Feb | 161.17 | 108.94 | 67.59% | 427.60 | 9.20 |
| Mar | 136.63 | 93.47 | 68.41% | 363.70 | 29.10 |
| Apr | 162.98 | 123.51 | 75.78% | 520.60 | 15.00 |
| May | 124.59 | 92.15 | 73.96% | 367.40 | 1.10 |
| Jun | 94.10 | 52.34 | 55.62% | 247.90 | 14.10 |
| Jul | 91.03 | 66.28 | 72.81% | 307.90 | 20.00 |
| Aug | 72.49 | 48.64 | 67.10% | 184.90 | 3.00 |
| Sep | 108.23 | 65.38 | 60.41% | 283.40 | 15.90 |
| Oct | 137.58 | 69.43 | 50.47% | 336.00 | 30.00 |
| Nov | 143.75 | 115.16 | 80.11% | 562.80 | 3.50 |
| Dec | 125.40 | 91.14 | 72.68% | 436.90 | 11.00 |




Source: Authors.
Note: Desvest stands for "standard deviation".

2.6. ***The analysis of monthly and annual rainfall data shows an increase in both excess rainfall and extreme drought events (see Table 2.3).*** Between the periods of 1971-1983 and 1997-2009, the total number of moderate[10] to severe excess rainfall events recorded by the fifteen selected weather stations increased from 18 to 26 events (or an increase of nearly 44% in the frequency of excess rain events). Similar results were also obtained by other researches who conducted more specialized meteorological studies in the SSA region. Such studies found a positive linear rainfall trend between 1960-1999. Interestingly, on the other hand, the number of moderate to severe drought events shows an even higher increasing frequency between these two time periods: during the period 1971-83 there were 10 severe droughts recorded across the 15 weather stations, but this had more than doubled to 21 events during the period 1997-2009.

[10] The estimation of moderate to severe events was calculated from the percentage of rain above (below) its norm (1971-2009). The following table the ranges 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 2.3. Distribution of moderate to severe excess rainfall and drought events, 1971 to 2009 for selected weather stations.**

| | | Moderate to Severe Excess Events | | | | Moderate to Severe Drought Events | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Partido** | **WS ID** | **1971-1983** | **1984-1996** | **1997-2009** | **Total** | **1971-1983** | **1984-1996** | **1997-2009** | **Total** |
| **Artigas** | **86330** | 1 | 1 | 2 | 4 | - | 2 | 3 | 5 |
| **Bella Unión** | **86315** | - | 3 | 2 | 5 | 1 | 1 | 1 | 3 |
| **Carrasco** | **86580** | 1 | - | 2 | 3 | 1 | 1 | 1 | 3 |
| **Colonia** | **86560** | 1 | 2 | - | 3 | 1 | - | 2 | 3 |
| **Durazno** | **86530** | 2 | - | 2 | 4 | 1 | 2 | 2 | 5 |
| **Melo** | **86440** | - | - | 3 | 3 | 1 | 1 | - | 2 |
| **Mercedes** | **86490** | 2 | 1 | 1 | 4 | 1 | - | 1 | 2 |
| **Paso de Toros** | **86460** | 2 | 1 | 1 | 4 | - | 1 | 2 | 3 |
| **Paysandú** | **86430** | 1 | 1 | 1 | 3 | - | 1 | 1 | 2 |
| **Prado** | **86585** | 1 | 1 | 2 | 4 | 1 | - | 1 | 2 |
| **Rocha** | **86565** | - | 1 | 2 | 3 | 1 | - | 1 | 2 |
| **Salto** | **86360** | - | - | 2 | 2 | - | - | 2 | 2 |
| **Tacuarembó** | **86370** | 1 | - | 3 | 4 | - | 1 | 2 | 3 |
| **Treinta y Tres** | **86500** | 1 | 1 | 1 | 3 | 1 | 2 | - | 3 |
| **Young** | **86450** | 5 | - | 2 | 7 | 1 | 2 | 2 | 5 |
| **Total** | | **18** | **12** | **26** | **56** | **10** | **14** | **21** | **45** |
| **Distribution/decade** | | **32%** | **21%** | **46%** | | **22%** | **31%** | **47%** | |

Source: Authors.

2.7. ***Similar to other areas within the SSA, the summer season in Uruguay usually registers the maximum precipitation values during the year.*** For the selected weather stations, the amount of summer rainfall ranges between 31% and 43% of the total annual rainfall. Extreme variations in rainfall amounts recorded during this period (December to February) have caused severe losses in the agricultural sector in the past. For instance, it is estimated that the flooding events recorded in 1983 and 1992 within the SSA region caused about US$1 billion in crop and property damage on each incident, while further severe floods were also registered in 1997-1998 and again in 2007 (Barros et al, 2000). The 2007 flooding was considered the worst flood event in 50 years in Uruguay, affecting seven of the 19 Departments, with Durazno, Soriano and Treinta y Tres the most affected[11]. On the other hand, since the early 1980s five[12] prolonged and severe droughts have been recorded in Uruguay. Out of these, the direct loss for the livestock sector in the country during the drought of 2008-2009 were around US$342 million; whereas the medium term impact for other sectors was about US$1 billion[13]. An analysis of the rainfall conditions experienced during the 2008/09 drought is provided in Box 2.1.

[11] Kun, L. (2012) 'Worst floods in 50 years displace thousands in Uruguay', *UNICEF* [Online] Available at: http://www.unicef.org/emerg/uruguay_39762.html

[12] Between 1980 and 2009, five extreme below normal rainfall conditions have been experienced in Uruguay. Those events include: 1988-1989, 1997, 1999-2000, 2004-2005 and 2008-2009 (Caffera, ND).

[13] Paolino, C., Methol, M. and Quintans, D. (2010) *Estimación del impacto de una eventual sequia en la ganadería nacional y bases para el diseño de políticas de seguros*, OPYPA-MGAP [Online] Available at: http://www.mgap.gub.uy/opypa/ANUARIOS/Anuario2010/material/pdf/23.pdf

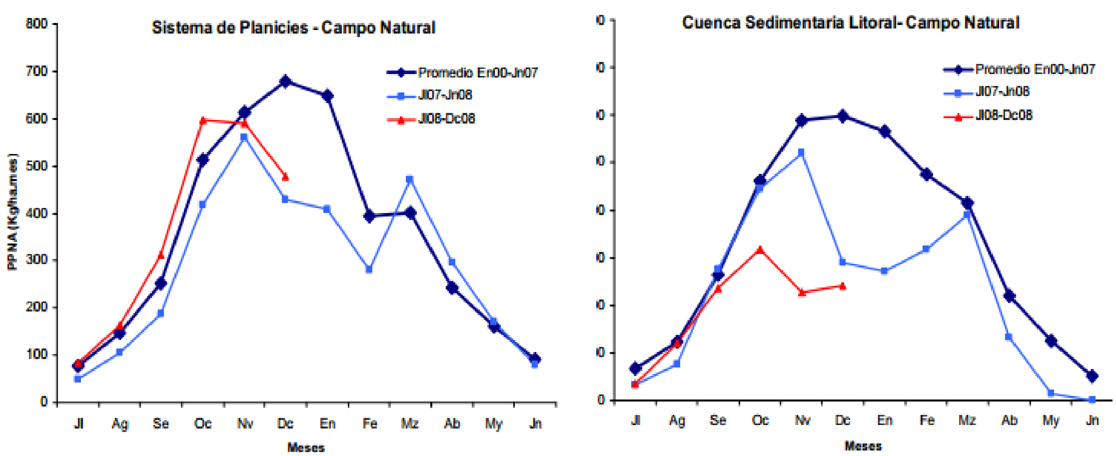
**Box 2.1. Uruguay 2008-2009 Drought Profile.**

Between 2008 and 2009, the registered precipitation values were considerable below normal in all the regions of Uruguay. During 2008, agro and hydrological droughts were particularly severe during the second half of the year due to the influence of La Niña phenomenon. Such climatic conditions, coupled with the presence of high temperature and late frosts, negatively affected the entire agricultural sector. Negative deviations of precipitation values continued until the second semester of 2009; however, important temperature anomalies were again registered during the winter and late frosts in September and October.

Although the drought conditions between 2008 and 2009 covered a wide geographic area, the magnitude of such conditions was not spatially homogeneous. The above responses to different factors, including: (i) rainfall spatial variability: precipitation values varied considerable between the regions and between areas within the same department; (ii) water holding capacity: soils conditions determine the amount of water that may be available for crop growth; and (iii) land cover: the type of vegetation cover and its water consumption also cause variations on the amount of water that is available for crop production and for livestock water intake (Paruelo et al, ND)

Big differences in terms of forage production were found between the regions during 2008 by technical experts[14] (See Figure 2.5). For instance, 6% of all sampling points showed reductions of pasture production by up to 50% less in comparison to normal values within the West Coast Basin, while other areas recorded below 30% of negative production values during the same period.

**Figure 2.5. Variations on Aboveground Net Primary Production (PPNA, acronym in Spanish) values within two regions in Uruguay.**




Source: Paruelo et al (ND).

[14] In 2008, researchers from the Project FPTA 175 conducted specialized studies in Uruguay with the objective to determine forage production variability between the regions.

2.8. ***The variability in the rainfall pattern in the country is highly influenced by several factors.*** For example, several studies[15] have documented the association between the El Niño Southern Oscillation (ENSO) and rainfall patterns. In general, during El Niño (La Niña) events above (below) normal rainfall conditions are registered all across the country. Other documented causes of inter annual rainfall variability are thought to be related to tropical convection patterns in central Brazil and sea surface temperature (SST) variability of the proximate Atlantic Ocean. The later factor of rainfall variability, for instance, is expected to increase (decrease) precipitation anomalies when positive (negative) SST values are registered.

## Impact of Climate (Drought) on Cattle Production in Uruguay

2.9. ***This section reviews the available information on the impact of major climatic events (all droughts) on natural pasture and grazing in Uruguay and the consequential losses incurred by the livestock industry due to depleted pasture and grazing.*** There appear to be no time-series studies in Uruguay which have quantified the impact of drought it terms of reduced pasture biomass production and yields per hectare on a month by month basis during the key drought years such as 1988/89, 1999, 2004 and 2008/09. There is, however, much more information on the impacts of drought in terms of lack of drinking water and lack of fodder and grazing on cattle pregnancy and calving rates, on the weight losses in cattle and mortality levels and in economic losses due to forced (untimely) sales of livestock and this information is reviewed for the major events over the past 30 years.

2.10. ***In Uruguay, the size of the national cattle stock has been relatively stable for the past 35 years with an average of about 10.5 million head of cattle per year, save for 2 periods between 1982 and 1986 and again between 1988 and 1990 when cattle numbers declined significantly.*** Reference to Figure 2.6 and Table 2.4 shows that between 1982 and 1986 the Uruguayan national cattle herd suffered a major reduction in size from 11.2 million head of cattle to 9.3 million animals or a reduction of nearly 17.2% in the national herd. The main reasons for this decline were economic and centred on the loss of export markets for Uruguayan beef to the European Union with a consequential collapse in beef prices in Uruguay leaving many cattle owners with unpayable debts: many farmers were forced to slaughter their cattle to service their debts and others switched into sheep production as world market prices for wool appeared more stable. (See Box 2.2. for further details).

2.11. ***Uruguay experienced prolonged drought in 1988/1989 with disastrous consequences in available natural pasture and grazing.*** The drought was the most severe of the 20th Century. At this time few farmers maintained fodder reserves and the problem of inadequate grazing resources was exacerbated by the fact that farmers also managed large numbers of sheep which competed against the cattle in times of drought stress for the limited fodder and grazing resources. A further problem was the lack of available water for the cattle to drink as many of the natural ponds and lakes had dried up. The 1988/89 drought led to widespread forced sales of breeding cattle, reduced pregnancies and calving rates, and deaths of tens of thousands of cattle through a combination of dehydration and starvation and a collapse in the numbers of replacement heifers over the next two years (see Box 2.2 for further details). Between 1988 and 1990, the national cattle herd suffered a reduction of 1.64 million head of cattle (15.9% of total) and the national herd fell to its lowest size in 35 years of only 8.7 million head of cattle.

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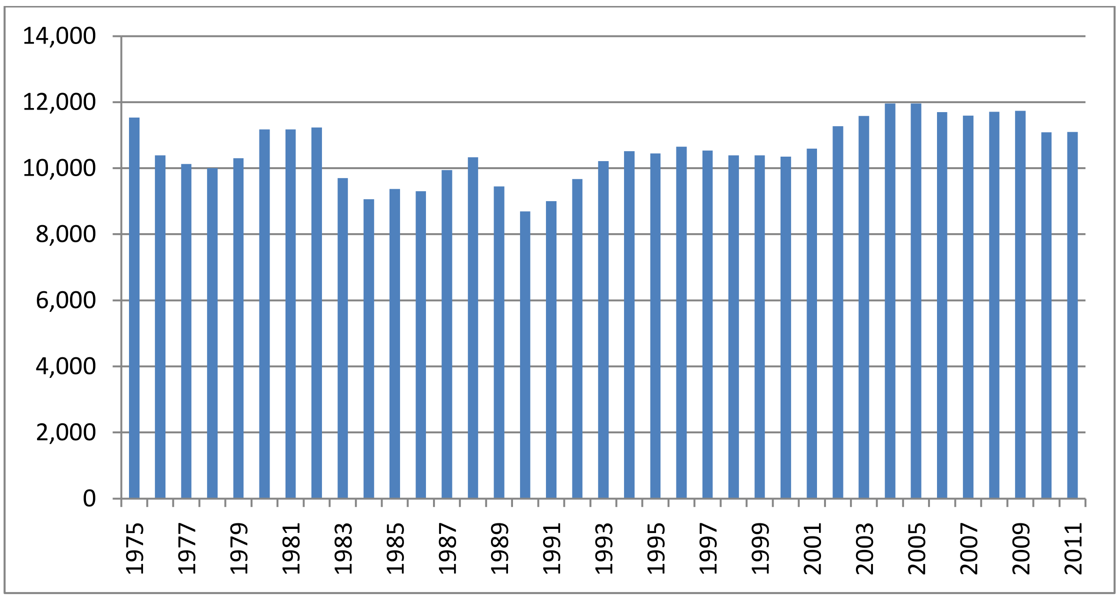
[15] Pisciottano et al, 1994; Grimm et al, 2000; cited by Liebmann et al, 2004.

2.12. ***Following the 1988/89 very severe droughts, the GoU through MGAP's livestock research and extension services invested in major programs of farmer education and improved pasture and grazing management systems.*** Some of the key measures included persuading livestock producers to switch from a mixed cattle-sheep grazing system to single enterprise cattle breeding and or fattening; to plant drought resistant fodder crops such as sorghum; to reduce stocking rates and to invest in on-farm water reservoirs and ponds.

2.13. ***It is notable that with the introduction of these improved pasture and grazing management systems that in the subsequent droughts of 1999, 2004 and 2008/2009 that the national cattle herd has not incurred such drastic reductions in size.*** Reference to Table 2.4 shows that following the 1999 drought, cattle numbers actually increased over the next two years by 2.0%; following the severe 2004 drought, the cattle herd decreased by slightly over a quarter of a million animals over the next 2 years (a 2.2% reduction) and in the very severe 2008 drought, the impact over the next 2 years was a reduction of about 611,000 head of cattle or 5.3% of the national herd.

**Figure 2.6 Uruguay Total Cattle Herd, 1975 to 2011 ('000 Head cattle)**




Source: SNIG/DICOSE

**Table 2.4. Impact of Major Droughts on National Cattle Herd Size in Uruguay (1975 to 2011)**

| Period | | National Cattle Herd Size ('000 Head of animals) | | Difference (000 animals) | % Change | Comment |
|---|---|---|---|---|---|---|
| **From** | **To** | **Start** | **End** | | | |
| 1982 | 1986 | 11,237 | 9,300 | -1,937 | -17.2% | Economic causes |
| 1988 | 1990 | 10,333 | 8,692 | -1,641 | -15.9% | Drought |
| 1999 | 2001 | 10,389 | 10,595 | 206 | 2.0% | Drought |
| 2004 | 2006 | 11,961 | 11,699 | -262 | -2.2% | Drought |
| 2008 | 2010 | 11,703 | 11,092 | -611 | -5.2% | Drought |

Source: Authors analysis of SNIG/DICOSE data

**Box 2.2. Impacts of Economic Shocks and Droughts on Uruguayan Beef Cattle Production in the 1980s**

Rising world beef prices stimulated the Uruguayan cattle industry in the late 1970s. At first, rising prices increased the profitability of cattle ranching but ultimately led to considerable instability in the sector. When many ranchers expanded their herds after the 1978-79 beef price increases, the price of pastureland grew almost tenfold. Because real interest rates were low or negative, ranchers were willing to borrow heavily to increase their landholdings. But beef prices soon leveled off, and many ranchers were left with large, unpayable debts. Land prices fell sharply; banks could not cover their loans even by foreclosing. As the bank crisis mounted, the Central Bank stepped in to provide refinancing in United States dollar-denominated loans. Most ranchers avoided bankruptcy but had to slaughter record numbers of cattle to service their debts. Many ranchers took the opportunity to switch to sheep ranching because wool appeared to face more stable world demand. Thus, Uruguay's cattle herds declined by 20% from 1981 to 1984.

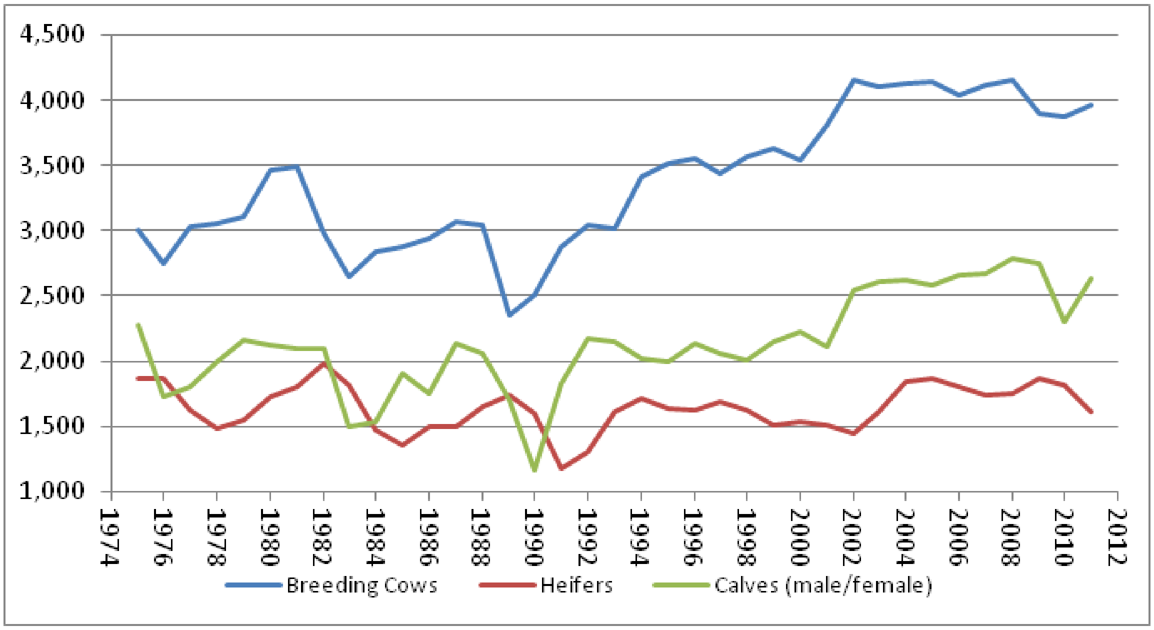
Cattle ranchers rebuilt their herds during the latter half of the 1980s but were hindered by limited credit and severe drought. Damage from the prolonged drought had reached alarming proportions by the end of 1989, when the cattle stock was down to 9.4 million head. The number of cattle fell by 738,000 head between June 1988 and June 1989, the largest annual drop in fifteen years. About 2% of the total had died, and the rest had been killed and sold prematurely (50% more than usual). In the July-November 1989 period, the beef cattle herd was depleted by an additional 622,000 head. The increased slaughter rates allowed meat-packing plants to pay less for beef, decreasing ranchers' profits. The drought lasted longest in the center of the country, where most of the largest cattle ranches were located (the departments of Cerro Largo, Durazno, and Tacuarembo). The leading sheep-ranching departments in the northwest (Artigas and Salto) were not as severely affected.

The continuing difficulty in the sector prompted the government to launch Operation Manufacture in March 1989. The program eased the ranchers' financial burden by extending them a special line of credit, lowering their tax rate by 20%, and providing for case-by-case assistance. The government also announced the opening of a line of credit with terms of up to eight years for herd replacement. Sheep ranchers, who suffered fewer losses from the drought, were not eligible for these government programs.

Source: http://www.mongabay.com/history/uruguay/uruguay-livestock_ranching.html

2.14. ***The stability of the beef cattle herd in Uruguay is highly dependent on maintaining numbers of breeding cows and replacement heifers.*** The analysis in Table 2.4. shows that following the 1988/89 very severe droughts, there was a major collapse in the breeding cattle herd over the next three years up to 1991. The first impact of the drought was an immediate reduction in the number of breeding cattle from 3.05 million head in 1988 to 2.36 million in 1989 or a reduction to number of breeding cattle of 0.69 million (23% reduction). This was followed by a 43% reduction in the number of calves born over the next two years from 2.06 million in 1988 to 1.71 million in 1989 and only 1.17 million calves in 1990. Finally with the reduced calving rates, the number of replacement heifers fell by 29% over the next three years to only 1.17 million in 1991 (see Figure 2.7 and Table 2.5). Conversely the impacts on the cattle breeding herd of the 1994, 1999 and 2004 droughts have been much less severe than in 1988/89 on account of the improved cattle pasture grazing management systems. The 2008-09 drought which was the second most severe drought according to the livestock industry did, however lead to major reductions in the cattle breeding herd, calving rates and replacement female calves/heifers between 2008 and 2011 (Figure 2.7 and Table 2.5).

**Figure 2.7. Impacts of the 1981, 1988-89 and 2008-09 droughts on Numbers of Breeding Cows and replacement stock of calves and heifers ('000 head of cattle).**




Source: SNIG/DICOSE data

**Table 2.5. Impact of 1988/89 and 2008/09 droughts on Breeding Cattle and Replacement Female Calves / Heifers (000 head of animals)**

| 1988/89 Drought Event | Breeding Cows (000 animals) | Calves (male / female) (000 animals) | Heifers (000 animals) |
|---|---|---|---|
| | | | |
| 1988 | 3,047 | 2,055 | 1,648 |
| 1989 | 2,355 | 1,705 | 1,738 |
| 1990 | | 1,166 | 1,603 |
| 1991 | | | 1,172 |
| Change (No. animals) | -692 | -889 | -476 |
| % Change | -22.7% | -43.3% | -28.9% |

| 2008/09 Drought Event | Breeding Cows | Calves (male / female) | Heifers |
|---|---|---|---|
| 2008 | 4,152 | 2,790 | 1,749 |
| 2009 | 3,894 | 2,748 | 1,861 |
| 2010 | | 2,307 | 1,810 |
| 2011 | | | 1,606 |
| Change (No. animals) | -258 | -483 | -143 |
| % Change | -6.2% | -17.3% | -8.2% |

Source: SNIG/DICOSE data

## Financial Costs of Droughts to the Livestock Sector

2.15. ***In Uruguay the most comprehensive study on the financial and economic impacts of droughts to the agricultural crop and livestock sectors dates from the 2008/09 drought event.*** This study was produced by the Rural Association of Uruguay and covered both losses to crops and to the dairy cattle and beef cattle sectors. For crops, losses were estimated according to data published by MGAP on reduced sown area and losses to production and yields. For dairy and beef cattle the study covered: losses in the live-weight of the national herd by class of cattle, reduced pregnancy and births of calves, reductions in the sales price – slaughter value of animals, for the dairy industry losses due to reduced production and sales of milk, losses to pasture and grazing based on the costs of replacement and finally the additional costs incurred by dairy and beef cattle producers in purchasing feed supplements and concentrates to feed to their starving cattle.

2.16. ***The direct financial losses caused by the 2008/09 droughts to the agricultural sector were estimated at US$ 874 million of which US$ 748 million of losses (86% of total) were incurred by the livestock sector and the remaining 14% of losses were in annual crops and citrus*** (Table 2.6). The direct losses in breeding cattle herds amounted to more than half a million tons of export beef meat valued at US$ 558 million, including the weight losses in the national herd, reduced pregnancies / calving rates, deaths of cattle which were estimated at about 28,000 head of animals, and reductions in the sale price of beef. The total damage or loss to sown pasture (Praderas) was estimated at 50% of the national sown area of grazing area of 1.34 million Ha and with average costs to rehabilitate the pasture of US$ 286/Ha spread over 4 years, the total losses in pasture were estimated at US$ 96.1 million or 11% of the total value of damage from the drought: damage to beef cattle ranches accounted for 77% of the value of losses to sown pasture. In view of the major lack of pasture and grazing livestock producers were forced to buy in large additional stocks of concentrates and whatever supplementary fodder stocks could be obtained (e.g. sunflower flout, wheat bran, sorghum or maize grain). The cost of buying-in additional feed supplements for a period of 5 months was estimated at US$ 64.5 million (nearly 260,000 tons of supplementary feed) with the bulk of the costs or US$ 44.7 million (69% of sub-total costs) incurred by the dairy cattle sector (Asociación Rural de Uruguay 2009).

2.17. ***Once indirect and consequential losses are taken into account, the total costs of the 2008/09 drought in the livestock sector to the Uruguayan economy were much higher than the direct losses shown in Table 2.6.*** In their analysis of the impact of the 2008/09 drought on the agricultural sector, Paolino, Methol and Quintans (2010) suggest that one monetary unit of value added by the livestock sector has a multiplier effect of about 3.0 in the economy and on the basis of their estimates of direct losses of US$ 342 million[16] to the livestock sector, the total impact may have been as high as US$ 1,026 million losses to the Uruguayan economy. Their study also analyzed the additional costs of the drought in terms of loss of employment in the agricultural/livestock sector and other sectors of the economy.

[16] The reasons for Paulino et al's much lower estimate of the value of direct losses to the livestock sector than the Rural Association's estimates shown in Table 2.6 are not explained.

**Table 2.6. Financial Costs of 2008/09 Drought on Crop and Livestock Sectors in Uruguay (US$ Million)**

| Sector | Details of Losses | | Sub-Total (US$ Million) | Total (US$ Million) | % of total |
|---|---|---|---|---|---|
| **Agriculture** | Losses due to reduced sown area (US$ Million) | Losses in Production & Yields (US$ Million) | | | |
| Soya | 4.3 | 66.9 | 71.2 | 95.4 | 11% |
| Maize | 0.8 | 18.3 | 19.1 | | |
| Sorghum | 0 | 2.5 | 2.5 | | |
| Sunflower | 0.2 | 3.8 | 4 | | |
| Rice[1] | 61.1 | -68.9 | -7.8 | | |
| Potatoes | 0 | 6.4 | 6.4 | | |
| **Citrus** | Losses due to reduced yields | | 30 | 30 | 3% |
| **Livestock (Cattle)** | | | | | |
| Meat Production | Losses in weight of stock | | 448.9 | 557.6 | 64% |
| | Loss of Calves | | 97.3 | | |
| | Loss of sale (slaughter) price | | 11.4 | | |
| Milk Production | Reduced production/sales of milk | | 30 | 30 | 3% |
| Loss of Capital | Beef cattle Sown Pasture losses | | 73.7 | 96.1 | 11% |
| | Dairy cattle Sown Pasture losses | | 22.4 | | |
| Increase in Costs | Additional feed rations: Beef | | 19.8 | 64.5 | 7% |
| | Additional feed rations: Dairy | | 44.7 | | |
| **TOTAL Value of Losses [2]** | | | **873.6** | **873.6** | **100%** |

Source: Rural Association of Uruguay (Asociacion Rural de Uruguay)

Notes:

[1] For rice the drought led to significant losses in terms of reduced planted area, but on account of the very dry clear conditions, these losses were more than compensated by the major increase in production and yields of irrigated rice in 2008/09.

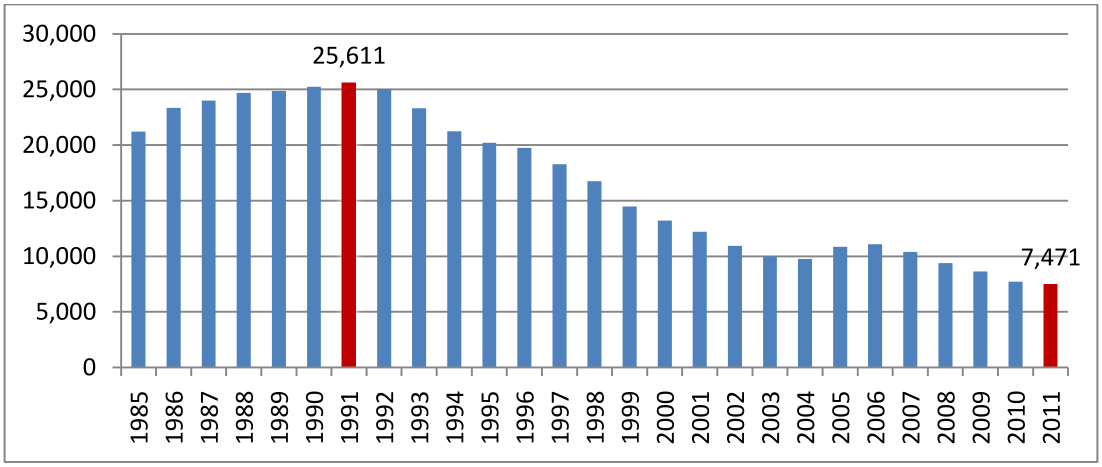
[2] Total losses of US$ 868.7 million were reported by the Rural Association of Uruguay, but the actual calculated losses shown in Table 2.6 are slightly higher at US$ 873.6 million.

## Management Changes in Beef Cattle Production in Uruguay since the 1980s

2.18. ***Following the 1988/89 very severe drought, the Government and MGAP invested in major programs of farmer education and improved pasture and grazing management systems.*** Some of the key measures included persuading livestock producers to switch from a mixed cattle-sheep grazing system to single enterprise cattle breeding and or fattening; to plant drought resistant fodder crops such as sorghum; to reduce stocking rates and to invest in on-farm water reservoirs and ponds. The shift from a mixed beef cattle and sheep extensive grazing system to focus on beef cattle production started in 1991 when the national sheep flock exceeded 25 million animals and today numbers have declined to slightly less than 7.5 million sheep (Figure 2.8).

2.19. ***It is notable that, with the introduction of these improved pasture and grazing management systems, in the subsequent droughts of 1999, 2004 and 2008 the national cattle herd has not experienced such drastic reductions in size.*** Reference to Table 2.4 shows that following the 1999 drought, cattle numbers actually increased over the next two years by 2.0%; following the severe 2004-05 drought, the cattle herd decreased by slightly over a quarter of a million animals over the next 2 years (a 2.2% reduction) and in the very severe 2008-09 drought, the impact over the next 2 years was a reduction of about 611,000 head of cattle or 5.3% of the national herd.

**Figure 2.8. Changes in National Sheep flock, 1985 to 2011 ('000 head of animals)**




Source: SNIG/DICOSE data

## Government of Uruguay Funding for Climatic Disasters in Agriculture

2.20. ***In Uruguay, Government has actively supported the fruit and horticulture, poultry and pig producing sectors, since 2002 under the Fund for the Reconstruction and Development of the Farm (FRFG).*** The FRFG was established by Law No. 17503 on 30 May 2002 and subsequently modified and replaced by Law No. 27844 of 21 October 2004. The FRFG was established to assist fruit and horticulture, poultry and pig producers who were adversely affected by climatic events in March 2002 to recuperate their enterprises. The Fund was destined to cancelling or repaying outstanding debts with the banks, to promote agricultural insurance by providing premium subsidies of not less than 35% of the cost of the premium and by supporting development projects for these sectors. The FRFG is administered by MGAP. Prior to 2008, however there was no formal government support mechanism for the cattle sector in Uruguay.

2.21. ***In the 2008/09 very severe drought, MGAP used its own budget to finance emergency livestock feed rations and to provide these rations for up to 6 months under a credit system to affected livestock producers in northern Uruguay.*** In 2008/09, MGAP in collaboration with the local departmental and municipality authorities mounted an ad hoc emergency relief program for livestock producers under which MGAP purchased livestock feed supplements (rations) and distributed these supplements to interested livestock producers under a system of zero interest credit payments, repayable in cash by the farmer over a three year period. This voluntary program was very popular with the smaller farmers and in total MGAP purchased and distributed about 31 million rations over a twelve month period in 2008-09. According to MGAP over the 12-month period they distributed a total of 30,400 metric tons (MT) of purchased livestock feed supplements to mainly beef cattle producers located throughout Uruguay. Reference to Table 2.7 shows that Departments receiving the highest amounts of livestock feeds under this credit program included Artigas (18% of total feed volume), Salto (16%), Tacuarembo (12%) and

Rivera (12%). With an assumed 2008 average value of US$ 200 per MT for livestock feed, the cost of this emergency livestock supplementary feed-credit program would have amounted to about US$ 6.1 million

**Table 2.7. Livestock Feed Rations distributed by MGAP in 2008 Drought by Department (in Metric Tons).**

| Department | Wheat Bran | Sunflower Pellets | Soya Chaff | Balanced Rations | Barley | Total | % of Total |
|---|---|---|---|---|---|---|---|
| **Artigas** | 261 | 341 | 4,337 | - | 504 | 5,443 | 18% |
| **Canelones** | 202 | 77 | 1,306 | 113 | 511 | 2,209 | 7% |
| **Cerro Largo** | 137 | 56 | 1,758 | 64 | 28 | 2,043 | 7% |
| **Colonia** | - | 27 | 223 | - | 227 | 477 | 2% |
| **Durazno** | 86 | 139 | 384 | 85 | 28 | 721 | 2% |
| **Flores** | 57 | 22 | 203 | - | 86 | 367 | 1% |
| **Florida** | 28 | 28 | 655 | 85 | 85 | 882 | 3% |
| **Lavalleja** | - | 112 | 603 | 256 | - | 971 | 3% |
| **Maldonado** | 58 | 28 | 141 | 57 | - | 284 | 1% |
| **Montevideo** | | | 91 | - | - | 91 | 0% |
| **Paysandu** | 407 | 87 | 577 | - | 283 | 1,354 | 4% |
| **Río Negro** | 201 | 86 | 168 | - | 86 | 541 | 2% |
| **Rivera** | 257 | 491 | 2,452 | 85 | 226 | 3,511 | 12% |
| **Rocha** | 58 | 28 | 494 | 56 | - | 636 | 2% |
| **Salto** | 324 | 712 | 3,645 | 115 | 140 | 4,936 | 16% |
| **San José** | 172 | 30 | 808 | - | 191 | 1,201 | 4% |
| **Soriano** | 60 | 142 | 346 | - | 58 | 606 | 2% |
| **Tacuarembó** | 87 | 222 | 3,076 | 84 | 281 | 3,750 | 12% |
| **Treinta y Tres** | 29 | 55 | 294 | - | - | 379 | 1% |
| **Total** | **2,424** | **2,683** | **21,561** | **1,000** | **2,733** | **30,401** | 100% |
| % of Total | 8% | 9% | 71% | 3% | 9% | 100% | |

Source: MGAP (Texeira undated)

2.22. ***In October 2008 as a response to the very severe drought, MGAP sought approval from the Government of Uruguay to create an Agricultural Emergency Fund, designed to provide financial assistance, productive infrastructure or inputs to assist in recuperating the losses incurred by crop and livestock producers as a consequence of climatic and natural disasters.*** The creation of the Agricultural Emergency Fund (*Fondo Agropecuario de Emergencias*, or FAE) was enacted under article 207 of the Law 18.362 of October 2008[17]. The FAE is owned by and administered by MGAP which is responsible for the declaration of agricultural crop and livestock emergencies with independent advice given by the Commission of Agricultural Emergencies (Comision de Emergencias Agropecuarias).

2.23. ***The Financing of the FAE has taken time to resolve***. It was originally envisaged that the FAE would be financed from various sources including excise taxes on the sugar industry, amounts from the General Revenue budget, other funding assigned by law or regulation. However, this funding has not been forthcoming. Following the declaration by MGAP in

[17] For further details of the FAE Law No 18.362 see the following web link: http://www.montevideo.com.uy/notnoticias_76052_1.html

December 2010 of an agricultural emergency due to rainfall deficit in northern Uruguay in the Departments of Artigas, Salto, Paysandu, Rivera, Tacuarembo and Rio Negro, in January 2011, MGAP appealed to the Court of Arbitrators of the Republic of Uruguay to authorize the transfer of Uruguay Pesos (UYU) 48 million (about US$ 2.4 million at current exchange rates) to the FAE to enable MGAP to compensate the affected farmers in northern Uruguay. On 26 January 2011 the Court of Arbitrators approved the transfer of the UYU 48 million to the FAE and this decision was ratified by the Presidential decree in March 2011. The Fund is financed out of the General Revenue budget, object of expenditure 591/011 Agricultural Emergency Fund. According to Paulino, Methol and Quintans (2010), the global amount allocated to preventing or compensating drought events has amounted to more than US$ 5 million, financed by fund of the FAE and from the Responsible Production Program (*Programa Producción Responsible, PPR*) and the Uruguay Rural Project (*Proyecto Uruguaya Rural PUR*).

### Identification of the Need for a Catastrophe Pasture Drought Risk Insurance Cover for Livestock Producers in Uruguay.

2.24. ***As part of MGAP's important role in managing the effects of climatic disasters on crop and livestock production in Uruguay in 2010 the organization also began to explore the potential role of parametric or index insurance to cover the risk of drought in the livestock sector.*** Paulino, Methol and Quintans (2010) note that in addition to financial support provided to livestock producers through the FAE, OPYPA-MGAP was interested in developing proposals with the collaboration of international organizations to develop a pilot project for a parametric or index insurance cover to protect the Uruguayan cattle livestock sector against severe drought in their pasture and grazing land.

2.25. ***In 2011 OPYPA-MGAP made a formal request to the World Bank to provide technical assistance to assist OPYPA-MGAP to design a suitable NDVI index insurance program for cattle producers located in Uruguay.*** The rest of this report presents the findings and recommendations of this NDVI pasture-index insurance Feasibility study in Uruguay.

# 3. NDVI Concepts and International Experience with NDVI Pasture Insurance

3.1. ***This Chapter presents a review of the Normalized Difference Vegetative Index (NDVI) and its applications to livestock pasture insurance.*** Traditional indemnity-based crop insurance programs have been widely developed for more than a century for a wide range of annual cereal, oil seed and horticultural crops, but to date indemnity based insurance has not been able to provide practical solutions for insuring extensive natural pasture and grazing lands against production and yield losses due to climatic and natural perils. Conversely the last decade has seen the development of new innovative parametric or index-based solutions to insure against production losses in pasture, all of which use satellite imagery to measure the Normalized Difference Vegetative Index (NDVI) in pasture. This Chapter explains NDVI concepts followed by a review of the features of and international experience with commercial pasture-NDVI insurance programs and highlights key challenges for the application of this product in Uruguay.

## Normalized Difference Vegetative Index: Concepts and Applications

3.2. ***The Normalized Difference Vegetative Index (NDVI), which is based on satellite imagery, can be used as an indicator of vegetation growth conditions over vast areas around the globe.*** NDVI imagery can be used not only to (1) distinguish between different types of land use cover for example, vegetation, from areas of sparse vegetation or bare soil, water and ice, but also (2) to measure the condition of the vegetative cover and to distinguish between healthy growing vegetation and vegetation which is dry or dead. Vegetation differs from other land surfaces because it tends to absorb strongly the red wavelengths of sunlight and to reflect light in the near-infrared wavelength. Several satellites including NOAA (and LANDSAT) measure the intensity of reflection from the Earth’s surface in both these wavelength ranges. The NDVI is a measure of the difference in reflectance between two wavelength ranges, the Red (R) and Near Infra Red (NIR) radiation, according to the equation (NIR-R)/(NIR+R). By normalizing the differences the NDVI takes values between -1 and 1, with values of 0.5 and above indicating dense vegetation and values between 0.0 and 0.1 for bare soil, while water and ice have values less than 0 (Table 3.1).

**Table 3.1. Typical NDVI Values for Different Cover Types**

| Cover Type | RED | NIR | NDVI |
|---|---|---|---|
| Dense vegetation | 0.1 | 0.5 | 0.7 |
| Dry Bare Soil | 0.269 | 0.283 | 0.025 |
| Clouds | 0.227 | 0.228 | 0.002 |
| Snow and Ice | 0.375 | 0.342 | -0.046 |
| Water | 0.022 | 0.013 | -0.257 |

Source: Holben 1986

3.3. ***NDVI also provides a very good indicator of the vegetative growth condition or plant vigor of any type of vegetation*** (e.g. annual crops, pasture, and forestry). The current state of vegetative growth conditions can indirectly be estimated and compared with previous vegetation growing seasons by calculating the amount of visible red light R or NIR light reflected by the vegetation to the satellites’ remote sensors. For instance, healthy plants that are photo-synthesizing absorb a great portion of visible red light (R) and reflect a large portion of the NIR light – this signature is unique to healthy green plants. Conversely, plants under stressed conditions and which are dying (i.e. due to severe dry spells) reflect very much less NIR light. In the case of natural pasture grown in Uruguay, typical monthly average NDVI values for healthy growing pasture are in the order of 0.60 to 0.65 while the lowest values associated with the winter dry season are about 0.50 to 0.55 and in the case of very dry drought years as low as 0.17.

3.4. ***The NDVI Index not only provides a good measure of the health of the vegetation cover, but it is also very closely correlated with climatic variables such as precipitation and potential evapotranspiration.*** A major study in temperate regions of Argentina showed that climatic variables explained 89% of the variability in the annual NDVI values: the NDVI values increased linearly with mean annual precipitation and decreased with potential evapotranspiration and 80% of the variation in NDVI values were explained by precipitation and 9% by evapotranspiration (Guerschman et al 2003). These close correlations between NDVI and plant photosynthesis and plant vigor, and in turn NDVI and amount of rainfall point to the fact that NDVI is potentially a very good proxy index to use to measure the impact on drought on pasture quality and productivity.

3.5. ***Remote sensing Normalized Difference Vegetative Indexes (NDVI) offer potential for insuring pasture and grazing lands against natural and climatic perils and several commercial schemes are now offering this insurance cover to livestock producers.*** The availability of computed reliable high spatial resolution and long term NDVI values and the possibility to use NDVI values to work as an indicator of crop productivity makes it a suitable historical source of data for insurance purposes. By analyzing monthly NDVI values over a series of between 20 or more years, it is possible to construct an NDVI index for insurance purposes and which is calibrated according the frequency of extreme climate years (e.g. major droughts) and the required frequency and magnitude of payouts. However, the application of NDVI by the insurance industry is very recent. Since 2000, four agricultural insurance markets including Spain, the USA, Canada and Mexico have developed commercial pasture insurance programs based on the design of NDVI triggers. This is due to the ability of the NDVI measurements to provide an accurate proxy measure of pasture-vegetative drought stress. Payouts in all of these programs are determined based on the negative deviation of actual NDVI values in the insured area from the NDVI mean within the period of cover, according to pre-agreed indemnity payout scales corresponding to each NDVI signature in each insured geographic area. Key features of these programs are reviewed later in this Chapter.

## Advantages and Limitations of NDVI Insurance for Pasture

3.6. ***The implementation of NDVI index-based insurance contracts has many potential technical and operational advantages in comparison to traditional crop insurance policies.*** Traditional indemnity-based damage or loss of yield crop insurance policies have not been successfully adapted for natural pasture and grazing anywhere in the world. There are several key potential advantages of an NDVI pasture index including: (i) reduced adverse selection and moral hazard because the indemnity payout is based on the NDVI index, which is less easy to manipulate by farmers[18] to increase the potential likelihood or magnitude of a loss to be indemnified by an insurance company; (ii) NDVI insurance can be designed to protect different

[18] In this context it is noted that there is an exposure to moral hazard at the micro-level where individual farmers can increase their stocking densities to a level where over-grazing results in the destruction of the pasture and very low NDVI values. This problem can be overcome by the Insurer specifying maximum stocking densities per hectare of pasture in each zone or Insured Unit

insurable interests, including: individual farmers (Micro-level insurance), regional aggregators such as input suppliers or rural banks (Meso-level insurance) and regional governments or authorities (Macro-level insurance); (iii) the possibility to provide NDVI insurance benefits to small livestock farmers: given that NDVI index insurance products are based on an agreed measured value that acts as an objective indicator of the losses incurred by the insured, there is no need to conduct pre-inspections on individual farms and to assess individual farmer losses, and this reduces the transaction and implementation costs of insurance for small farm units; (iv) the transparent structure of NDVI insurance products may facilitate the understanding process of the contract wording; and (v) the advantage of complete and consistent spatial coverage at low cost.

3.7. ***Despite the many advantages of NDVI index insurance contracts; there are several technical limitations of the technology:*** (i) NDVI sensors are very sensitive to cloud cover which scatters the red radiation thereby reducing the NDVI values and /or resulting in missing values. Similarly volcanic ash fallout reduces the NDVI values and although correction procedures have been developed by NASA not all corrected imagery is of high quality; (ii) The spatial resolution of the sensors is also a major limiting factor especially in the design of pasture insurance covers[19]. The first NDVI LANDSAT sensors in the 1980s and 1990s typically produced NDVI imagery for Uruguay at a resolution of 5 km x 5 km grids or pixels, and although this was reduced by MODIS in 2000 to 250 meters x 250 meters, where long time-series NDVI datasets of 20 years or more are required for index contract design and rating purposes, the highest resolution is still 5 km x 5km for Uruguay. Such a resolution can be used to construct a general NDVI-pasture index for the 5 km x 5 km area, but not to provide index insurance at the individual farmer and field level. This may, however, change in future with the increasingly cheap access to satellite imagery at resolutions as low as 30 meters x 30 meters or less; (iii) Another issue related to the development of NDVI indexes is that the land use within the pixel is seldom 100% one vegetation type and therefore the NDVI value measured by the remote sensor at any time is the sum of the reflection of all vegetation and land cover types. Also land use patterns may change over time and for example, motivated by market conditions (i.e. increase in crop prices); farmers may decide to plough up their natural pasture and grazing land and to plant annual cereal crops. The design of an NDVI Index therefore requires very careful analysis of the historical land use and also preparation of land use maps to distinguish pasture resource units from all other types of land use (See Chapter 4 for further discussion in relation to the development of the NDVI database for pasture areas in Uruguay).

3.8. ***From a contract design and operational viewpoint one of the major challenges which has to be addressed with any form of parametric or index insurance is the issue of basis risk and this is extremely relevant for any NDVI-Pasture index insurance programs.*** Basis risk is the difference between the loss as measured by the proxy indicator (in this case the NDVI index value as measured by the satellite for a specific pixel or area grid) and the actual loss incurred by the Insured livestock producer(s) on the ground (in this case losses in pasture production / grazing quality for land located in the specific pixel). Basis Risk can arise from a number of reasons which are summarized in Box 3.1 below. In the case of the current NDVI policy that has been designed for Uruguay, the major source of basis risk is **spatial risk** namely the fact that with a resolution of 5 km x 5 km images, the average NDVI value over an area of 2,500 Ha is not necessarily representative of the actual NDVI values in individual fields of pasture and grazing belonging to individual farmers. Under the current feasibility study every attempt has been made

[19] For a good review of the limitations of NDVI see Grimes S.W.S. (ND), Normalised Difference Vegetation Index (NDVI), Department of Meteorology, University of Reading, UK.

to reduce **Temporal basis risk** by triggering payouts on a monthly basis during the cover period. **Product basis risk** is generally less of a problem for a pasture NDVI index than a single peril rainfall-deficit weather index cover, because the NDVI is a direct measure of the vegetative health of the pasture and therefore includes a wide range of natural, climatic and biological perils which can impact on pasture production and quality. Finally **Contract design basis risk** arises where threshold triggers and exit trigger are incorrectly specified and do not bear an adequate relationship to actual losses which may be incurred on the ground. In the design of an NDVI pasture-index every attempt should be made to ensure that index is as carefully calibrated as possible to reflect actual losses in pasture on the ground. (See Chapter 5).

**Box 3.1. Sources of Basis Risk in Weather Index (and NDVI) Insurance**

**Basis Risk:** Basis risk in Weather Index Insurance (WII) is a key constraint. For micro-level individual farmer insurance basis risk is the difference between the loss experienced by the farmer and the payout triggered by the Index. 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. Basis risk is less of an issue for meso or macro-level index insurance policies where the intention is to compensate catastrophe regional loss events and not localized losses at the individual farmer-level. Index insurance works best where losses are homogenous in the defined area, and highly correlated with the indexed peril. 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.
- **Contract design basis risk:** Which occurs where the threshold triggers and exit triggers are not carefully calibrated with actual losses experienced on the ground.

Source: Adapted from World Bank Weather Index Training Manuals 2011

## International Experience with NDVI Insurance for Pasture

3.9. ***Currently NDVI is being used for commercial livestock pasture insurance programs in four countries and several other countries are experimenting with this product.*** Table 3.2 presents a summary of the international experience of the uses of remote sensing NDVI index-based insurance to insure livestock producers against losses in pasture and grassland production and key features of these programs are reviewed below. The four countries that have offered commercial pasture NDVI insurance programs to livestock producers since the early 2000s include USA, Alberta Province in Canada, Spain and Mexico. All four programs are aimed primarily at the cattle livestock sectors but in Spain sheep and goats and horses can also be insured.

3.10. ***Three of the NDVI Pasture Index Insurance programs in the USA, Canada and Spain are designed as individual livestock producer programs, while the Mexican program is a government catastrophe index cover designed to make payouts to small livestock producers in times of major drought losses in pasture.*** In USA, Canada and Spain the pasture NDVI programs are marketed by insurance companies on a voluntary basis to interested individual livestock producers (micro-level insurance). In Mexico, however, the federal and state governments purchase macro-level NDVI cover which is used to finance payouts in the event of catastrophe losses in pasture and grazing to the large numbers of small livestock producers (defined as owning less than 60 livestock units), in each state. These small livestock producers are registered and are the automatic beneficiaries of the insurance payouts, but they do not contribute to the premium costs of this cover which are 100% born by federal and state governments. The Mexican government calculates that it is much more cost effective to purchase insurance cover on behalf of this sector of smallholder livestock producers and to receive indemnity payouts in the event of a loss rather than to rely on ex-post disaster compensation payments which would have to be 100% financed out of the national and state budgets.[20]

3.11. ***The three voluntary individual livestock producer NDVI programs all carry very high levels of premium subsidy support and the Mexican macro-level program is 100% financed by government.*** A feature of these NDVI programs is the high average premium rates typically about 10% or in the case of Canada, much higher (Tables 3.3 to 3.5). In USA, Canada and Spain the individual programs attract very high levels of government financed premium subsidies (in the order of 50% to 65% of the cost of the full premium) and which are intended to promote the insurance covers to the livestock community. In Mexico, government finances 100% of the premium and uses the insurance cover to replace ex-post disaster relief payments.

## Basis of NDVI Pasture-Index Insurance Cover

3.12. ***The spatial resolution of the remote sensors used by these four NDVI pasture index insurance programs varies considerably*** from the highest resolution in Spain where MODIS has been deployed since 2000 at a resolution of 250 meters by 250 meters (an area of 6.25 hectares) to a low resolution of 8 km x 8 km (an area of 6,400 hectares) in the USA. The frequency of NDVI recording varies by satellite and country from daily records in USA and Mexico to every dekad (10 days) in Spain. The time-series used to construct the historical NDVI average values for pasture also varies from 11 years for MODIS in Spain, up to 22 years in the case of USG-EROS in the USA (Table 3.2).

3.13. ***The basis of insurance and indemnity under the four NDVI programs is essentially the same.*** The underlying principle of all four programs is to establish a historical NDVI data-base for each defined pasture resource pixels or grid and to calculate the average NDVI value for each cover period over the pasture growing season or the insurance coverage period. Insurance payouts are then made if during the insurance period the actual measured NDVI value in each pixel falls below the average historical NDVI value in that pixel. In practice, the Insured triggers are defined as a percentage or deviation from the historical average NDVI value and the threshold is set at a level to reflect the onset of pasture production losses (e.g. due to drought and or other natural or climatic perils).

[20] SAGARPA 2012, personal communication with authors

**Table 3.2. Summary of International Experience with Commercial Pasture NDVI Index-based Insurance**

| ID | Description | España | México | USA | Canada |
|---|---|---|---|---|---|
| 1 | **Inception** | 2001 | 2007 | 2007 | 2001 |
| 2 | **Source of Remote Sensing Data** | MODIS (2000-present) | NOAA-AVHRR (1.1 km spatial resolution) | USG-EROS (1989-present). 8 km spatial resolution | NOAA-AVHRR (1.1 km spatial resolution) |
| 3 | **Temporal Specificity** | Every 10 days | Daily | Daily | Weekly |
| 4 | **Insurable Interest** | Feed supplement cost | Cost of Government support in case of weather contingencies. | Loss of benefits associated with the reduction of forrage production. | Loss of benefits associated with the reduction of forrage production. |
| 5 | **Policyholder** | Individual farmers | Federal Government and Provincial Governments. | Individual farmers. | Individual farmers |
| 6 | **Sum Insured (SI)** | Declared value: feed supplement unit cost x declared number of animals. | Declared value ($Mex 450/animal) divided in 3 phases:<br>(i) Phase 1: 30% of the SI x registered number of animals<br>(ii) Phase 2: 50% of the SI x registered number of animals<br>(iii) Phase 3: 20% of the SI x registered number of animals | Basic value per acre at the county level based on expected costs or revenues of grass production. | Reference yield (kg DM/ha) x Reference price<br>Basic value per acre at the county level based on dryland pasture types (native pasture, improved pasture, bush pasture, community pasture and forestry grazzing leases) |
| 7 | **Operation** | Negative anomalies in the actual NDVI value (10-day period) vs NDVI mean value for the same period.<br>NDVI values are estimated by the University of Valladolid | Negative anomalies in the actual NDVI value (10-day period) vs NDVI mean value for the same period.<br>NDVI values are estimated by the Collegue of Post Graduate studies (COLPOS) | Deviation from normal NDVI (expected grid index) within the grid and index interval(s) selected). | Negative anomalies in the actual NDVI value vs NDVI mean value for the same period. |
| 8 | **Coverage period** | Is divided into cycles: spring and autumn | 1 May to 30 November (seasonal pasture growth curve) | 3-month intervals | .- Short Split (mid-May until the end of July).<br>.- Late Split (mid-May until the end of August) |
| 9 | **Coverage Options** | **Option A:** actual NDVI < insured NDVI within for more than three 10-day period.<br>**Option B:** trigger a payout when cumulative claims in the 10-day period within the covered period is > 10% of the insured amount. | Deviation from NDVI mean values from triggers defined for each phase. | .- Farmers insured part or all of their farms.<br>.- Productivity factors range from 60% to 150%, and<br>.- Coverage levels range from 70% to 90% (intervals of 5%) | .- Full Season (cumulative NDVI values for the entire season).<br>.- Split Season (cumulative NDVI values for each sub-period) |

Source: Authors based on each individual Country livestock-pasture index program.

3.14. ***For each program a homogenous pasture zone is defined and this forms the Insured Unit on which basis the NDVI policy is triggered and payouts made to any livestock producer whose land holding is registered within that Insured Unit.*** In the USA the individual 8 km x 8 km grid forms the Insured Unit[21]. Conversely in Spain, the policy is triggered at the level of an individual homogenous risk zone (HRZ) which is normally the Comarca or county. In Mexico, the Insured Unit is defined as a homogeneous pasture zone and which is normally aggregated to the level of the municipality for operational purposes. Finally in Canada, the Insured Unit is the Township (similar to a county).

3.15. ***The basis of the sum insured and indemnity varies between the four countries but is designed to cover the additional costs livestock producers face in purchasing animal feed supplements if their pasture production fails during the cover period.*** The Mexican program carries the simplest sum insured which is an agreed value basis for each head of livestock with agreed payouts according to the stage of the season when the loss is triggered. In Spain a similar valuation is established per head of insured animals and the payouts are then made according to the pre-agreed NDVI payout scales. In the USA the sum insured is established per acre of pasture or fodder and livestock producers therefore have to register the amount of acres they have in each grid and to elect the sum insured coverage level they wish to insure. In Canada the sum insured is established according to a reference yield for each type of pasture and forage grazing and an insured value for each type of pasture.

3.16. ***The NDVI insurance cover periods are defined to cover the pasture growing seasons in each country.*** The three North American programs in Canada, USA and Mexico provide up to six month cover during the pasture growing season from April/May until October/November. In Canada, livestock producers can either elect short-season coverage from mid-May until end of July, or Long-full season coverage from mid-May until the end of August. In Spain coverage is defined by risk region (Autonomous Provinces) and in some parts of the country cover can be contracted during almost all the year and in other parts of the country with a very dry summer season (July through September), NDVI pasture cover is not available during these dry months.

## Performance and Results

3.17. ***The four NDVI pasture index insurance programs vary considerably in their scale and coverage.*** The Spanish and Canadian programs are both voluntary programs and demand is relatively low for NDVI cover. Over the past four years, the Spanish program has achieved an average of 4,185 policy sales per year with an average of 1.5 million head of animals insured each year which is equivalent to an average penetration rate of about 5.5% of all eligible insurable animals in Spain. In Canada, the Alberta Province pasture NDVI insurance program has achieved average annual sales of 1,220 individual policies and an average of 3.9 million head of cattle each year since inception back in 2001: there is however, evidence that the voluntary demand for this product has slowed down in recent years. Conversely in Mexico, the macro-level or state-level pasture NDVI program has expanded enormously since its introduction: in 2007 the program insured 13 million hectares of pasture in 6 states, by 2010 this had risen to 55 million Ha of pasture in 20 states. It is estimated that about two thirds of all eligible small and marginal cattle producers in Mexico are now automatically insured under the State-level pasture NDVI programs.

3.18. ***In spite of the very high average premium rates only one of the pasture NDVI index***

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[21] For full details see RMA 2011.

***insurance programs is currently operating profitably.*** The only NDVI program which is currently operating profitably is the Spanish NDVI program: over the period 2008 to 2011 the program has experienced an average loss ratio of 90%, but on account of high losses in the start-up years, the overall loss ratio since 2001 is running at 127%. The average premium rate on the Spanish program over the past 4 years has been 10.9% (Table 3.3). In Alberta Province Canada the pasture NDVI insurance program had a long term loss ratio at the end of 2009 of 117% in spite of the very high average premium rate of 19.9%: the program experienced severe drought loss payout years in 2001 and 2002 and again in 2009. In Canada the Federal and Provincial Governments subsidize about 60% of the costs of premiums and farmers contribute 40% of the cost of the insurance premiums (Table 3.4). Finally in Mexico, where the pasture NDVI program is relatively new the average loss ratio is running at 194% at the end of 2011 against an average premium rate of 9.5%. (Table 3.5).

## Lessons for NDVI Pasture Insurance in Uruguay

3.19. ***The restrictions of the 5 km x 5 km spatial resolution of the NDVI imagery available in Uruguay means that any NDVI pasture index is not able to approximate the losses incurred by individual livestock producers in their individual fields of natural pasture and grazing lands.*** As such the technology is best suited to insuring against catastrophe losses in pasture at a zonal level caused for example by severe drought. This in turn requires the identification of homogenous risk zones (HRZ) and agreement by key stakeholders at an early stage as to whether to design a meso-level or macro-level insurance cover (as in Mexico) instead of attempting to design individual farmer NDVI-pasture insurance and possibly incurring unacceptably high levels of basis risk which would negate the purpose of the program (these issues are discussed further in subsequent Chapters of this report).

3.20. ***The international experience with NDVI pasture index insurance clearly shows this is a catastrophe product which is exposed to drought loss payouts and that great care must be exercised in the design of the NDVI policy and in the setting of the index triggers and payout scales.*** The results of the commercial schemes reviewed above are generally poor and demonstrate the need for careful design to ensure that premium rates do not become unsustainable either for individual livestock producers and or governments to afford. In the design of the NDVI product for Uruguay, the authors recommend that a maximum average commercial premium rate of no more than 10% should be targeted for this product (this theme is addressed fully in Chapter 5).

**Table 3.3. Spain: Summary of Insurance Results NDVI Pasture Insurance 2001-11**

| Year | No of Policies | No. Insurable animals (000) | No. Insured animals (000) | Insurance Uptake Rate (%) | Sum Insured (Euro Million) | Earned Premium (Euro Million) | Average Premium Rate (%) | Claims (Euro Million) | Loss Ratio (%) |
|---|---|---|---|---|---|---|---|---|---|
| 2008 | 2,949 | 29,558 | 1,090 | 3.69% | 67.6 | 10.7 | 15.9% | 4.7 | 44% |
| 2009 | 5,369 | 28,782 | 2,019 | 7.02% | 142.0 | 8.7 | 6.1% | 19.9 | 230% |
| 2010 | 4,437 | 27,578 | 1,595 | 5.79% | 108.6 | 12.6 | 11.6% | 4.4 | 35% |
| 2011 | 3,984 | 25,838 | 1,446 | 5.60% | 96.5 | 9.8 | 10.1% | 8.6 | 88% |
| **Total accumulated 2001-2011** | | | | | | **81.6** | **10.9%** | **103.5** | **127%** |

Source: Agroseguro Annual Reports. www.agroseguro.es

**Table 3.4. Canada: Summary of Insurance Results NDVI Pasture Insurance 2001-09**

| Year | No Policies | Insured Acres (Million) | Total Sum Insured (C$ Million) | Total Premium (C$ Million) | Average Premium Rate (%) | Claims Payouts (C$) | Loss Ratio (%) |
|---|---|---|---|---|---|---|---|
| 2001 (pilot) | 675 | 2.1 | 18.7 | 3.4 | 18.4% | 16.1 | 467% |
| 2002 | 1,989 | 5.6 | 59.0 | 11.2 | 19.0% | 29.8 | 265% |
| 2003 | 1,980 | 5.6 | 65.7 | 13.6 | 20.7% | 0.2 | 1% |
| 2004 | Program not offered in 2004 | | | | | | |
| 2005 | 1,375 | 4.6 | 35.0 | 8.6 | 24.5% | 0.3 | 3% |
| 2006 | 1,047 | 3.6 | 32.0 | 5.4 | 16.9% | 1.3 | 25% |
| 2007 | 917 | 3.2 | 33.1 | 4.5 | 13.4% | 5.3 | 118% |
| 2008 | 924 | 3.3 | 23.3 | 5.3 | 22.8% | 1.1 | 20% |
| 2009 | 849 | 3.0 | 23.4 | 5.6 | 24.0% | 13.7 | 244% |
| **Total** | **9,756** | **31.0** | **290.3** | **57.6** | **19.9%** | **67.7** | **117%** |

Source: AFSC 2010 and AFC Annual Reports www.afsc.ca

**Table 3.5. Mexico: Summary of Insurance Results NDVI Pasture Insurance 2007-11**

| Year | No States | Insured Area (Ha Million) | No insured animals (Million) | Total Sum Insured (MXN Million) | Total Premium (MXN Million) | Average Premium Rate %) | Claims: No animals | Claims: % Insured Animals | Claims: Value (MXN Million) | Loss Ratio (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 6 | 13.0 | 0.93 | 247 | 20 | 8.0% | 0.20 | 21.4% | 3.1 | 15% |
| 2008 | 19 | 58.8 | 2.92 | 984 | 69 | 7.0% | 0.12 | 4.2% | 39.7 | 58% |
| 2009 | 18 | 54.6 | 3.50 | 1,163 | 135 | 11.6% | 1.65 | 47.2% | 374.2 | 276% |
| 2010 | 20 | 54.6 | 3.81 | 1,394 | 159 | 11.4% | 0.16 | 4.1% | 21.7 | 14% |
| 2011 | 21 | n.a. | 3.88 | 1,964 | 165 | 8.4% | 1.97 | 50.8% | 625.0 | 378% |
| Total | | | 15.04 | 5,752 | 549 | 9.5% | 4.10 | 27.3% | 1,063.6 | 194% |

Source: Agroasemex 2010; SAGARPA 2012

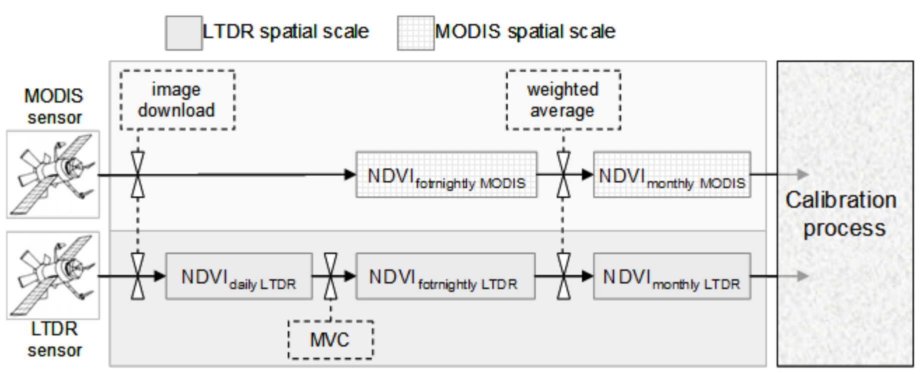
# 4. NDVI-Pasture Insurance Database Development in Uruguay

## Features of the NDVI Information and Data Analysis for Uruguay

4.1. ***As a starting point to this study, the World Bank held a competitive tender in the first half of 2011 to identify an international company specializing in Remote Sensing to construct a time-series NDVI Database for Uruguay and also to classify and map the land use (forage resources) of the country.*** The successful candidate was the Remote Sensing and Regional Analysis Laboratory of the Faculty of Agronomy, University of Buenos Aires (LART-FAUBA) which is a recognized specialist in the analysis and interpretation of remote sensing data relating to natural resources and agricultural land use and the environment. LART-FAUBA has previous experience in the design of NDVI data-bases for pasture-index insurance programs. In 2008 the Office of Agricultural Risks (*Oficina de Riesgos Agropecuarios*, ORA) of the Ministry of Agriculture, Livestock and Fisheries (MAGyP), Argentina, contracted LART-FAUBA to develop an NDVI data-base for selected provinces and regions of Argentina for the purposes of monitoring vegetation status and as a precursor for the ORA-MAGyP-World Bank Feasibility study into the applications of NDVI to pasture insurance in Argentina (2011 to 2012).

4.2. ***LART-FAUBA has developed an NDVI database for the Uruguay.*** Between July 2011 and June 2012, LART-FAUBA developed a long-term historical remote sensing data-base (30 years of data from 1981/82 to 2010/11, with a monthly temporal resolution) of NDVI and digitized pasture maps at a spatial resolution or scale of 5 Km x 5 Km for the 19 Departments of Uruguay. The generation of this NDVI database has been obtained by combining NOAA imagery from 1981 to 1999 at a resolution of 5 Km x 5 Km (2,500 ha) and MODIS imagery from 2000 to 2011 at a resolution of 250 meters x 250 meters (6.25 Ha). Figure 4.1 presents a schematic representation of the procedures followed for the development of the NDVI database. The final database contains 30 years of monthly average NDVI values for a total of 6,232 5 km x 5km pixels (also known as grids). Further details of the methodology employed by LART-FAUBA are presented in Annex 2.

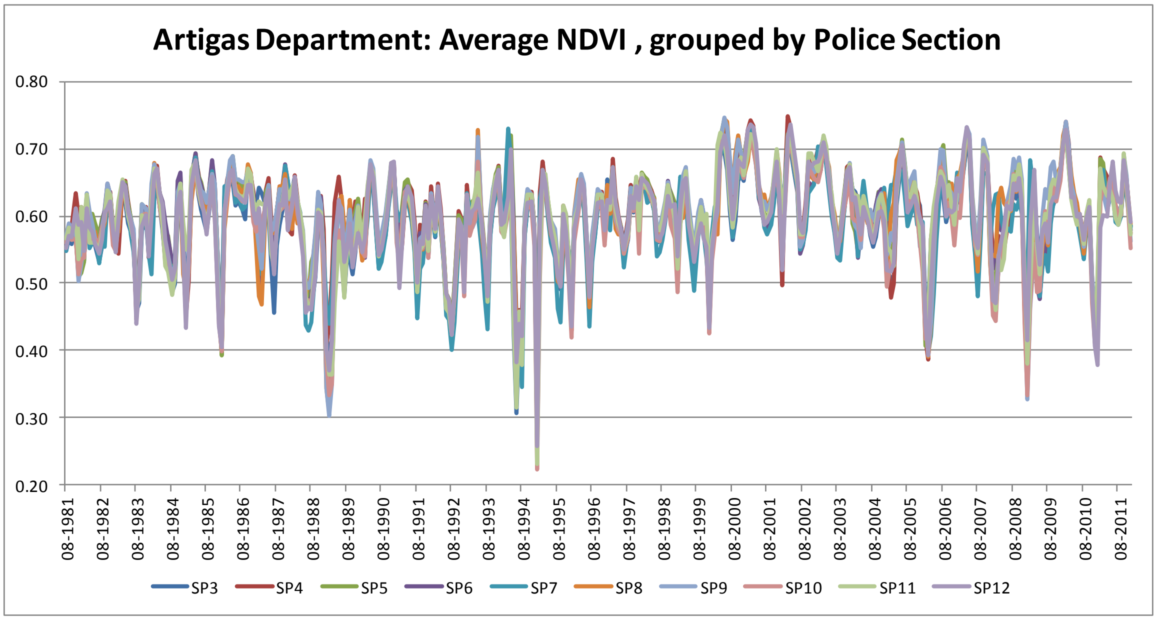
**Figure 4.1 Schematic representation of the procedure followed to obtain monthly values derived from two satellite platforms with different characteristics**




Source: LART-FAUBA, 2011

4.3. ***The NDVI is a good estimator of the rate of growth of the forage biomass.*** The NDVI series can be used as a good proxy to estimate the variation of forage production at the landscape level. Based on this fact, NDVI time series data can be used as the underlying data for the development of an index based insurance product in Uruguay. An example of the average monthly NDVI data is illustrated in Figure 4.2 for Artigas Department[22]: drought years in which pasture production and grazing were severely impacted such as 1988/89 and 2008/09 are shown by the low NDVI values below 0.4, while years of good rainfall and high pasture vigor and production are shown by NDVI values greater than 0.6. Further details about the methodology employed by LART-FAUBA to develop the NDVI database are presented in Annex 2.

**Figure 4.2. Example of 30-Year Average Monthly NDVI by Police Section for Artigas Department, Uruguay**




Source: Authors analysis of LART-FAUBA NDVI Data-base

## NDVI Data Checking, Cleaning and Missing Data

4.4. ***The first task was to sort the 30 years NDVI Database into "forage resources[23]" (including natural pasture and grazing areas) and other land use areas.*** In practice many of the 5 km x 5 km pixels are not exclusively devoted to natural pasture and livestock grazing and if

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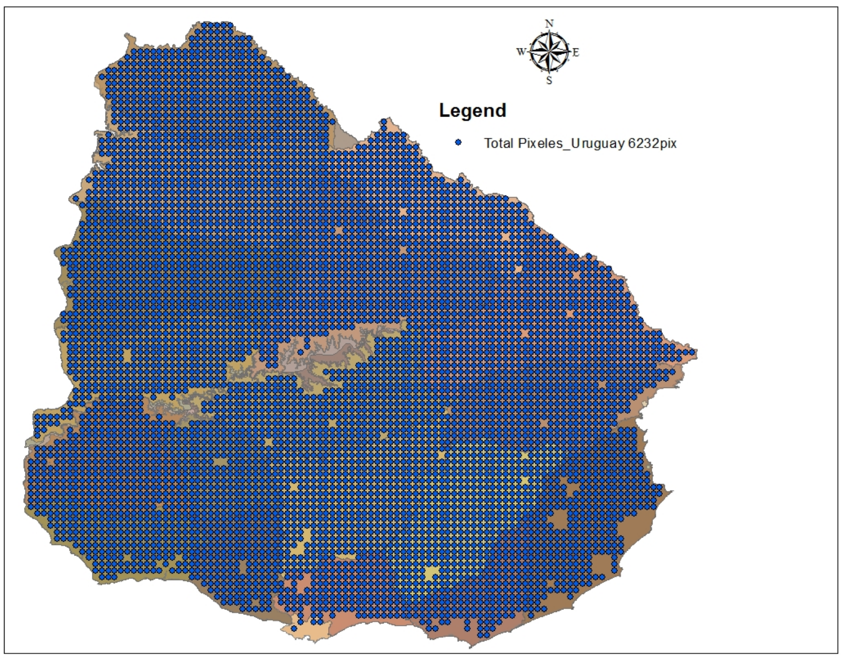
[22] There were missing data in the NDVI Database and therefore it was necessary to fill in the values (see Chapter 5 and Annex 3 for further details), and this could smooth some drought events. As an example, January 1995 showed the lowest NDVI value in Artigas, but the data between September and December 1994 are missing, so it is not possible to confirm or to reject the occurrence of a severe drought in 1994-95.

[23] The NDVI imagery captured by the MODIS remote sensor was used to classify the vegetative cover in each Pixel: this imagery has a spatial and temporal resolution of 250 x 250 m and 16 days, respectively. The combination of supervised and non-supervised cluster statistical methods were used in order to get different vegetation classes for each image. The final output of this analysis is a land use map at a scale of 5km x 5 km grids comprised of the following categories, namely: (i) permanent forage resources, (ii) summer crops, (iii) double cropping – winter and summer, (iv) natural and planted forestry, (v) water, (vi) urban and not classified. Further explanation on the vegetative coverage characterization in the Uruguayan regions is provided in Annex 2.

only pure pasture areas were included in this satellite index insurance program, many important cattle producing areas in Uruguay would be excluded. At the other extreme, if less than 50% of the pixel area is covered by forage then there is a danger that the average monthly NDVI value generated for that pixel is no longer representative of the pasture and grazing quality, but rather that the NDVI signature is blurred by other types of land use such as annual crops or forestry which are not the purpose of the pasture index insurance program. On the basis of discussions with LART-FAUBA it was agreed that the criterion for the definition of a "forage pixel" would be that a minimum of 60% of the area should be classified as forage resources. In addition, the pixels with more than 6.7% of missing data were excluded of the analysis. Using these two criteria, a total of 4001 pixels (or 64.2% of the total number of pixels initially provided) qualified as forage pixels which would be included in the cluster analysis. Table 4.1 and Figure 4.3 show the distribution of selected pixels for cluster analysis in relation to the total number of pixels provided by LART-FAUBA. (See Annex 2 for full details of the methodology used by LART-FAUBA to process the NDVI data and classify forage resource pixels).

**Figure 4.3. Total number of pixels provided within the NDVI database for Uruguay.**




Source: The authors based on the NDVI database provided by LART-FAUBA.

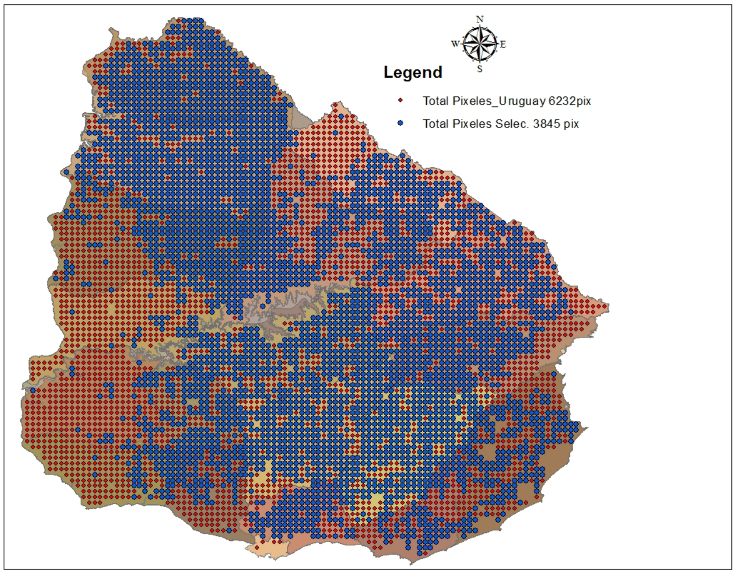
**Table 4.1. Total number of pixels selected for the conduct of a Cluster Analysis in Uruguay.**

| Dpto_INE | Department | Total Initially Provided | | Forage Area <=60% | | Forage Area >=60% | | Missing Values. >=6.7% | | Cluster Analysis | | Missing Values (<6.7%) | Infilled Values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N. Values Provided | Total Pixels | N. Values | Pixels | N. Values | Pixels | Datos | Pixeles | N. Values | Pixels | Datos | Datos |
| [1] | [2] | [3] | [4] | [4] | [6] | [7=3-5] | [8=4-6] | [9] | [10] | [11=7-9] | [12=8-10] | [13] | [14] |
| **1** | Montevideo | - | - | - | - | - | - | - | - | - | - | - | - |
| **2** | Artigas | 154,395 | 423 | 11,680 | 32 | 142,715 | 391 | 6,935 | 19 | 135,780 | 372 | 8,928 | 8,928 |
| **3** | Canelones | 54,385 | 149 | 8,760 | 24 | 45,625 | 125 | 2,190 | 6 | 43,435 | 119 | 2,856 | 2,856 |
| **4** | Cerro Largo | 183,960 | 504 | 48,910 | 134 | 135,050 | 370 | 1,095 | 3 | 133,955 | 367 | 8,808 | 8,808 |
| **5** | Colonia | 77,015 | 211 | 55,115 | 151 | 21,900 | 60 | - | - | 21,900 | 60 | 1,440 | 1,440 |
| **6** | Durazno | 143,810 | 394 | 27,010 | 74 | 116,800 | 320 | 2,920 | 8 | 113,880 | 312 | 7,488 | 7,488 |
| **7** | Flores | 69,715 | 191 | 22,265 | 61 | 47,450 | 130 | - | - | 47,450 | 130 | 3,120 | 3,120 |
| **8** | Florida | 144,175 | 395 | 25,915 | 71 | 118,260 | 324 | 2,190 | 6 | 116,070 | 318 | 7,632 | 7,632 |
| **9** | Lavalleja | 140,160 | 384 | 17,885 | 49 | 122,275 | 335 | 6,205 | 17 | 116,070 | 318 | 7,632 | 7,632 |
| **10** | Maldonado | 57,670 | 158 | 24,820 | 68 | 32,850 | 90 | - | - | 32,850 | 90 | 2,160 | 2,160 |
| **11** | Paysandu | 188,705 | 517 | 82,490 | 226 | 106,215 | 291 | 1,825 | 5 | 104,390 | 286 | 6,864 | 6,864 |
| **12** | Rio Negro | 116,435 | 319 | 85,775 | 235 | 30,660 | 84 | 3,650 | 10 | 27,010 | 74 | 1,776 | 1,776 |
| **13** | Rivera | 122,640 | 336 | 53,655 | 147 | 68,985 | 189 | 6,570 | 18 | 62,415 | 171 | 4,104 | 4,104 |
| **14** | Rocha | 124,100 | 340 | 40,880 | 112 | 83,220 | 228 | 10,220 | 28 | 73,000 | 200 | 4,800 | 4,800 |
| **15** | Salto | 187,610 | 514 | 11,315 | 31 | 176,295 | 483 | 2,920 | 8 | 173,375 | 475 | 11,400 | 11,400 |
| **16** | San Jose | 65,700 | 180 | 33,580 | 92 | 32,120 | 88 | 2,190 | 6 | 29,930 | 82 | 1,968 | 1,968 |
| **17** | Soriano | 116,435 | 319 | 101,105 | 277 | 15,330 | 42 | - | - | 15,330 | 42 | 1,008 | 1,008 |
| **18** | Tacuarembo | 200,385 | 549 | 71,905 | 197 | 128,480 | 352 | 3,285 | 9 | 125,195 | 343 | 8,232 | 8,232 |
| **19** | Treinta y Tres | 125,925 | 345 | 35,040 | 96 | 90,885 | 249 | 2,555 | 7 | 88,330 | 242 | 5,808 | 5,808 |
| **NA** | Excluded 1* | 1,460 | 4 | - | - | 1,460 | 4 | - | - | 1,460 | 4 | 96 | 96 |
| | **Total** | **2,274,680** | **6,232** | **758,105** | **2,077** | **1,516,575** | **4,155** | **54,750** | **150** | **1,461,825** | **4,005** | **96,120** | **96,120** |

Note: Excluded 1* corresponds to pixels whose location falls outside the boundary of the country.
Source: The authors based on the NDVI database provided by LART-FAUBA.

4.5. ***The second step consisted of excluding pixels where the predominant land use is natural and/or planted forestry.*** For the purpose of this analysis, the World Bank team superimposed ArcGIS forest layers with the location of selected pixels for Cluster Analysis (4001 pixels). This procedure led to the exclusion of a further 156 pixels where forestry has been planted over the past 30 years and which if they had been included in the NDVI data base could have affected the overall pasture/forage resources signature as well as altering the index triggers and probability of payouts. As a result of the classification of "pure" forage pixels (pixels with a minimum of 60% of the area covered by forage resources and whose percentage of missing monthly values was no greater than 6.7% of the total 30-year time series), the NDVI risk analysis was conducted with a final database of 3,845 pixels (or 61.7% of total pixels initially provided). The location of these "pure" selected pixels is shown in Figure 4.4. The next section presents a further discussion of the land use mapping system and NDVI database design issues.

**Figure 4.4. Selected pixels for risk analysis (criterion >= 60% of the area of the pixels allotted for livestock fodder production, percentage of missing values <6.7% of total time-series, and not located in forest area).**




Source: the Authors based on the NDVI database provided by LART-FAUBA.

4.6. ***For each selected pixel (3,845 in total), a linear interpolation technique was used for infilling time-series gaps to avoid systematic changes to the data or the average value of the NDVI readings[24].*** After applying these statistical procedures the number of unfilled values (96,120) was reduced to zero (0) of the total NDVI database and which was considered excellent for grouping pixels with similar characteristics (see last column of Table 4.1 above). It is understood that one of the main reasons for missing NDVI values is due to cloud cover which prevents the satellite sensor from receiving the reflected visible and near infrared radiation.

## Mapping of Natural Pasture Areas in Uruguay

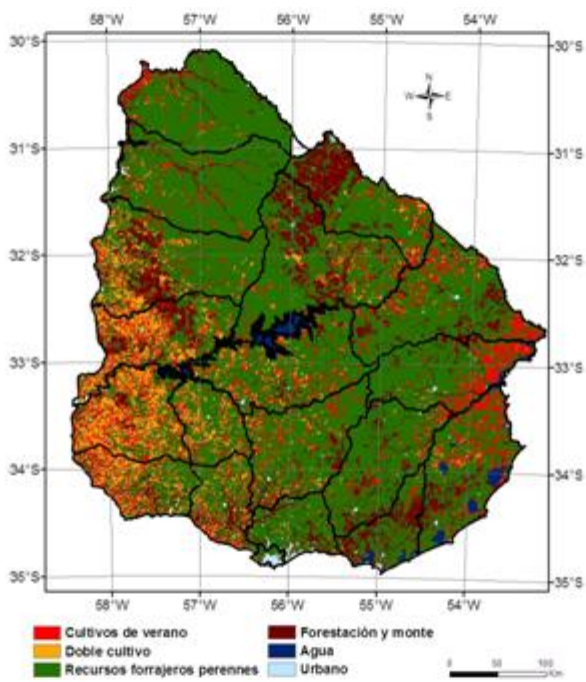
4.7. ***LART-FAUBA mapped and classified the vegetation cover and land use in each of the pixels and specifically for identifying and distinguishing areas of natural pasture and grazing from other types of land use and ground cover.*** For the purposes of this vegetation cover mapping exercise, three activities were carried out, including: (1) use of high resolution LANDSAT images to generate a land-cover classification for the 19 departments, (2) use of ground truth surveys to validate the land use classification; and then (3) use of MODIS 250 meter x 250 meter resolution NDVI imagery to characterize different types of land covers to establish the NDVI "phenological signature" over the 12 month period for forage and non forage resources.

4.8. ***The LART-FAUBA land classification system distinguished for all pixels located in Uruguay the proportion of the pixels occupied by six different land cover classes***, including:

[24] It is important to note that the linear interpolation technique was applied only for the purposes of the cluster analysis. For risk analysis, an infilling using average monthly NDVI values was used (see Annex 3 for further details).

forage resources (>60% of pixel are under pasture and grazing), annual crops, permanent crops, planted and native forests, water bodies and urban areas. Through a ground-truth survey LART-FAUBA was able to confirm that their satellite-based land use classification procedure had a level of precision of 91% for individual pixels. This level of precision was considered by LART-FAUBA to be good enough to capture catastrophic events whose effects are evident in large areas. This degree of accuracy in classification of land use could be improved in future; nevertheless, a less generic land cover classification and, potentially, more land control points would be needed to increase the level of precision. The results of this classification indicate that agricultural crop production predominates in the Western and Eastern regions of Uruguay, there are some important areas of forestry in Western, Northern and Southern Uruguay and permanent forage resources (livestock pasture and grazing) is the predominant land use type in the rest of the country (See Figure 4.5). Further details of the LART-FAUBA land use classification system are presented in Annex 2 and in Texeira, Oyarzabal and Arocena (2011)[25].

**Figure 4.5. Land cover characterization of the Uruguay based on remote sensing data and filed observations.**




Source: Texeira et al 2011a, Texeira et al 2011b.

4.9. ***The main technical limitation of the land use classification system utilized is that it is not possible to identify sown pasture or sown fodder crops.*** This problem arises because of the low resolution of the NDVI imagery (5 km x 5 km). In general, sown pasture shows a lower resilience to adverse climatic and soil conditions. The total area of sown pasture in Uruguay is significantly less in comparison to areas devoted to natural pastures or grasslands. In this sense,

[25] Texeira, M., M. Oyarzabal and D. Arocena (2011b). Patrones espaciales y temporales en el funcionamiento de la vegetación del sudoeste de Buenos Aires y el norte de la Patagonia: generación de una base de datos de aplicación en la implementación de seguros agropecuarios. Facultad de Agronomia, Universidad de Buenos Aires, Argentina.

when working with a pixel of 2,500 hectares such type of pastures or fodder crops are not displayed as such. On the other hand, the temporal specificity (monthly) does not allow the accurate detection of land cover changes throughout the year; therefore, it is not feasible to have a consistent NDVI database from which to conduct risk analysis for this type of land cover areas.

4.10. ***A further limitation applies to areas of mixed agriculture and grazing where more than 40% of the land in each pixel is annually ploughed and under different crop rotations and this prohibits the construction of a historical NDVI data base which is representative of pasture and grazing lands.*** This problem of a very low number of qualifying forage pixels applies especially in the Western and Eastern regions which are important cereal producing areas but where there are also important concentrations of cattle breeding and cattle fattening (see Figure 2.1 and 4.4). In areas where there are no qualifying forage resource pixels, the NDVI insurance policy cannot be offered to cattle producers.

4.11. ***There are big differences in the geographical area of each department and also in the area under natural pasture and grazing in Uruguay.*** Reference to Table 4.2 shows that Salto is the Department with the highest concentration of natural pasture with an estimated area from the satellite imagery of 1.13 million hectares or 11.8% of the total geographical area of 9.6 million hectares covered by pasture / forage pixels (3845 pixels), followed by Artigas with 0.92 million hectares (9.5%) and Cerro Largo and Tacuarembó with approximately 0.8 million hectares each (9% of total forage area). At the other extreme, Soriano Department has only 0.1 million hectares (or 1.1% of total) of land which fit under the two classification criterion for forage pixels. Other very small livestock grazing departments include Colonia (1.4% of total pasture area), and Rio Negro (1.9% of grazing area). For the purpose of this analysis it was assumed that the whole pixel area fits under the forage land cover classification.

**Table 4.2. Estimated Pasture Area (Ha) per District from Remote Sensing Imagery**

| Dpto_INE | Department | Excluded 2* | N. Pixels* | Max. Pasture Area (Ha) | % of Pasture area | Total Pixels | Total (Ha) | Area % of total area |
|---|---|---|---|---|---|---|---|---|
| **1** | Montevideo | - | - | - | 0.0% | - | - | 0.0% |
| **2** | Artigas | 5 | 367 | 917,500 | 9.5% | 423 | 1,057,500 | 6.8% |
| **3** | Canelones | 4 | 115 | 287,500 | 3.0% | 149 | 372,500 | 2.4% |
| **4** | Cerro Largo | 25 | 342 | 855,000 | 8.9% | 504 | 1,260,000 | 8.1% |
| **5** | Colonia | 5 | 55 | 137,500 | 1.4% | 211 | 527,500 | 3.4% |
| **6** | Durazno | 8 | 304 | 760,000 | 7.9% | 394 | 985,000 | 6.3% |
| **7** | Flores | 3 | 127 | 317,500 | 3.3% | 191 | 477,500 | 3.1% |
| **8** | Florida | 8 | 310 | 775,000 | 8.1% | 395 | 987,500 | 6.3% |
| **9** | Lavalleja | 24 | 294 | 735,000 | 7.6% | 384 | 960,000 | 6.2% |
| **10** | Maldonado | 4 | 86 | 215,000 | 2.2% | 158 | 395,000 | 2.5% |
| **11** | Paysandu | 9 | 277 | 692,500 | 7.2% | 517 | 1,292,500 | 8.3% |
| **12** | Rio Negro | 2 | 72 | 180,000 | 1.9% | 319 | 797,500 | 5.1% |
| **13** | Rivera | 4 | 167 | 417,500 | 4.3% | 336 | 840,000 | 5.4% |
| **14** | Rocha | 4 | 196 | 490,000 | 5.1% | 340 | 850,000 | 5.5% |
| **15** | Salto | 22 | 453 | 1,132,500 | 11.8% | 514 | 1,285,000 | 8.3% |
| **16** | San Jose | 1 | 81 | 202,500 | 2.1% | 180 | 450,000 | 2.9% |
| **17** | Soriano | 1 | 41 | 102,500 | 1.1% | 319 | 797,500 | 5.1% |
| **18** | Tacuarembo | 14 | 329 | 822,500 | 8.6% | 549 | 1,372,500 | 8.8% |
| **19** | Treinta y Tres | 13 | 229 | 572,500 | 6.0% | 345 | 862,500 | 5.5% |
| | **Total** | **156** | **3,845** | **9,612,500** | **100.0%** | **6,228.00** | **15,570,000** | **100.0%** |

Note: Excluded 2* refers to pixels whose location is within forestry areas.
Source: Authors

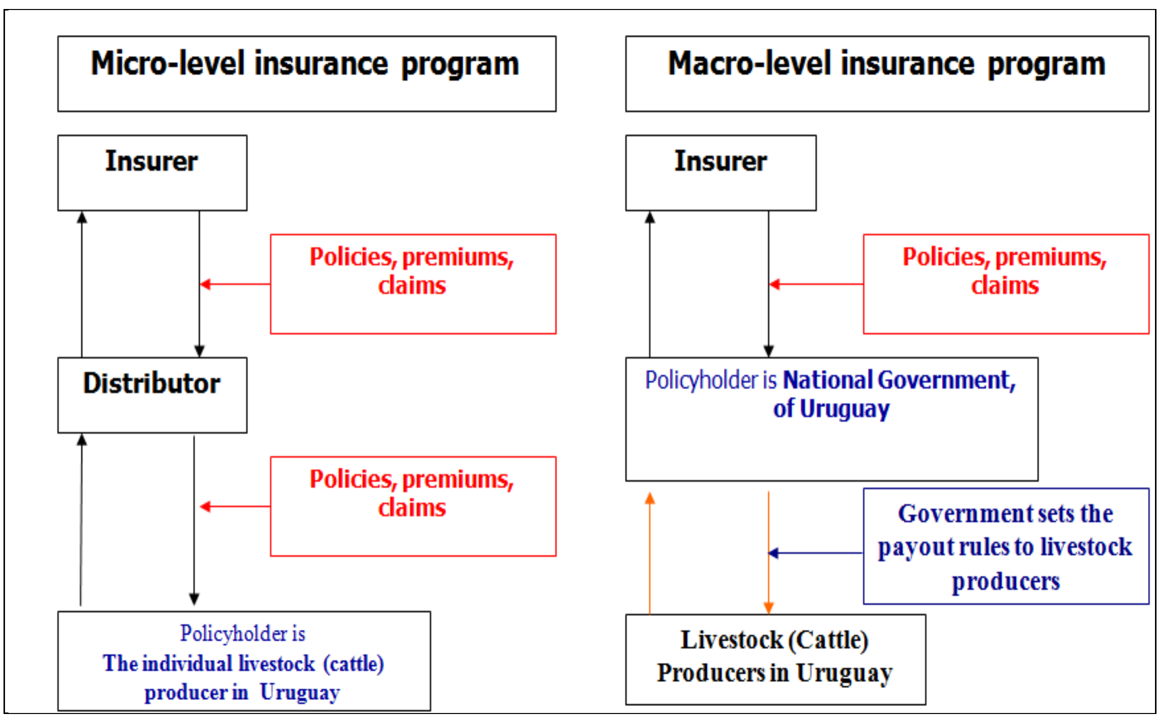
# 5. NDVI Pasture Index Insurance: Product Design and Rating

5.1. ***This Chapter presents full details of the proposed NDVI Pasture Index Insurance Product Cover Design and Rating Methodology for livestock (cattle) producers located in Uruguay.*** The first part of the Chapter presents the prototype cover design options and features. This is followed by a detailed description of the actuarial and rating methodology used to establish pure loss costs rates and adjusted technical rates for each of the cover design options and Insured Units. The final part of this section outlines the methodology used to establish the probable maximum loss (PML) expected on this NDVI program for different return periods.

### Insured Interest and Rationale for Macro-Level NDVI Cover

5.2. ***Parametric or index insurance is a very flexible agricultural insurance tool which can be designed to operate at different levels of aggregation ranging from the individual livestock producer through to the level of the national government.*** To start with, index cover can be offered to the individual farmer or livestock producer (termed micro-level insurance); at an intermediate level of aggregation the product can be designed to protect the financial interest of an agricultural service organization such as an input supplier, or a rural bank (termed meso-level insurance); and then finally, index insurance can be offered to regional or national governments to protect their financial interests in the event of major catastrophe loss events (termed macro-level insurance). The differences between micro-level and macro-level index insurance programs are illustrated in Figure 5.1.

**Figure 5.1. Comparison of Organizational Structure for Micro-Level and Macro-level NDVI Insurance program in Uruguay**




Source: Authors

5.3. ***In Uruguay, the first step in the design of the NDVI livestock pasture index insurance product was to define the insured interest.*** The insured interest is the interest that exists when an insured person derives a financial or other kind of benefit from the continued existence of the insured object. The insured interest is intrinsically linked with the objective of the coverage. For the purposes of this study the insurable interest was defined as that of the Government of Uruguay with regard to the cost of the financial assistance that it would have to provide to livestock producers in the event of natural or climatic disasters which seriously affect pasture and forage production in any region of Uruguay. Chapter 2 showed that currently these disaster relief payments are financed under the MGAP operated national Agricultural Emergency Fund (*Fondo Agropecuarios de Emergencias Agropecuarios*, FAE). In the 2008-09 drought, the MGAP distributed 30,400 metric tons of feed supplement to livestock producers, conservatively valued by the authors at US$ 6.1 million. The full cost to the cattle sector of buying-in additional feed supplements for a period of 5 months was estimated at US$ 64.5 million (nearly 260,000 tons of supplementary feed) with the beef cattle sector incurring additional feed costs of US$ 19.8 million or 31% of total and the dairy cattle sector costs of US$ 44.7 million or 69% of sub-total costs (Asociación Rural de Uruguay 2009).

5.4. ***There are several potential advantages for government of a Macro-level index insurance program over traditional ex-post disaster relief payments.*** These advantages include: (i) through the payment of an up-front premium, governments can transfer to the insurance market their unknown financial liability following a disaster in order to stabilize the fluctuation in the budget and (ii) because claims payments are triggered by an index following an insured event, financial claims can be rapidly settled to governments to pay on to their small farmers rather than waiting several months for in-field damage assessments to be completed and compensation funds to be made available either out of contingency budgets or from international aid donors.

5.5. ***The main objective of the Macro-level NDVI Pasture index based insurance coverage is to provide contingency payouts, based on the evolution of the NDVI index, to the Government of Uruguay (GoU)*** in order to provide timely assistance to the livestock herders in case of the occurrence of natural calamities and to avoid major losses for not acting in time. In other words, it is proposed that the NDVI pasture index cover would be a macro-level insurance product which would be bought by government as a financial instrument to protect its budget for emergency intervention in years of catastrophe (mainly drought) induced losses in the livestock sector and to ensure ex-ante timely payouts to livestock producers in areas where the quantity and quality of pasture is seriously reduced. Under the proposed macro-level insurance program, all ± 38,000 cattle producers located in the qualifying pasture areas of Uruguay would be automatically registered with the insurer(s) along with their individual livestock holding details (the number of cattle in each eligible category of livestock) and where the NDVI cover is triggered they would be the recipients of the financial payouts.

5.6. ***The alternative of offering micro-level or individual livestock producer voluntary pasture insurance was not considered technically or operationally feasible under the start-up phase of any new NDVI pasture index insurance program in Uruguay.*** With the current low resolution of the satellite imagery it is not possible to identify individual farmer's pasture fields or holdings, and their often very different pasture management practices, in order to offer individual farmer insurance. An additional drawback is that under an individual farmer scheme with an index resolution of 2,500 ha there is a potential for very high spatial basis risk namely, that the difference between the pasture quality as determined by the NDVI index for that pixel and the actual pasture quality in individual livestock producer's fields may be so high as to invalidate an individual cover (see Chapter 3 for earlier detailed discussion of the issue of basis risk). Further details of the individual livestock NDVI pasture index insurance option are included in Annex 4.

5.7. ***Another reason for developing a macro-level cover is that the local agricultural insurance companies in Uruguay indicated at an early stage of the feasibility Study that they did not have the experience or local networks to administer a voluntary individual farmer NDVI-pasture insurance program.*** These companies noted that the administrative costs of trying to promote and market individual farmer livestock insurance would be prohibitively expensive. In contrast, under the operation of a macro-level NDVI program where a single policy would be issued to Government, the payment of premium is made in a single installment and all eligible cattle livestock producers located in insurable forage resource pixels would be automatically included, which would result in major administrative costs savings to the insurers, and these savings could be passed on to the Insured in the form of a lower insurance premium. The insurance companies indicated they would only be willing to insure a macro-level NDVI insurance program issued to Government as the Insured in the start-up phase (see Chapter 6 for further discussion).

## Insured Unit and Definition of Homogeneous Risk Zones

5.8. ***The definition of the Insured Unit is critical for the design and operation of the NDVI insurance product.*** The Insured Unit is a pre-agreed geographical area of natural pasture and grazing which can be identified on the ground and for which the remote sensor takes an NDVI reading at an agreed time interval (every 16 days in the case of MODIS) and which forms the operational unit for determining whether insurance payouts are triggered or not according to the number of insured cattle each producer has located in that Insured Unit. As noted in Chapter 4 the NDVI database was developed at a resolution of 5 km x 5 km pixels (square grids) and a total of 4,001 pasture / forage resource pixels were classified under the mapping study and after final data quality control procedures to exclude pixels with unacceptably high levels of missing NDVI monthly data[26] a total of 3,845 pasture resource pixels were included in the insurance rating and risk assessment tool.

5.9. ***In Uruguay the selected Insured Unit for the operation of the Livestock-pasture NDVI index insurance program was the Police Section (Seccion Policial) which is an administrative unit at the sub-departmental level.*** The definition of the Insured Unit for this NDVI-pasture insurance program was based on two criteria: (i) definition of homogeneous risk zones and (ii) NDVI Insurance contract operational considerations. It was not deemed feasible to operate an NDVI insurance program in Uruguay with the individual 5 km x 5 km pixel as the Insured Unit given the very large number of pixels and the complications of (i) trying to establish a system of identifying and allocating livestock producers and their animals to these very small grids and (ii) the issue of basis risk of operating at this scale and (iii) the potentially high administrative costs of managing triggered payouts in the very large number of 3,845 pasture resource pixels. At the other extreme, the individual Department was considered far too large an Insured Unit given the evidence of variation in NDVI values between pixels located in a single department. In Uruguay, livestock census data and registers are held at Departmental-level and also at the sub-departmental level termed the Police Section (*Seccion Policial*), and from an operational viewpoint it was agreed by all stakeholders that the Police Section would be most realistic Insured Unit for the NDVI pasture insurance program. There are a total of 252 Police Sections in the 18 Departments under analysis, but the 3,845 pasture pixels included in the NDVI risk analysis are spread over a total of 195 Police Sections or an average of about 11 Police Sections analyzed per

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[26] Pixels with more than 6.7% of missing data in the 30-year time series were excluded from the final NDVI database.

Department: Canelones Department has the largest number or 20 Police Sections included in the risk analysis and San José the lowest number or 6 Police Sections analyzed (see column 3 of Table 5.2).

5.10. ***In order to test whether the "Police Section" would form a sufficiently homogenous risk zone for the operation of the NDVI pasture-insurance program, a statistical cluster analysis was conducted on the LART-FAUBA time series NDVI data base using SPSS software.*** The cluster analysis was applied to the historical monthly average NDVI values for each selected pixel to establish groups or clusters of adjacent pixels with similar NDVI values and which comprise a Homogenous Risk Zone (HRZ). For the given NDVI sample data, the parameters that were considered for the cluster analysis were: (i) The Centroid as the method of similarity to create the clusters; and (ii) The Square Euclidean Distance which is the formula that estimates the distance among variables. The steps in the cluster analysis are illustrated in Figure 5.2.a and 5.2.b for the Police Section number 2 (SP2) in Florida with 7 pixels where the cluster analysis produced a best fit of 2 HRZs one with 6 pixels, the other with 1 pixel. It is important to note that, even though the risk analysis was focused on a specific 7-month period of the year (September to December; January to March), variables from all months were used for completing the cluster analysis mentioned above. This analysis produced a total of 363 HRZs across the 195 Police Sections included in the analysis (see Table 5.2).

**Figure 5.2.a. Decisive pixel classification based on a centroid cluster as a hierarchical cluster method (Police Section 2, Florida Department)**

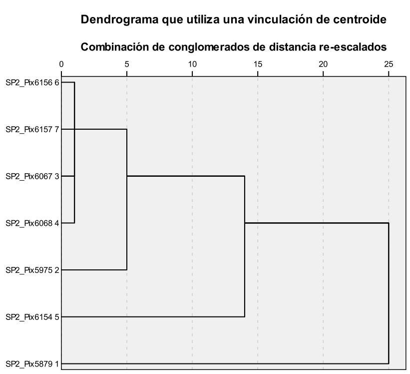
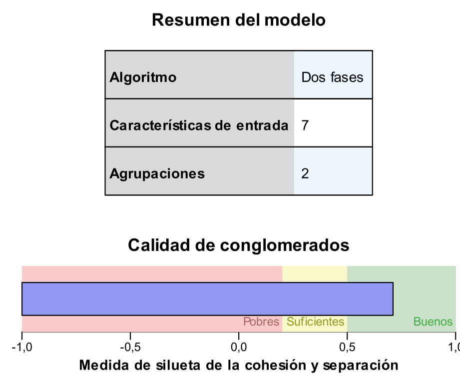



**Figure 5.2.b. Two Step Cluster Summary analysis and Cluster Quality Example (Police Section 2, Florida Department)**

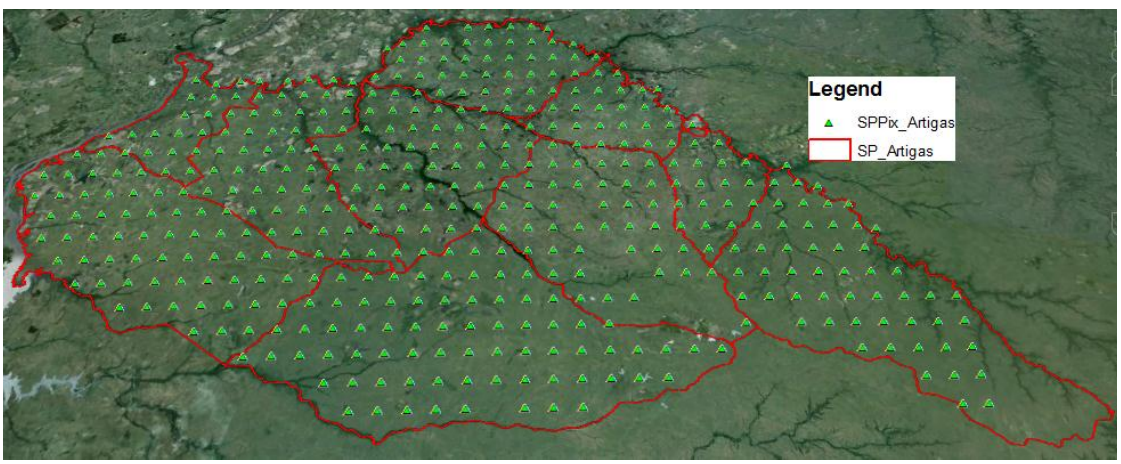



Source: Authors' analysis

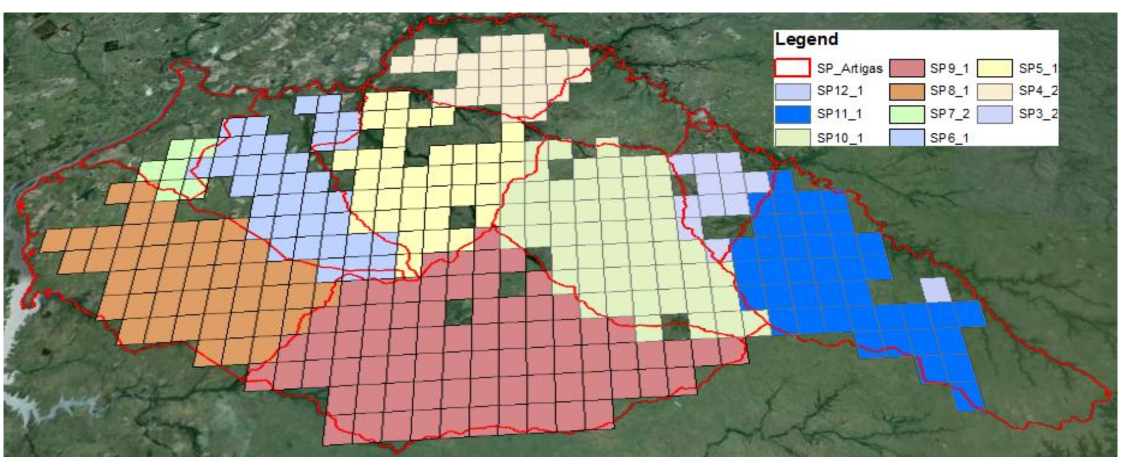
5.11. ***The results of the clustering process showed that the homogeneous risk area of the clustered pixels with similar NDVI signature values was often very similar to the area of the Police Section.*** This is illustrated in Figure 5.3 and Table 5.1 for Artigas Department, which shows the variation in the 367 individual pasture / forage resource pixel NDVI values within the ten "qualifying" Police Sections located in this department. A "qualifying" Police Section must have a minimum of one Homogeneous Risk Zone or Cluster of pasture resource pixels with > 60% of the pixel area classified as being forage resources and less than 6.7% missing monthly NDVI data over the past 30 years, and also registered breeding cows located in the HRZ according to the DICOSE 2011 livestock data base. In most of the ten qualifying Police Sections in Artigas Department the NDVI values are very homogeneous across pixels and therefore there is one dominant HRZ in each Police Section accounting for nearly all the pasture area. In most of the other departments, the results of the cluster analysis are similar to Artigas suggesting that the Police Section is a suitable size of Insured Unit for the operation of the NDVI program. There are, however, exceptions to this rule and in some departments, there are is considerably more variation in the NDVI values between HRZs within a single Police Section. For example in Tacuarembo Department, Police Section 4 has a total of 19 pixels and the cluster analysis produced two HRZs, SP4-1 with 13 pixels (68% of total area) and SP4-2 with 6 pixels (32% of area) and in Florida Department, Police Section 3 has 14 pixels split into SP3-1 with 5 pixels (36%) and SP3-2 with 9 pixels (64% of pixels). In these Police Sections in Tacuarembo and Florida it would probably be more accurate to subdivide the Police Section into two separate HRZs for the purposes of the NDVI insurance program. At this initial stage it would, however, be difficult to operate an insurance program with such a level of spatial detail (disaggregation) and with Insurance Units smaller than the Police Section for a number of operational reasons, including the fact that a farm-level census would be required to re-register each and every livestock holding according to the number of animals located in each Insured Unit. This potential issue should, however, be closely monitored during the start-up implementation of any NDVI program in Uruguay.

**Figure 5.3. NDVI Risk Zoning for Artigas Department**

**(a) Artigas is comprised of 12 Police Sections and includes 423 Pixels (5km x 5 km)**




**(b) Artigas showing 10 qualifying Police Sections comprising 367 pasture resource Pixels**




Source: Authors' analysis of NDVI Data Base

**Table 5.1. Cluster Analysis to identify Homogeneous Risk Zones, Artigas Department**

| Police Section | Homogeneous Risk Zone 1 | No. Pixels in HRZ | Homogeneous Risk Zone 2 | No. Pixels in HRZ | Total No. Pixels in Police Section | Excluded Homogeneous Risk Zones | No. Excluded Pixels |
|---|---|---|---|---|---|---|---|
| SP3 | SP3_1 | 3 | SP3_2 | 11 | **16** | SP3_1 | 3 |
| SP4 | SP4_1 | 4 | SP4_2 | 28 | **33** | SP4_1 | 4 |
| SP5 | SP5_1 | 37 | SP5_2 | 1 | **39** | SP5_2 | 1 |
| SP6 | SP6_1 | 36 | SP6_2 | 1 | **38** | SP6_2 | 1 |
| SP7 | SP7_1 | 1 | SP7_2 | 6 | **7** | Sp7_1 | 1 |
| SP8 | SP8_1 | 47 | SP8_2 | 1 | **48** | SP8_2 | 1 |
| SP9 | SP9_1 | 75 | SP9_2 | 1 | **76** | SP9_2 | 1 |
| SP10 | SP10_1 | 52 | SP10_2 | 2 | **54** | SP10_2 | 2 |
| SP11 | SP11_1 | 41 | SP11_2 | 1 | **42** | SP11_2 | 1 |
| SP12 | SP12_1 | 18 | SP12_2 | 1 | **19** | SP12_2 | 1 |
| | Total | **314** | | **53** | **372** | | **16** |

Source: Authors' analysis of NDVI database

5.12. ***In the start-up phase of the NDVI pasture insurance program in Uruguay it is therefore recommended that the "Police Section" should be adopted as the Insured Unit.*** This means that in practice the most representative homogeneous risk zone (HRZ) or cluster of pixels is selected for each Police Section and the monthly NDVI values for each pixel in this representative HRZ zone are averaged to provide a single average NDVI value for that Police Section and both premium rates and insurance payouts are calculated for this representative HRZ in each Police Section.

5.13. ***Uruguay has a total of 252 Police Sections in the 18 Departments included in this study, of which 195 Police Sections (Insured Units) were classified by this study as meeting the minimum requirements of insurability (in terms of the area pasture / forage resources plus they are cattle breeding areas) and are therefore insurable under the proposed pasture NDVI Insurance program***. Under this NDVI study, Pixels and Police Sections that were not classified as being pasture/forage resource areas for livestock production and grazing were excluded from the analysis so that the final NDVI database contains a total of 195 qualifying Police Sections representing 3,845 pasture / forage resource pixels and a maximum pasture area of about 9.6 million hectares. The average pasture area per Police Section is about 49,000 Ha. There is, however, considerable variation across Departments in the average pasture area per Police Section ranging from an average low of 14,375 Ha per Police Section in Canelones to an average high of 87,115 Ha per Police Section in Salto Department (Table 5.2).

**Table 5.2. Summary of Pasture Resources Pixels, and Pasture Insured Units (Police Sections) per Department, Uruguay**

| Department | Total No. of Police Sections per Dept.[1] | No. of Excluded Police Sections | No. of Qualifying Police Sections in NDVI Program | Final No. of Pasture / Forage Resource Pixels | Average Number of Pasture Resource Pixels per Qualifying Police Section | Maximum Pasture Area / District (Ha) | Average Pasture Area per Police Section (Ha) |
|---|---|---|---|---|---|---|---|
| Artigas | 12 | 2 | 10 | 367 | 37 | 917,500 | 91,750 |
| Canelones | 27 | 7 | 20 | 115 | 6 | 287,500 | 14,375 |
| Cerro Largo | 16 | 4 | 12 | 342 | 29 | 855,000 | 71,250 |
| Colonia | 17 | 9 | 8 | 55 | 7 | 137,500 | 17,188 |
| Durazno | 15 | 2 | 13 | 304 | 23 | 760,000 | 58,462 |
| Flores | 9 | 1 | 8 | 127 | 16 | 317,500 | 39,688 |
| Florida | 16 | 2 | 14 | 310 | 22 | 775,000 | 55,357 |
| Lavalleja | 13 | 0 | 13 | 294 | 23 | 735,000 | 56,538 |
| Maldonado | 13 | 4 | 9 | 86 | 10 | 215,000 | 23,889 |
| Paysandú | 13 | 2 | 11 | 277 | 25 | 692,500 | 62,955 |
| Río Negro | 12 | 5 | 7 | 72 | 10 | 180,000 | 25,714 |
| Rivera | 9 | 1 | 8 | 167 | 21 | 417,500 | 52,188 |
| Rocha | 11 | 0 | 11 | 196 | 18 | 490,000 | 44,545 |
| Salto | 16 | 3 | 13 | 453 | 35 | 1,132,500 | 87,115 |
| San José | 10 | 4 | 6 | 81 | 14 | 202,500 | 33,750 |
| Soriano | 12 | 5 | 7 | 41 | 6 | 102,500 | 14,643 |
| Tacuarembó | 16 | 1 | 15 | 329 | 22 | 822,500 | 54,833 |
| Treinta y Tres | 11 | 1 | 10 | 229 | 23 | 572,500 | 57,250 |
| **TOTAL** | **248** | **53** | **195** | **3,845** | **20** | **9,612,500** | **49,295** |

[1] Police Sections with breeding cows according to DICOSE 2011

Source: Authors analysis of Uruguay NDVI Database

## Definition of the Cover Period for the NDVI Pasture Insurance Program

5.14. ***The NDVI Pasture policy cover period is designed to match the periods of normal pasture growth and peak vegetative biomass productivity in Uruguay and when extreme drought will severely impact on the available pasture and grazing for the predominantly breeding cattle herds in Uruguay*** In Uruguay Bermúdez and Ayala (2005)[27] report that the peak growth rates in natural pasture and grazing are in spring (September to November) which commences with increasing rainfall and temperatures, and in summer (December through February). An NDVI pasture-insurance cover is intended to provide protection during these peak pasture growth periods. The cover is not, however, designed to insure pasture and grazing lands in the autumn and winter months from April to August when pasture vigor and growth is normally low.

5.15. ***On the basis of discussions with the livestock industry in Uruguay, a seven month cover period was finally selected for the NDVI pasture Index insurance program starting in September and running through to March in the subsequent year.*** During the conduct of the feasibility study the cover period was refined on the basis of discussions with livestock technicians and beef cattle breeders in Uruguay. Initially a single four month spring cover period from September to December was identified by the livestock industry, but in further discussion

[27] See http://prodanimal.fagro.edu.uy/cursos/PASTURAS%20CRS/26%20-%20Pasturas%20Naturales.pdf

they noted a second critical period of pasture production in summer (January to March) when drought can have very adverse implications for livestock producers because it means that they enter the autumn and winter months with no pasture or forage stocks.

5.16. ***In Uruguay, the spring cover period from September to end November coincides with the period when the demand by beef cattle for pasture production and grazing is at the most critical stage.*** The reason for the selection of this cover period is because it is the most critical period for cattle rearing production systems in Uruguay. Cattle production systems in Uruguay are synchronized in such way that the period of highest nutritional requirement of the herd matches the period of highest productivity of forage. During this spring period of the year the cows, which are currently calving, then enter into the breeding season; thus the nutritional demand of the herd is at its highest level. The occurrence of an event affecting forage production during spring not only reduces the pregnancy rates in cows and therefore the calving rate, but will also generate disturbances for the forthcomings herd production cycles. The second period of peak demand by cattle for fodder in January to March coincides with the period when the cows are suckling their calves and require large quantities of high quality pasture and grazing to produce milk[28].

5.17. ***Under the proposed macro-level NDVI pasture Index Insurance Cover, the GoU (Insured) may elect to purchase cover for the proposed full seven month period September to March inclusive, or if it prefers to restrict cover to the four month spring period only from September to end December.*** The excel rating tool which has been designed by the World Bank team in conjunction with OPYPA is programmed to enable underwriters to calculate sums insured and pure rates and technical premium rates for either the spring only or spring and summer seasons (see Rating section for further discussion).

## Insured Categories of Cattle and Numbers of Insured Animals in Uruguay

5.18. ***In 2011, the national cattle herd in Uruguay was 11.2 head of cattle of which there were 4.0 million head of breading cattle (36% of total animals),*** followed by Calves (2.7 million head; 24% of total), bullocks (2.4 million head, 21% of total) and heifers (1.6 million head; 15% of total). These figures are based on the National Service for Livestock (SNIG) / DICOSE 2011 statistics which are fully reported in Chapter 2, Table 2.1**.**

5.19. ***Under the proposed NDVI pasture index insurance program, the key stakeholders agreed that the primary objective of the insurance program should be to protect the <u>Breeding Cows ("Vaca de Cria")</u> in the event of severe drought induced pasture and fodder shortages.*** On the basis of the 2011 SNIG/DICOSE figures in Table 5.3, this would imply up to a maximum of about 4.0 million breeding cows. The rationale of the livestock industry for insuring breeding cows only is that in periods of severe fodder scarcity and when it is necessary to reduce stocking densities it is essential to maintain the breeding herd rather than lower value calves and bullocks and which are much cheaper and easier to replace than the breeding cows. By maintaining the breeding cows, livestock producers are able to recover much more quickly after the end of a severe drought. In previous discussions over the past 2 years, the stakeholders identified a need to

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[28] Under the separate Argentina NDVI feasibility study, the livestock industry finally selected two three month cover periods Spring, 3-month cover period from September to end November to coincide with calving and then in Autumn, 3-months from March to end May when the cows need to be fattened before entering the winter season (World Bank 2012).

also insure heifers aged 1-2 and more than 2 years old which would add another 1.63 million head of cattle to the insurance program (see Table 2.1). The addition of heifers would, however, significantly increase the sums insured and capacity requirements on this national cattle NDVI insurance program as well as the premium payable by government: it was therefore decided in the start-up phase to concentrate solely on insuring breeding cattle and over time as experience is built up with the product to consider adding heifers.

5.20. ***The proposed NDVI Program can only insure breeding cows in Police Sections where there is an adequate density of pasture resources (pixels with at least 60% of the area under pasture and no more than 6.7% of missing data) for the NDVI policy to operate.*** Using the DICOSE 2011 geo-referenced (by latitude and longitude) individual livestock holding data, the study team has allocated all the 2011 registered breeding cows to the Insurable Police Sections which have an adequate density of pasture resource pixels. A summary is presented below which shows that of the total of 4,004,582 million registered breeding cows in Uruguay in 2011, a total of 3,868,089 or 97% of total could be insured under the NDVI program as they are located in Insurable Police Sections (see Table 5.3 and Table 5.4. and Figure 5.4). For livestock owners whose farms are located outside the insurable areas (Insured Units) alternative mechanisms for compensating them in the event of severe droughts will have to be considered. The most important Departments with more than 0.36 million head of insurable breeding cows include Tacuarembo (9.4% of all breeding cows), followed by Cerro Largo (8.8%), Salto (8.2%), Florida (7.4%), Rocha (7.0%), Artigas (6.9%), Durazno (6.9%), and Lavalleja (6.4%). Reference to Figure 5.4 shows that most of these important cattle breeding departments are located in northern and central Uruguay.

**Table 5.3. Total Number of Breeding Cattle registered with DICOSE and Total Number of Insurable Breeding Cattle by Department (2011 statistics)**

| Department | Total No. of Breeding Cows registered with SNIG/DICOSE in 2011 | Total No. of Insured Breeding Cows included in NDVI program | % Insurable Breeding Cows |
|---|---|---|---|
| **Artigas** | 266,746 | 266,666 | 100.00% |
| **Canelones** | 81,768 | 80,910 | 99.00% |
| **Cerro Largo** | 345,170 | 340,069 | 98.50% |
| **Colonia** | 147,124 | 90,002 | 61.20% |
| **Durazno** | 267,227 | 267,095 | 100.00% |
| **Flores** | 119,986 | 119,970 | 100.00% |
| **Florida** | 288,477 | 286,450 | 99.30% |
| **Lavalleja** | 248,028 | 248,028 | 100.00% |
| **Maldonado** | 108,703 | 104,088 | 95.80% |
| **Montevideo** | 799 | 0 | 0.00% |
| **Paysandù** | 265,994 | 265,954 | 100.00% |
| **Río Negro** | 147,191 | 126,326 | 85.80% |
| **Rivera** | 247,005 | 245,064 | 99.20% |
| **Rocha** | 270,835 | 270,835 | 100.00% |
| **Salto** | 317,349 | 316,916 | 99.90% |
| **San José** | 140,605 | 124,822 | 88.80% |
| **Soriano** | 124,638 | 98,166 | 78.80% |
| **Tacuarembó** | 364,794 | 364,594 | 99.90% |
| **Treinta y Tres** | 252,143 | 252,134 | 100.00% |
| **Total** | **4,004,582** | **3,868,089** | **96.60%** |

Source: DICOSE 2011 livestock statistics; Authors' NDVI Rating Tool

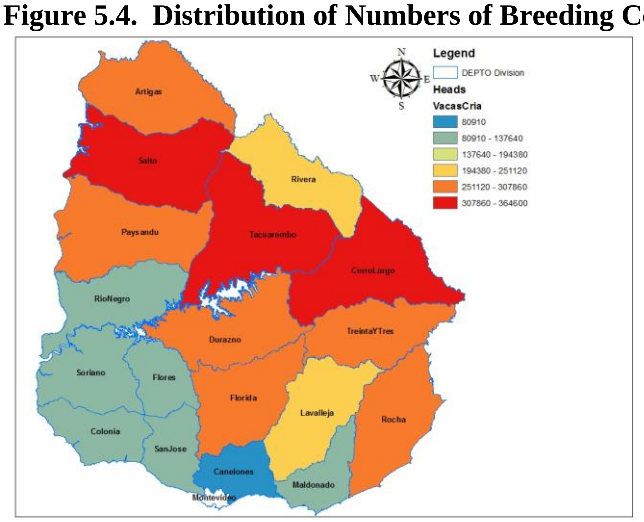
5.21. ***Livestock (cattle) holding capacities vary by Department across Uruguay***. Table 5.4. shows the average pasture area per Police Section (based on the criterion that greater than 60% of the area of each pixel must be devoted to pasture and grazing) and then the average number of breeding cows per hectare and which varies from an average high density of 1 breeding cow per hectare in Soriano in South Western Uruguay to an average low stocking density of over 1 cow per more than 3.0 Ha in the northern departments of Artigas, Salto and Canelones where soil are poor and where pasture and grazing quality are equally low. Table 5.4 also shows that there is a wide range in the minimum and maximum number of insured breeding cattle in a single Police Section in each department. The distribution of breeding cows by Police Section is shown in Figure 5.5.

**Table 5.4 Summary of Insurable Breeding Cows per Department and Police Section (2011 figures)**

| Department | No. of Insurable Police Sections in NDVI Program | Maximum Pasture Area / District (Ha) | Average Pasture Area per Police Section (Ha) | Average pasture Area per insurable Breeding cow (Ha/Cow) | Minimum No. Breeding Cows per Police Section | Maximum No. Breeding Cows per Police Section | Total No. of Insured Breeding Cows | % of Total Insured Breeding Cows per Dept. |
|---|---|---|---|---|---|---|---|---|
| Artigas | 10 | 917,500 | 91,750 | 3.4 | 4,849 | 43,436 | 266,666 | 6.9% |
| Canelones | 20 | 287,500 | 14,375 | 3.6 | 93 | 12,517 | 80,910 | 2.1% |
| Cerro Largo | 12 | 855,000 | 71,250 | 2.5 | 9,344 | 47,722 | 340,069 | 8.8% |
| Colonia | 8 | 137,500 | 17,188 | 1.5 | 1,877 | 20,998 | 90,002 | 2.3% |
| Durazno | 13 | 760,000 | 58,462 | 2.8 | 4,030 | 37,429 | 267,095 | 6.9% |
| Flores | 8 | 317,500 | 39,688 | 2.6 | 5,316 | 29,311 | 119,970 | 3.1% |
| Florida | 14 | 775,000 | 55,357 | 2.7 | 7,899 | 34,665 | 286,450 | 7.4% |
| Lavalleja | 13 | 735,000 | 56,538 | 3.0 | 6,620 | 28,532 | 248,028 | 6.4% |
| Maldonado | 9 | 215,000 | 23,889 | 2.1 | 445 | 22,325 | 104,088 | 2.7% |
| Paysandú | 11 | 692,500 | 62,955 | 2.6 | 1,147 | 46,169 | 265,954 | 6.9% |
| Río Negro | 7 | 180,000 | 25,714 | 1.4 | 9,945 | 27,230 | 126,326 | 3.3% |
| Rivera | 8 | 417,500 | 52,188 | 1.7 | 2,023 | 49,823 | 245,064 | 6.3% |
| Rocha | 11 | 490,000 | 44,545 | 1.8 | 6,166 | 42,566 | 270,835 | 7.0% |
| Salto | 13 | 1,132,500 | 87,115 | 3.6 | 1,506 | 40,146 | 316,916 | 8.2% |
| San José | 6 | 202,500 | 33,750 | 1.6 | 12,052 | 34,409 | 124,822 | 3.2% |
| Soriano | 7 | 102,500 | 14,643 | 1.0 | 7,814 | 18,066 | 98,166 | 2.5% |
| Tacuarembó | 15 | 822,500 | 54,833 | 2.3 | 1,908 | 46,152 | 364,594 | 9.4% |
| Treinta y Tres | 10 | 572,500 | 57,250 | 2.3 | 4,258 | 39,526 | 252,134 | 6.5% |
| **TOTAL** | **195** | **9,612,500** | **49,295** | **2.5** | | | **3,868,089** | **100.0%** |

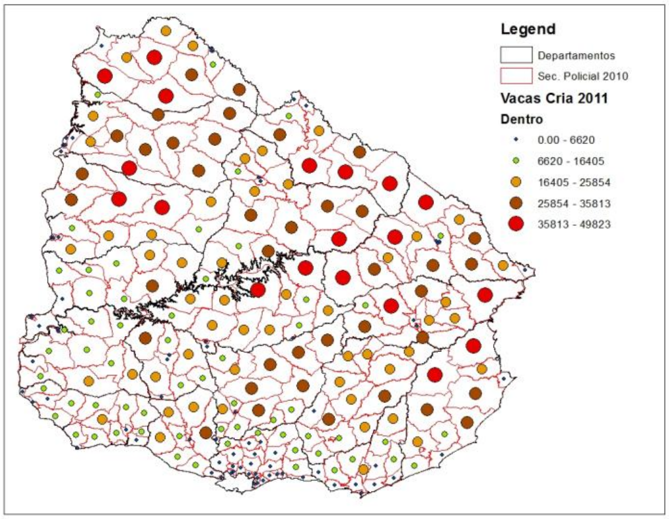
Source: Authors' analysis of SNIG/DICOSE 2011 livestock Data

**Figure 5.4. Distribution of Numbers of Breeding Cows by Department (2011)**




Source: Authors' analysis of DICOSE 2011 livestock Data

**Figure 5.5. Distribution of Numbers of Breeding Cows by Police Section (2011)**




Source: Authors' analysis of DICOSE 2011 livestock Data

## Basis of Valuation and Sum Insured

### Basis of Valuation

5.22. ***The basis of valuation and the sum insured is determined according to the nutritional requirements of the insured cattle during the insurance cover period and assuming the animals are fed on supplementary feed rations that can be purchased locally in the Uruguayan market in times of natural grazing scarcity.*** This insurance program uses the daily and monthly nutritional requirements of Breeding Cows which are considered equivalent to one Livestock Units (LU). For the purposes of calculating the sum insured the supplementary feed requirements for 1 LU have been based on the actual feed rations that MGAP distributed to livestock producers in the extreme drought of 2008. This emergency feed ration was based on a 4 kilogram per day ration of sunflower pellets and wheat bran mixed in a ratio of 25% sunflower pellets to 75% wheat bran. At 2012 prices per metric tonne the mixed cattle feed ration would cost US$ 0.775 per LU per day or US$ 23.5 per LU per month (Table 5.5.). It is noted that the NDVI rating model is programmed to permit the user to easily change the insured price of this supplementary feed mix to reflect current 2013 prices. Equally the feed supplements can be changed if required by the end user.

5.23. ***For the 7-month insurance cover period, the total cost of providing supplementary feed is estimated at US$ 163 per breeding cow.*** The basis of establishing these costs is shown in Table 5.5 where the cost per day of US$ 0.775 is then calculated over the 7 month (210 day) insurance cover period to give a total cost of feeding one breeding cow is US$ 162.75. The NDVI rating tool is programmed to calculate the supplementary feed cost requirements of other classes of cattle in case GoU wish to insure these in future: for example the nutritional requirements of heifers were advised by local livestock specialists as being 0.8 times that of an adult breeding cow and as such the costs of feeding a heifer would be US$ 0.62 per day, US$ 18.6/month and US$ 130.2 for the 7 month insurance cover period.

5.24. ***The purpose of this NDVI insurance cover is not, however, to offer full value protection for 100% of the breeding cow's nutritional requirements during the cover period, as***

***this may act as a disincentive for the producer to manage his livestock and to maintain fodder reserves and or to preserve his grazing lands***. Furthermore losses in pasture are usually progressive losses over a period of time (for example due to drought) during which it would be incorrect to compensate 100% of the cow's nutritional requirements. For these reasons it is recommended that the monthly sum insured per animal be set at 50% of the monthly and total nutritional requirements which would be equal to a sum insured value per breeding cow (LU) of US$ 11.63 per month and US$ 81.38 for the 7 month cover period (Table 5.5.). This basis of valuation and the 50% sum insured cover level was discussed with and agreed by MGAP, the insurance companies and representatives of the livestock sector in Uruguay during the design of the NDVI program. The NDVI Rating tool is, however, programmed to permit the user to amend the cover period (months) and the sum insured level as required.

**Table 5.5. Basis of Calculation of the Daily and Monthly Sum Insured for Breeding Cows (US$)**

| Cattle supplementary feed based on 2008 drought rations | Sunflower flour | | Wheat bran | | Feed per day per LU | Cost per day per LU (US$) | Cost per month per LU (US$) |
|---|---|---|---|---|---|---|---|
| | % of ration | Price(US$/MT) | % of ration | Price(US$/MT) | | | |
| | 25% | 235.00 | 75% | 180.00 | 4 kg. | **0.775** | **23.250** |

| | Sep | Oct | Nov | Dec | Jan | Feb | Mar |
|---|---|---|---|---|---|---|---|
| Cover % | 50% | 50% | 50% | 50% | 50% | 50% | 50% |
| **Monthly Sum Insured per LU (US$)** | 11.625 | 11.625 | 11.625 | 11.625 | 11.625 | 11.625 | 11.625 |

| | |
|---|---|
| **Total Sum Insured per Breeding Cow (LU) for 7 month cover period (US$)** | **81.375** |

Source: Authors' NDVI Rating Database and Model (See Annex 3)

## Total Sum Insured

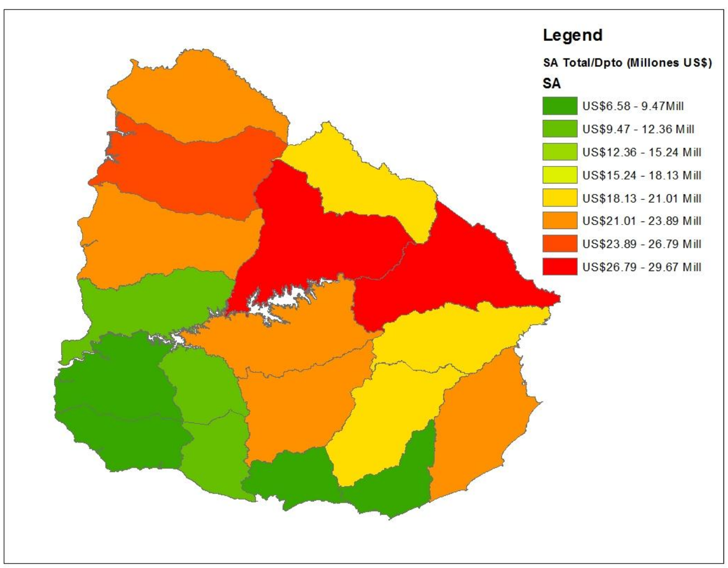
5.25. ***The total sum insured for the Macro-level NDVI insurance program for breeding cattle only in Uruguay is estimated at about US$ 315 million.*** The total sum insured is calculated on the basis of the number of insurable breeding cows in each Insured Unit valued according to the monthly sum insured value for the 7 month cover period. The sums insured per Department and in Total are shown in Table 5.6 and Figure 5.6. There is a relatively good spread of risk (insured liability) across the 18 departments of Uruguay included in the analysis with the highest sum insured of US$ 29.7 million in Tacuarembo Department (9% of total liability) and the lowest sum insured in Canelones Department of US$ 6.6 million (2% of total liability). Full details of the basis of valuation and estimation of the sum insured are presented in Annex 3 and in the excel-based NDVI rating tool for Uruguay which accompanies this report. The rating tool is enabled to allow the user to change the sum insured levels from 0% to 100% of the estimated costs of supplementary feed for the desired cover period.

**Table 5.6. Uruguay Estimated Total Sum Insured by Department for 7 Month NDVI Insurance Cover (US$)**

| Department | Total No. of Insured Breeding Cows | Minimum Sum Insured per Police Section US$ | Maximum Sum Insured per Police Section US$ | Total Sum Insured per Department US$ | % of Total Sum Insured |
|---|---|---|---|---|---|
| Artigas | 266,666 | 394,587 | 3,534,605 | 21,699,946 | 6.89% |
| Canelones | 80,910 | 7,568 | 1,018,571 | 6,584,051 | 2.09% |
| Cerro Largo | 340,069 | 760,368 | 3,883,378 | 27,673,115 | 8.79% |
| Colonia | 90,002 | 152,741 | 1,708,712 | 7,323,913 | 2.33% |
| Durazno | 267,095 | 327,941 | 3,045,785 | 21,734,856 | 6.91% |
| Flores | 119,970 | 432,590 | 2,385,183 | 9,762,559 | 3.10% |
| Florida | 286,450 | 642,781 | 2,820,864 | 23,309,869 | 7.41% |
| Lavalleja | 248,028 | 538,703 | 2,321,792 | 20,183,279 | 6.41% |
| Maldonado | 104,088 | 36,212 | 1,816,697 | 8,470,161 | 2.69% |
| Paysandú | 265,954 | 93,337 | 3,757,002 | 21,642,007 | 6.88% |
| Río Negro | 126,326 | 809,274 | 2,215,841 | 10,279,778 | 3.27% |
| Rivera | 245,064 | 164,622 | 4,054,347 | 19,942,083 | 6.34% |
| Rocha | 270,835 | 501,758 | 3,463,808 | 22,039,198 | 7.00% |
| Salto | 316,916 | 122,551 | 3,266,881 | 25,789,040 | 8.19% |
| San José | 124,822 | 980,732 | 2,800,032 | 10,157,390 | 3.23% |
| Soriano | 98,166 | 635,864 | 1,470,121 | 7,988,258 | 2.54% |
| Tacuarembó | 364,594 | 155,264 | 3,755,619 | 29,668,837 | 9.43% |
| Treinta y Tres | 252,134 | 346,495 | 3,216,428 | 20,517,404 | 6.52% |
| **TOTAL** | 3,868,089 | | | 314,765,742 | 100.00% |

Source: Authors analysis, Livestock NDVI Rating Data-base

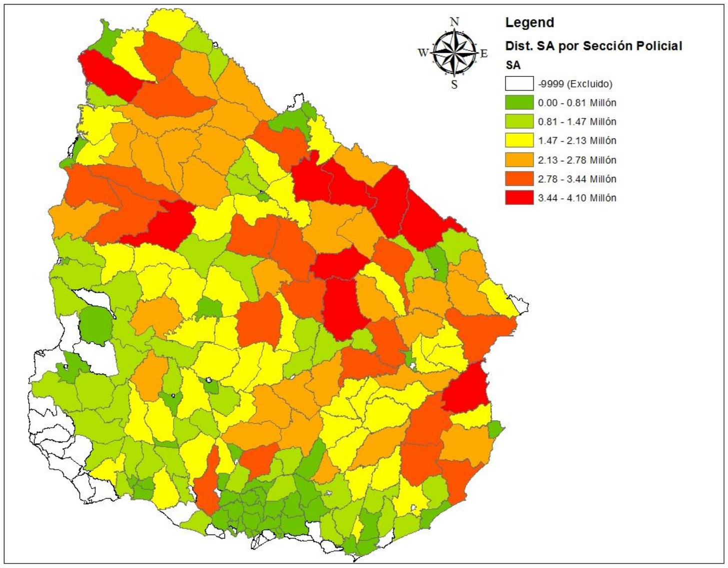
**Figure 5.6. Distribution of NDVI Total Sum Insured by Department (US$ Million)**




Source: Authors analysis, Livestock NDVI Rating Data-base

5.26. ***There is a wide range in the sum insured per Police Section (Insured Unit) within each Department*** varying from a minimum of US$ 7,568 in Police Section Number 16 (SP16) in Canelones Department to a maximum of US$ 4.0 million in Police Section Number 6 (SP6) of Rivera Department (Table 5.6 and Figure 5.7).

**Figure 5.7. Distribution of NDVI Sum Insured by Police Section (US$ Million)**




Source: Authors analysis, Livestock NDVI Rating Data-base

## Definition of the Insured Event and Basis of Insurance Payouts

5.27. ***The definition of the insured event is critical for the design of the NDVI index based insurance policy for Uruguay and to ensure that the triggered payouts represent as accurately as possible the pasture quantity and quality losses experienced on the ground.*** The insured event for a NDVI index based pasture insurance product can be defined by two parameters, the duration of the event and the intensity of the event.

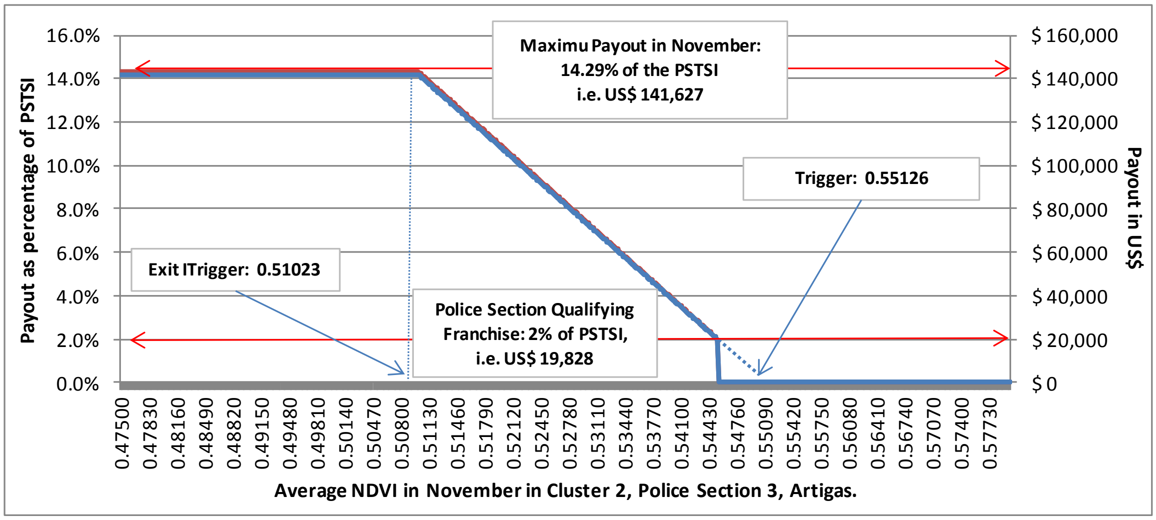
5.28. ***In the design phase of this NDVI product two different options for the definition of duration of the insured event affecting forage production were considered.*** The first option for the duration of the insured event was defined as "two or more consecutive months within the cover period during which the actual NDVI values fall short of the NDVI trigger values leading to an insurance payout". The second option was defined as "the occurrence of one or more months within the period of coverage during which the actual NDVI values fall short the NDVI trigger values leading to an insurance payout". Under the two consecutive month option for defining the insured event, there would be an additional time-lag of at least 30 days for the NDVI values to be accessed and analyzed by the appointed Remote Sensing Operator (see Chapter 6) and for the Insurer(s) to process the claim and to approve a payment to the Insured (Government) and the final recipients of the coverage (livestock producers in the triggered Police Sections) – or a total of 3 months since the onset of the drought event and the deterioration of the quantity and quality of pasture and grazing in the affected insured unit. Livestock producers noted that the three month delay to receive insurance payouts was far too long and that by that time they would have been forced to sell large numbers of their livestock. They indicated their strong preference for the second option whereby a payout would be made in any month where the defined NDVI threshold was triggered. For this reason the final version of the NDVI product has been designed to make payouts in any month during the seven month cover period if the defined trigger-levels are exceeded.

5.29. ***The intensity of the insured event leading to a payout is defined by the NDVI threshold triggers that are set in each month of the cover period.*** The opening or "threshold trigger" was calculated according to the probability distribution of the NDVI values in each month over the 30 years and the frequency with which payouts would be triggered according to a pre-determined return period. For example if the Trigger Index return period is set at 1 in 10 years, the NDVI index value is selected so that it will trigger a payout 1 in 10 years for the selected month: this would be equivalent to three payouts (in that month of the cover period) over the 30 years of historical data. Conversely if the return period is set at 7 years, this will result in a higher frequency of 4 triggered payouts for the selected month over the 30 year period. The Threshold Trigger NDVI value can be calculated using two methods: (i) according to the monthly historical distribution over the 30 years of available monthly NDVI data, or (ii) by a parametric probability method where the NDVI data is calibrated to a normal distribution. The Excel-based NDVI Rating Tool is programmed to permit the user to select different payout return periods according to the user's requirements and also to select the historical distribution or normal distribution method to select the NDVI threshold trigger leading to a payout (see Annex 3 for full details of the Index Trigger procedures).

5.30. ***The definition of the payouts of the index based insurance products must be aligned with the objectives of the coverage and with the insured interest.*** The payout system must also reflect the duration and the severity of the insured event. Two types of payout system were tested under the NDVI study. The first payout system considered for Uruguay was based on a monthly lump sum amount which is paid to the Insured if the Threshold trigger is hit, leading to an insurance payout in that month. This lump sum amount is equal to the full sum insured for the month in which a payout is triggered. The second payout system considered for Uruguay was based on a linear payout scale which makes graduated payments according to the actual NDVI value for that month up to a minimum NDVI value termed the Exit Trigger when it is assumed that a total loss has occurred and the maximum payout equal to 100% of the sum insured for that month is paid out. The graduated payout scale is commonly referred to as the "Increment" or "tick" in index insurance circles. The Exit Trigger level was set at 1 standard deviation below the Threshold Trigger for each Police Section and each month; however the Uruguay NDVI rating tool is very flexible and includes both payout systems and enables the user to select the desired Exit Trigger value in each month in terms of the number of standard deviations below the Trigger. Figure 5.8 presents an example of the payout scale for the Uruguay NDVI index.

5.31. ***For the purposes of the Uruguay NDVI pasture Index policy, it is recommended that a qualifying franchise be adopted in order to eliminate very small triggered payouts.*** The analysis shows that with a NDVI policy which is designed to make payouts on a monthly basis there is a high frequency of very small triggered payouts across the 195 Police Sections in the 18 Departments under analysis. These may amount to a few hundred dollars per Police Section and it would cost more to settle the payments of a few dollars to each of the several hundred individual livestock producers registered in each Police Section than the value of the payments to these producers. For this reason three qualifying franchises have been incorporated into the rating tool which are designed to eliminate these small claims payments. The first one is applied to a Police Section level, and for the purposes of the rating exercise set out in this report has been set at 2% of the annual total sum insured in each Police Section. This means that if the calculated payout in any month of the coverage is less than 2% of the Police Section total sum insured (TSI) no payout would be made; if the payout is greater than 2% of TSI of the Police Section, the payment is made in full (see Figure 5.8 for the operation of the Police Section qualifying franchise). The second franchise is applied at a Department level: the Department payout (calculated as the sum of the payout of the Police Sections included in the Department) must be greater than the Department franchise in order to make the full payment in the Department, and otherwise no payment will be made in that Department. Finally, a Global Franchise is applied: if the total payout in the whole country (calculated as the sum of the payout of the Departments) is less than the global franchise, no payment is made on the policy, otherwise the total payout is made in full. The user may alter the level of any of the qualifying franchises. For further details of the working of the three qualifying franchises, see Annex 3.

**Figure 5.8. Example of the NDVI Pasture Index Payout structure for Police Section 3, Artigas Department for the month of November.**




Source: Author's analysis, NDVI Rating Tool.
Notes: Police Section Total Sum Insured = US$ 991,392, Method = Normal, Return Period = 15 years, Police Section Franchise = 2%, Exit Trigger Deviation =1

## NDVI-Pasture Index Rating Methodology and Calculated Technical Rates

## Rating Methodology and Rating Model

5.32. ***The NDVI Rating Model is programmed to calculate pure loss cost rates, technical rates and indicative commercial premium rates for each Police Section (Insured Unit).*** The pure loss cost rates are calculated on a historical burning cost basis. Once the user has defined the cover period (number of months and calendar year or pasture growth cycle basis), the sum insured for each month of coverage, the monthly frequency of payouts (which sets the Trigger Index of each cluster for each month of coverage), and the parameter k (which determines the Exit Trigger of each cluster for each month of the cover period), the model proceeds to calculate automatically the pure loss cost (payout amount divided by sum insured) that would have occurred in each month and in total for the 30 years of NDVI values analyzed in the database for each Police Section and then the summary data per Department and for the whole Portfolio. The average loss cost rate for each Police Section is calculated as the simple average of the 30-year loss costs. The parameters for running the NDVI rating tool are demonstrated in Table 5.7. Further information on the rating methodology is contained in Annex 3.

5.33. ***For the purposes of the Uruguay NDVI Database, missing monthly NDVI values were in-filled by using the long-term average for that month and Police Section.*** In any Police

Section, where less than 6.7% of the total monthly NDVI values over the 30 year series (1981-82 to 2010-11) were missing for the selected Homogeneous Risk Zone (dominant cluster of pixels with similar NDVI values), the missing monthly values were filled in using the historical long-term average NDVI value for that month and Police Section (As previously noted, pixels with more than 6.7% missing data were excluded from the database).

5.34. ***The Rating Model developed does not include any trend analysis because there is no evidence from the 30-year NDVI data of any systematic trends in the NDVI values in any Police Section or Department.*** Therefore even though there is evidence of an increase in rainfall deficit in the past decade, we do not believe that any NDVI trending analysis is required and in any case would be highly influenced by the severe events in the last three years of data, namely 2008 to 2010. Theoretically, any deterministic trending analysis should be based in a "model" that explained the trend, and not just in the observation of a few years that present certain pattern[29]. Besides this theoretical argument, in practice the insurers will want to be sure that the premiums charged to the NDVI-insurance will be enough to cover the claims that could arise in the next years. If the insurers do not feel comfortable with the rates calculated with the proposed Rating Model (which does not include trend), they could apply a higher Risk Loading to the Risk Premiums in order to be more conservative, and therefore charge higher Technical Premiums (see Annex 3). Furthermore, it is important to highlight again that the final decisions regarding the premium rates to be charged on this NDVI-insurance program will be made by the insurers and their local and international reinsurers.

**Table 5.7. NDVI Insurance Rating Model Parameters for Uruguay**

| NDVI Rating Model Parameters | Value |
|---|---|
| Month by Month Payout Frequency (No. Years) | 10 |
| Method (Historical vs. Normal Distribution) | Normal |
| Deviation from Mean for Threshold Trigger Index | -1.282 |
| Deviation from Threshold Trigger for Exit Trigger (K) | 1 |
| Cover Period (Calendar Year basis or Pasture Season basis) | Pasture Season |
| Franchise level applied per Police Section and month (% of PSTSI): | 2% |
| Franchise level applied per Department (% of Department TSI): | 2% |
| Franchise level applied to Portfolio (% of TSI): | 0.86% |
| Security Loading (% of Loss standard deviation): | 15% |

Source: Authors, NDVI Rating Model.

## Police Section-level Rates

5.35. ***A worked example of the calculation of the NDVI pure loss cost rates at the level of the individual Police Section is presented below*** for Police Section 3 (HRZ or pixel cluster SP3_2), Artigas Department. Key assumptions used in this analysis include: the coverage period is seven months pasture season basis (September to December year t and January to February year t+1), the monthly payout frequency is set at 1 in 10 years; the Exit Trigger factor k is set at 1 and the franchise is set at 2% of the total sum insured for the Police Section (parameters as per Table 5.7).

[29] See Cryer and Chan (2008), Chapter 3, to see the difference between a "deterministic" trend and a "stochastic" trend that could arise in a time series data set.

Under these assumptions, Table 5.8 shows the calculated Threshold and Exit Triggers for each month of the 6 month cover period for the Police Section. Table 5.9 then shows that under the same assumptions, the NDVI policy would have triggered payouts in 22 months out of the total of insured 210 months equivalent to a frequency of payouts of nearly 10% of all months. The policy would have incurred payouts in 14 of the 30 years (47% of years) or nearly 1 in every 2 years, with a maximum payout in the very severe drought year of 1988/89 of 33% of the Police Section Total Sum Insured, followed by further major payouts in 2010/11 (29% loss cost), 2005-06 (26% loss cost) and 1989-90 (20% loss cost). Over all 30 years, the average annual pure loss cost rate in this Police Section is 6.98%. The losses are fairly evenly distributed over the seven month cover period (September to March).

5.36. ***The analysis for Police Section 3, Artigas Department shows that the NDVI model conforms closely to the actual pattern of major drought-induced losses in natural pasture in Uruguay, with the worst loss (payout) years falling in 1988 to 1990.*** Moreover, by adding all the loss costs across the country, the worst year was 1988-89 followed by 2008-09. This is a very important factor which was closely examined in the design of the NDVI cover and in the setting of the Threshold and Exit Triggers: the years with major modeled NDVI payouts were cross-checked with the livestock insurance industry to ensure that these years matched the major drought years experienced in Uruguay.

5.37. ***The NDVI rating model is also programmed to provide Technical Premium rates.*** The model was set with a security load of 15% of the standard deviation (SD) of the average pure loss cost rate in each Police Section, but this security load can be increased or decreased by the user. The security loading is designed to cover two important factors, (i) uncertainties in the 30-year data set and (ii) extreme pasture-loss (drought) years which have not yet been experienced and to establish a catastrophe load for these events in the technical rate for each Police Section. For Police Section 3 (Cluster 2), Artigas Department, the 15% of SD security load adds 1.43% points to the pure loss cost premium rate and the technical premium rate increases to 8.42% (see Table 5.9).

**Table 5.8. Calculated Monthly NDVI Average, Threshold and Exit Triggers for Police Section 3, Artigas Department for 10-year payout frequency/month**

| Artigas Department<br>Police Section Nº 3<br>Cluster Nº 2 (SP3-2) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NDVI Average: | 0.55227 | 0.58174 | 0.61607 | 0.62260 | 0.60393 | 0.57381 | 0.55108 | 0.53966 | 0.56864 | 0.61160 | 0.61285 | 0.57558 |
| NDVI Standard Deviation: | 0.10130 | 0.07849 | 0.07298 | 0.05218 | 0.05345 | 0.06849 | 0.05600 | 0.05611 | 0.04150 | 0.03858 | 0.04103 | 0.06301 |
| Trigger: | 0.42244 | 0.48115 | 0.52254 | 0.55572 | 0.53543 | 0.48603 | 0.47931 | 0.46775 | 0.51546 | 0.56215 | 0.56026 | 0.49483 |
| Exit: | 0.32113 | 0.40267 | 0.44957 | 0.50354 | 0.48197 | 0.41755 | 0.42331 | 0.41165 | 0.47396 | 0.52357 | 0.51923 | 0.43182 |
| % of PSTSI Allocated to Each Month | 14.29% | 14.29% | 14.29% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 14.29% | 14.29% | 14.29% | 14.29% |

Source: Authors' analysis, NDVI Rating Model

**Table 5.9. Calculated Pure Loss Cost Rates for Police Section 3_(based on Cluster 2), Artigas Department with 10-year Payout frequency factor per month**

| Year/Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Pasture Season Year | Total Loss Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | | | | | | | | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 81-82 | 0.0% |
| 1982 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 82-83 | 0.0% |
| 1983 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **14.3%** | 0.0% | 0.0% | 0.0% | 83-84 | **14.3%** |
| 1984 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **5.1%** | 0.0% | 0.0% | 0.0% | 84-85 | **5.1%** |
| 1985 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 85-86 | 0.0% |
| 1986 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 86-87 | 0.0% |
| 1987 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 87-88 | 0.0% |
| 1988 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **2.1%** | 0.0% | 0.0% | 0.0% | 88-89 | **32.8%** |
| 1989 | **2.1%** | **14.3%** | **14.3%** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **14.3%** | **6.0%** | 0.0% | 89-90 | **20.3%** |
| 1990 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 90-91 | 0.0% |
| 1991 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **8.4%** | 0.0% | 0.0% | 91-92 | **8.4%** |
| 1992 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **12.2%** | 0.0% | 0.0% | 0.0% | 92-93 | **12.2%** |
| 1993 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 93-94 | 0.0% |
| 1994 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 94-95 | **14.3%** |
| 1995 | **14.3%** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **9.4%** | 0.0% | 0.0% | 0.0% | 95-96 | **9.4%** |
| 1996 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 96-97 | 0.0% |
| 1997 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 97-98 | 0.0% |
| 1998 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 98-99 | 0.0% |
| 1999 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **5.2%** | 99-00 | **5.2%** |
| 2000 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 00-01 | 0.0% |
| 2001 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 01-02 | 0.0% |
| 2002 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 02-03 | 0.0% |
| 2003 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 03-04 | 0.0% |
| 2004 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 04-05 | **8.2%** |
| 2005 | 0.0% | 0.0% | **8.2%** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 05-06 | **25.6%** |
| 2006 | 0.0% | **11.3%** | **14.3%** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 06-07 | 0.0% |
| 2007 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 07-08 | **13.8%** |
| 2008 | 0.0% | **9.6%** | **4.2%** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **4.4%** | 08-09 | **11.4%** |
| 2009 | **7.0%** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 09-10 | 0.0% |
| 2010 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | **14.3%** | **14.3%** | 10-11 | **28.6%** |
| 2011 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | - | NC |
| | | | | | | | | | | | | | **Average Pure Loss Cost Rate (Burn Rate):** | 6.98% |
| | | | | | | | | | | | | | **Standard Deviation (SD) of Pure Loss Cost:** | 9.57% |
| | | | | | | | | | | | | | **Technical Rate with 15% of SD Security Load:** | 8.42% |

Source: Authors' analysis, NDVI Rating Model

5.38. ***The pure loss cost rates on the Uruguay livestock-pasture NDVI program are very sensitive to the selected return period (frequency of payouts).*** This concept is illustrated in Table 5.10 and Figure 5.9 for Police Section 3 Cluster 2, Artigas by changing the monthly payout frequency (thereby raising the threshold trigger NDVI value) from 1 in 7 years to 1 in 10 years, 1 in 12 years and finally 1 in 15 years. With a 1 in 7 year payout frequency, the NDVI policy would have made payouts in 16 years (53% of all years), with a maximum payout in the insurance year 1988-89 of 39% of the Police Section TSI with an average calculated pure loss cost rate of 8.72% and an average technical premium rate of 10.34%. By reducing the payout frequency from 1 in 7 years to 1 in 10 years the number of years in which a payout would have been made is reduced from 16 to 14 years (the very small payouts in 1981-82 of 4.4% of TSI and again in 1985-86 of 3.19% of TSI would have been eliminated); the maximum payout in 1988-89 would be slightly reduced to 33% of TSI and the average pure loss cost rate would be reduced to 6.98%. In the maximum modelled case of 15 years payout frequency, the number of years with payouts would be reduced to 13 years and the calculated pure loss cost rate would be reduced to 5.38% (average technical premium rate of 6.67%) and the maximum payout in 1988-89 would have been reduced to 28% of TSI. Figure 5.9 shows that the NDVI model continues to be robust even if the payout frequency is reduced with payouts continuing to be made in severe pasture drought years such as 1988-89, 2008-09, and 2005-06.

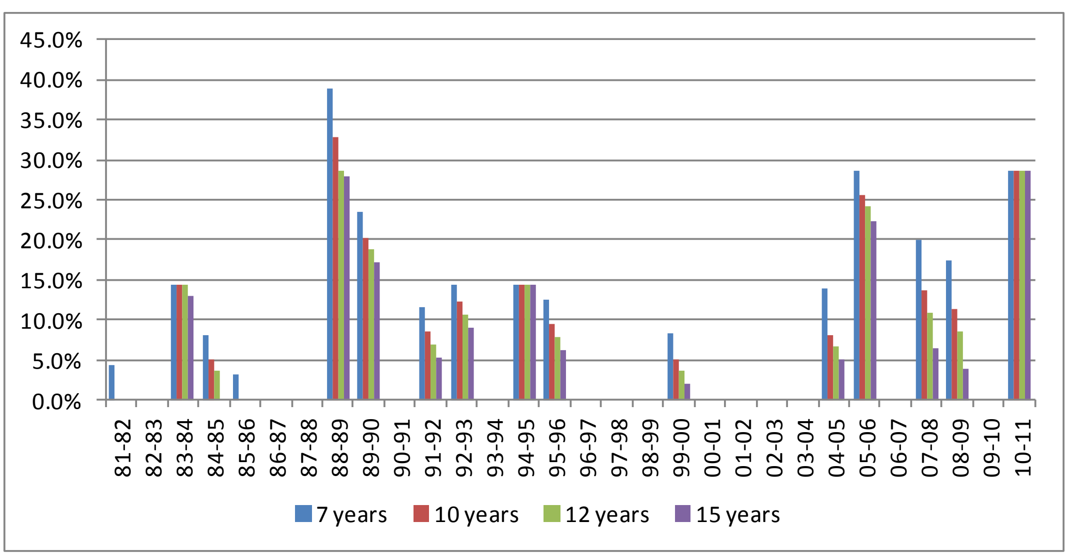
5.39. ***The above analysis for Police Section 3 Cluster 2,, Artigas Department clearly shows the influence of altering the payout frequency (return period) on the calculated pure loss costs and technical premium rates on this NDVI policy***. There is a need to weigh-up very carefully the premium costs of the NDVI insurance program and the level of drought protection afforded by the product: a payout frequency of 7 years for any month in the 6 month cover period opens the policy up to more frequent small claims; however, with a 15-year payout frequency the coverage is moved to a purely catastrophe basis and moderate drought-pasture-loss years are either excluded or only receive a very small payout. Caution must, however, be exercised, to avoid situations where in order to achieve the lowest possible premium rate for the NDVI policy that the monthly payout frequency is adjusted to say 1 in 15 or even 1 in 20 years or a "catastrophe only" structure, as this may result in situations where the NDVI policy does not make payouts when in reality livestock producers in Uruguay are incurring pasture-drought losses. This theme is addressed further in Chapters 6 and 7.

**Table 5.10. Police Section 3_2, Artigas Department: Effect of the selected monthly payout frequency on pure loss cost rates and technical premium rates.**

| Payout Frequency (per Month) | Annual Average Pure Loss Cost Rate (% of PSTSI) | Standard Deviation of Loss Cost | Technical Premium Rate (% of TSI) | Payouts (No. of Years) | Payouts (% of Years) | Max. Payout Year (% of TSI) |
|---|---|---|---|---|---|---|
| 1 in 7 years | 8.72% | 10.79% | 10.34% | 16 | 53% | 38.96% |
| 1 in 10 years | 6.98% | 9.57% | 8.42% | 14 | 47% | 32.85% |
| 1 in 12 years | 6.26% | 8.89% | 7.59% | 14 | 47% | 28.57% |
| 1 in 15 years | 5.38% | 8.58% | 6.67% | 13 | 43% | 28.57% |

Source: Authors' analysis in NDVI Rating Model

**Figure 5.9. Police Section 3, Artigas: Annual loss costs for monthly payout frequencies of 1 in 7 years to 1 in 15 years**




Source: Authors' analysis in NDVI Rating Model

## Departmental-level NDVI Rates

5.40. ***The variation in Police Section rates within a single department is illustrated for the 10 qualifying Police Sections in Artigas Department.*** This analysis is based on the same parameters presented for Police Section 3, Cluster 2 (see Table 5.7). In Artigas, the pure loss cost premium rates for a 1 in 10 year (month by month) payout frequency vary between an average low of 6.10% in Police Section 7 to a high of 7.05% in Police Section 8 with an overall Departmental pure loss cost rate of 6.64%, calculated as the weighted average per sum inured of the Police Sections pure loss cost. The corresponding simple average (assuming no benefits from portfolio diversification) Departmental technical premium rate is 8.05% with range from 7.44% (Police Section 7) to 8.52% (Police Section 8). The effect of diversification at a Departmental-level is to reduce the standard deviation of the calculated pure loss cost rates for the 10 Police Sections and therefore the security loading applied to the departmental average pure loss cost such that the average Technical Rate is reduced to 7.98%. Details of the number of insured animals, sum insured and pure loss cost and technical premiums are also shown by Police Section for Artigas Department with TSI of US$ 21.7 million and a calculated average technical premium of US$ 1.75 million (assuming no benefits from portfolio diversification) and an aggregated technical premium of US$ 1.73 million (assuming gains from portfolio diversification). (See Table 5.11).

**Table 5.11. Artigas Department: Average loss cost rates and technical premium rates by Police Section, 10 year payout frequency by month**

| Police Section (SP) | Main HRZ (Cluster) | Average Loss Cost (%) | St. Dev. Loss Cost (%) | Technical Premium Rate (%) | No Insured Breeding Cows | Total Sum Insured (US$) | Pure Risk Premium (US$) | Technical Premium (US$) |
|---|---|---|---|---|---|---|---|---|
| 1 | | Excl. | Excl. | Excl. | Excl. | Excl. | Excl. | Excl. |
| 2 | | Excl. | Excl. | Excl. | Excl. | Excl. | Excl. | Excl. |
| 3 | SP3_2 | 6.98% | 9.57% | 8.42% | 12,183 | 991,392 | 69,219 | 83,444 |
| 4 | SP4_2 | 6.72% | 8.63% | 8.02% | 24,636 | 2,004,755 | 134,736 | 160,685 |
| 5 | SP5_1 | 6.51% | 9.43% | 7.92% | 38,465 | 3,130,089 | 203,774 | 248,058 |
| 6 | SP6_1 | 6.64% | 9.96% | 8.13% | 19,707 | 1,603,657 | 106,419 | 130,366 |
| 7 | SP7_2 | 6.10% | 8.98% | 7.44% | 4,849 | 394,587 | 24,064 | 29,376 |
| 8 | SP8_1 | 7.05% | 9.75% | 8.52% | 43,436 | 3,534,605 | 249,340 | 301,026 |
| 9 | SP9_1 | 6.53% | 9.59% | 7.97% | 40,676 | 3,310,010 | 216,151 | 263,759 |
| 10 | SP10_1 | 6.38% | 8.47% | 7.65% | 33,156 | 2,698,070 | 172,032 | 206,331 |
| 11 | SP11_1 | 6.51% | 9.25% | 7.90% | 32,197 | 2,620,031 | 170,657 | 207,007 |
| 12 | SP12_1 | 6.74% | 10.15% | 8.26% | 17,361 | 1,412,751 | 95,211 | 116,729 |
| **Total Artigas (rates as weighted average per sum insured)** | | **6.64%** | **9.38%** | **8.05%** | **266,666** | **21,699,946** | **1,441,605** | **1,746,781** |
| **Artigas with Portfolio diversification** | | **6.64%** | **8.90%** | **7.98%** | **266,666** | **21,699,946** | **1,441,605** | **1,731,350** |

Source: Authors' NDVI Rating Model

5.41. ***The effect of reducing the frequency of payouts to 1 in 15 years is to reduce the pure loss rates and technical rates by about 25% for the ten Police Sections in Artigas.*** Table 5.12 shows that if the monthly payout frequency is reduced from 1 in 10 years to 1 in 15 years this reduces the pure loss cost and technical premium rates in each of the 10 Insured Units (Police Sections), as well as a reduction in the average departmental loss cost by about 25% from 6.64% to 5.00% and the average technical rate to 6.24% (no diversification effect) and aggregated technical rate to 6.17% (if the effect of diversification is included).

**Table 5.12. Artigas Department: Average loss cost rates and technical premium rates by Police Section, 15 year payout frequency by month**

| Police Section (SP) | Main HRZ (Cluster) | Average Loss Cost (%) | St. Dev. Loss Cost (%) | Technical Premium Rate (%) | No Insured Breeding Cows | Total Sum Insured (US$) | Pure Risk Premium (US$) | Technical Premium (US$) |
|---|---|---|---|---|---|---|---|---|
| 1 | | No Incl. | No Incl. | No Incl. | No Incl. | No Incl. | No Incl. | No Incl. |
| 2 | | No Incl. | No Incl. | No Incl. | No Incl. | No Incl. | No Incl. | No Incl. |
| 3 | SP3_2 | 5.38% | 8.58% | 6.67% | 12,183 | 991,392 | 53,352 | 66,116 |
| 4 | SP4_2 | 4.49% | 7.45% | 5.61% | 24,636 | 2,004,755 | 89,961 | 112,373 |
| 5 | SP5_1 | 4.85% | 8.51% | 6.13% | 38,465 | 3,130,089 | 151,861 | 191,822 |
| 6 | SP6_1 | 5.24% | 8.95% | 6.58% | 19,707 | 1,603,657 | 83,954 | 105,478 |
| 7 | SP7_2 | 4.56% | 7.92% | 5.75% | 4,849 | 394,587 | 17,988 | 22,675 |
| 8 | SP8_1 | 5.31% | 8.38% | 6.56% | 43,436 | 3,534,605 | 187,590 | 232,010 |
| 9 | SP9_1 | 4.76% | 8.11% | 5.97% | 40,676 | 3,310,010 | 157,446 | 197,717 |
| 10 | SP10_1 | 4.90% | 7.69% | 6.05% | 33,156 | 2,698,070 | 132,110 | 163,212 |
| 11 | SP11_1 | 5.25% | 8.54% | 6.53% | 32,197 | 2,620,031 | 137,458 | 171,011 |
| 12 | SP12_1 | 5.13% | 8.87% | 6.46% | 17,361 | 1,412,751 | 72,432 | 91,220 |
| **Total Artigas (rates as weighted average per sum insured)** | | **5.00%** | **8.28%** | **6.24%** | **266,666** | **21,699,946** | **1,084,152** | **1,353,634** |
| **Artigas with Portfolio diversification** | | **5.00%** | **7.81%** | **6.17%** | **266,666** | **21,699,946** | **1,084,152** | **1,338,204** |

Source: Authors' NDVI Rating Model

## <u>Analysis of Technical Premium Rates by Department for Uruguay</u>

5.42. ***This section presents the pure risk rates and technical rates by Department and in total for the overall NDVI insurance program in Uruguay.*** For the purposes of this analysis, the pure rates and technical rates are presented for monthly payout frequencies of 1 in 10 years and 1 in 15 years, considering a Departmental Franchise of 2% of the Department Sum Insured and a Global Franchise of US$ 2.7 million (or 0.86% of the Total Sum Insured). For payout frequencies of 7 years or less the cost of the NDVI insurance program become very expensive for GoU: however as the Rating tool is programmed to accept any payout frequency, GoU can select any payout frequency it wishes.

<u>Monthly Payout Frequency 1 in 10 years</u>

5.43. ***Table 5.13 presents the overall department and national portfolio analysis assuming a 10-year payout frequency per month in any Police Section***. The analysis shows that to insure the national breeding cow herd of 3.87 million head of animals with a corresponding TSI of US$ 315 million (and assuming no benefits from the effect of portfolio diversification through the pooling of risk), the national calculated pure lost cost rate would amount to 5.59% with an average expected payout on this livestock insurance program of US$ 17.61 million per year and with a corresponding aggregated technical premium rate of 6.84% and technical premium of US$ 21.53 million. There is considerable variation in average pure loss cost rates (and technical rates) across departments with range from an average low of 4.56% (5.75%) in Canelones Department to an average high of 6.55% (7.91%) in Artigas Department (Table 5.13).

**Table 5.13. NDVI Program per Department and National total sum insured, pure risk premium and technical premium for monthly payout frequency 1 in 10 Years**

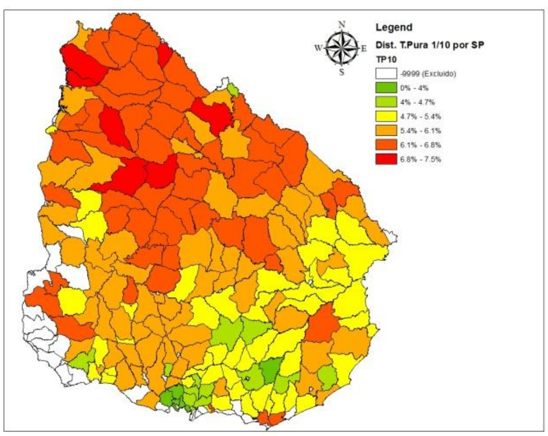
| Department | No. Insured Animals | Sum Insured | Pure Risk Premium | | Technical Premium [1] | |
|---|---|---|---|---|---|---|
| | Breeding Cows | US$ | % rate | US$ | % rate | US$ |
| Artigas | 266,666 | 21,699,946 | 6.55% | 1,421,661 | 7.91% | 1,715,686 |
| Canelones | 80,910 | 6,584,051 | 4.56% | 300,076 | 5.75% | 378,582 |
| Cerro Largo | 340,069 | 27,673,115 | 5.71% | 1,579,972 | 7.17% | 1,984,621 |
| Colonia | 90,002 | 7,323,913 | 4.93% | 360,919 | 6.30% | 461,664 |
| Durazno | 267,095 | 21,734,856 | 5.72% | 1,243,597 | 7.33% | 1,593,088 |
| Flores | 119,970 | 9,762,559 | 5.69% | 555,478 | 7.21% | 704,253 |
| Florida | 286,450 | 23,309,869 | 5.07% | 1,181,821 | 6.57% | 1,532,383 |
| Lavalleja | 248,028 | 20,183,279 | 4.75% | 959,239 | 6.12% | 1,235,193 |
| Maldonado | 104,088 | 8,470,161 | 4.90% | 415,152 | 6.07% | 513,875 |
| Paysandú | 265,954 | 21,642,007 | 6.04% | 1,307,718 | 7.64% | 1,652,784 |
| Río Negro | 126,326 | 10,279,778 | 5.90% | 606,047 | 7.26% | 746,228 |
| Rivera | 245,064 | 19,942,083 | 6.49% | 1,293,554 | 8.05% | 1,604,528 |
| Rocha | 270,835 | 22,039,198 | 5.22% | 1,151,068 | 6.47% | 1,426,457 |
| Salto | 316,916 | 25,789,040 | 6.28% | 1,620,246 | 7.76% | 1,999,941 |
| San Jose | 124,822 | 10,157,390 | 5.57% | 565,560 | 7.09% | 719,972 |
| Soriano | 98,166 | 7,988,258 | 5.81% | 463,817 | 7.29% | 582,706 |
| Tacuarembo | 364,594 | 29,668,837 | 6.21% | 1,843,758 | 7.68% | 2,279,426 |
| Treinta y Tres | 252,134 | 20,517,404 | 5.35% | 1,098,023 | 6.80% | 1,395,523 |
| **TOTAL with Portfolio Diversification** | **3,868,089** | **314,765,742** | **5.59%** | **17,605,714** | **6.84%** | **21,528,294** |

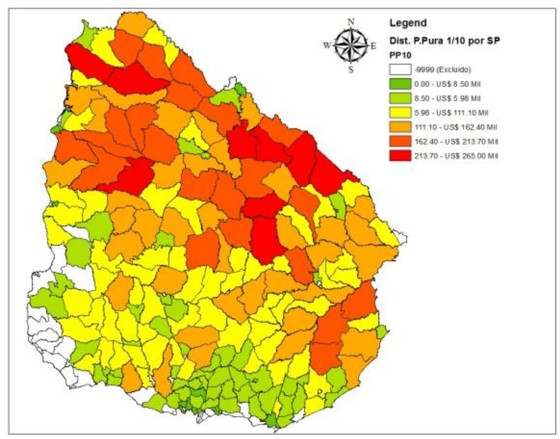
Source: Authors' NDVI Rating Model
Notes:
[1] Technical premium is calculated as pure loss cost rate + security load of 15% of standard deviation

5.44. ***The individual Police Section pure risk rates for a 1 in 10 year payout frequency are also shown for all 18 departments*** in the maps in Figure 5.10. The highest average pure loss costs (pure risk rates) per Police Section of between 8.4% and 9.2% (shown in red) are found in the Central and Northern Regions which comprise the Basalto region of Uruguay and the Police Sections with the lowest pure loss cost rates of less than 5.9% (shown in light green and green) are located in the South East of the country. This pattern of exposure to pasture and grazing losses is inversely related to the annual average rainfall which is lowest in southern Uruguay with an average of about 1,100 mm per year compared to the much higher average in northern Uruguay of 1,500 mm per year. Rainfall is the main determinant of pasture and grazing quality, however, other factors such as soil type and moisture retention capability and temperature and evapotranspiration are also important factors. In the Basalto Region of Uruguay soils are very poor with low moisture capacity, average temperatures are much higher and with high evapotranspiration rates natural pasture is much more rapidly and seriously affected by moisture deficit conditions than in the south of Uruguay. It is also important to note that the differences in the calculated Police Section pure loss cost premium rates would in fact have been higher if the team had not elected to adjust the Threshold Triggers and Exit Triggers in each Insured Unit (Police Section) to achieve more balanced or smoothed rates. Therefore in Police Sections with generally lower and more variable NDVI values, the Triggers were set at lower levels to reduce rates and in Police Sections with very high and stable NDVI values the Triggers were set higher.

**Figure 5.10. Average Police Section Pure Risk Rates (%) and average loss costs (US$) for 1 in 10 Year Payout frequency**

**(a) Pure Risk Rates (% of SI)** **(b) Average Annual Loss Costs (US$ 000)**




Source: Authors NDVI Rating Model

Monthly Payout Frequency 1 in 15 Years

5.45. ***For the Uruguay NDVI insurance program significant reductions in the pure risk premium rates and technical premium rates can be achieved by reducing the frequency of payouts to 1 in 15 years.*** In this case the overall pure risk premium rate is reduced to 4.1% with pure risk premium of US$ 13.0 million and the calculated technical premium rate is 5.1% with technical premium of US$ 16.2 million – under the assumption of portfolio diversification (Table 5.14). The corresponding pure risk rates and calculated annual average loss costs per Police Section for a monthly payout frequency of 1 in 15 years are shown in Figure 5.11.

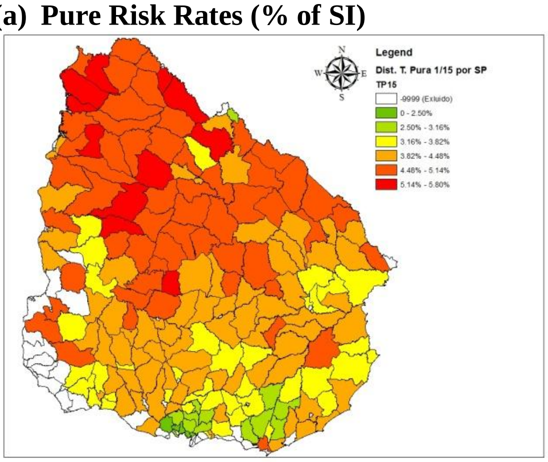
**Table 5.14. NDVI Program per Department and National total sum insured, pure risk premium and technical premium for monthly payout frequency 1 in 15 Years**

| Department | No. Insured Animals | Sum Insured | Pure Risk Premium | | Technical Premium [1] | |
|---|---|---|---|---|---|---|
| | Breeding Cows | US$ | % rate | US$ | % rate | US$ |
| Artigas | 266,666 | 21,699,946 | 4.93% | 1,069,993 | 6.12% | 1,327,974 |
| Canelones | 80,910 | 6,584,051 | 3.23% | 212,719 | 4.15% | 273,076 |
| Cerro Largo | 340,069 | 27,673,115 | 4.39% | 1,214,708 | 5.54% | 1,532,399 |
| Colonia | 90,002 | 7,323,913 | 3.38% | 247,487 | 4.54% | 332,148 |
| Durazno | 267,095 | 21,734,856 | 4.37% | 950,404 | 5.73% | 1,244,996 |
| Flores | 119,970 | 9,762,559 | 4.21% | 410,900 | 5.55% | 541,475 |
| Florida | 286,450 | 23,309,869 | 3.55% | 826,515 | 4.83% | 1,125,908 |
| Lavalleja | 248,028 | 20,183,279 | 3.59% | 723,942 | 4.77% | 963,748 |
| Maldonado | 104,088 | 8,470,161 | 3.18% | 268,970 | 4.07% | 344,948 |
| Paysandú | 265,954 | 21,642,007 | 4.67% | 1,010,540 | 6.01% | 1,301,633 |
| Río Negro | 126,326 | 10,279,778 | 4.34% | 446,023 | 5.51% | 566,057 |
| Rivera | 245,064 | 19,942,083 | 4.74% | 945,972 | 5.95% | 1,186,226 |
| Rocha | 270,835 | 22,039,198 | 3.77% | 829,920 | 4.78% | 1,054,484 |
| Salto | 316,916 | 25,789,040 | 4.87% | 1,255,680 | 6.10% | 1,574,265 |
| San Jose | 124,822 | 10,157,390 | 4.08% | 414,409 | 5.38% | 546,149 |
| Soriano | 98,166 | 7,988,258 | 4.24% | 338,762 | 5.51% | 440,364 |
| Tacuarembo | 364,594 | 29,668,837 | 4.32% | 1,282,162 | 5.53% | 1,641,728 |
| Treinta y Tres | 252,134 | 20,517,404 | 3.74% | 767,941 | 4.86% | 996,307 |
| **TOTAL with Portfolio Diversification** | **3,868,089** | **314,765,742** | **4.12%** | **12,974,799** | **5.13%** | **16,156,834** |

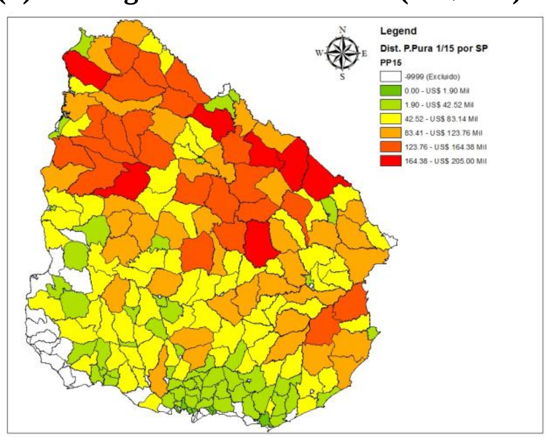
Source: Authors' NDVI Rating Model
Notes:
[1] Technical premium is calculated as pure loss cost rate + security load of 15% of standard deviation

**Figure 5.11. Average Police Section Pure Risk Rates (%) and average loss costs (US$) for 1 in 15 Year Payout frequency**

**(a) Pure Risk Rates (% of SI)**




**(b) Average Annual Loss Costs (US$ 000)**




Source: Authors NDVI Rating Model

## Validation of Uruguay NDVI-Pasture Index Model and Payouts

5.46. ***This subsection presents a comparison of the modelled payouts on the NDVI pasture-index insurance scheme for the 30-year period 1981-82 to 2010-11 with the major drought loss years reported by the livestock industry, MGAP and other sources during the conduct of the Feasibility study.*** The analysis benefitted from two workshops that were held with livestock specialists from INIA and MGAP and local cattle producers from Salto Department Basalto Region northern Uruguay and Lavalleja Department in central-southern Uruguay.

5.47. ***At a national level the Uruguay NDVI rating model generates major payouts for the seven month cover period September through to March in 1988-89, followed in reducing order of severity by 2008-09, and in third place 1999-2000.*** Figure 5.12 shows the overall NDVI program modelled annual loss costs for monthly payout frequencies of one in 7, 10, 12 and 15 years. The major modelled NDVI loss year was 1988-89 when the payout would have been 33.9% of TSI or US$ 107 million for a monthly payout frequency set at 1 in 10 years. This was followed by 2008-09 (loss cost of 22.5%), 1999-00 (loss cost 17.4%), 1984-85 (loss cost 16.6%), 1994-95 (14.3%) and 1992-93 (loss cost 13.6%) with other smaller loss years including 1983-84 and 2010-11. Over the 30 year period, payouts would have been made in 16 years (53% of all years) for the monthly payout frequency of 1 in 10 years.. The effect of lowering the payout frequency is clearly demonstrated in Figure 5.12. For the 7-year payout frequency (month by month basis) the peak loss cost year is 42.1% in 1988-89 and the long term average loss cost is 7.6%; for the 10 year payout frequency the average loss cost reduces to 5.6% and the worst loss cost is 33.9% (1988-89); for the 1 in 12 year option the average loss cost is 4.9% and the worst loss cost 30.6%; and finally for 1 in 15 year payouts (month by month basis) the average loss cost is 4.1% and the worst loss year, 1988-89 would be reduced to a 27.1% loss cost. With a 1 in 7 year payout frequency, there would have been NDVI payouts in 22 years (73% of total years), but with the 1 in 15 year payout frequency, this reduces to 14 years with payouts (47% of all years).

5.48. ***At a national level the NDVI calculated payout years closely match up to the actual major drought years in Uruguay and also to the opinions of the livestock industry regarding the worst years for pasture production and grazing***. Reference to Chapter 2 shows that the worst rainfall deficit years in Uruguay over the past 30 years include 1989, 1999, 2004 and 2008 when average annual rainfall was between 20% and more than 40% below normal average rainfall across the sampled weather stations and these coincide with major NDVI payout years in which the NDVI measured pasture and grazing growth/quality was severely reduced leading to major payouts throughout Uruguay[30]. According to the livestock producers spoken to in Salto, the worst pasture-drought loss years included 1988-89 (two consecutive years), 2008 and then 1999. This pattern of severe loss years was also reported by livestock producers in Lavalleja.

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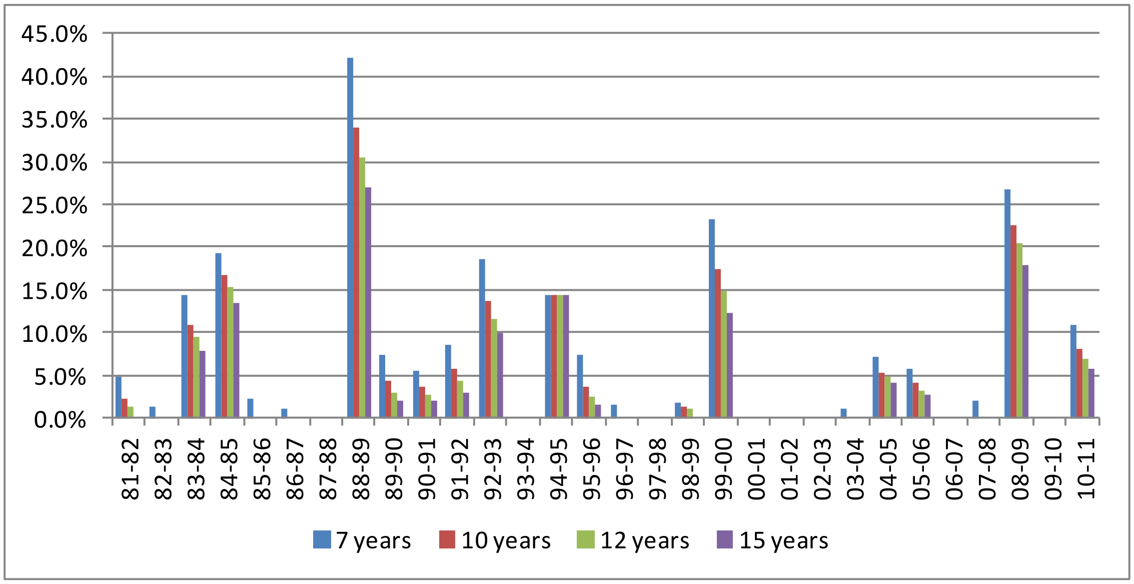
[30] The simple $R^2$ value for the national NDVI calculated loss costs (September to March) and the annual average monthly rainfall deviation from average for the basket of 15 weather stations is -0.45.

**Figure 5.12. Uruguay: Summary of Annual Average Loss Costs for Payout Frequencies of 7, 10, 12 and 15 years (month by month payouts)**

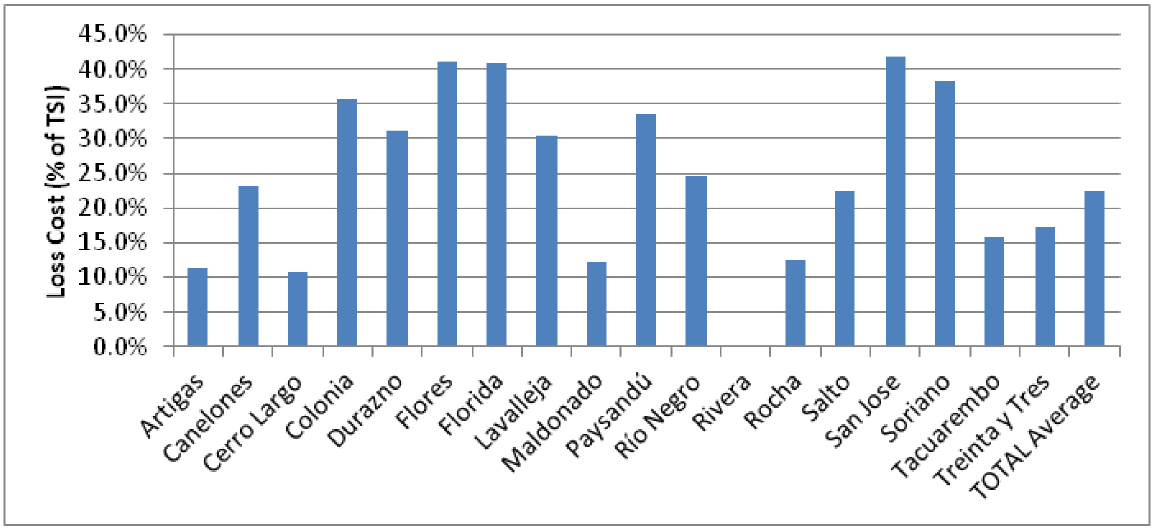



Source: Authors NDVI Rating Model

5.49. ***Another way of testing the validity of the NDVI Rating Model is to compare the modelled payouts for the NDVI Pasture Policy at a Departmental level (and or Police Section level) for the recent 2008-09 drought with the technical experts' knowledge of the losses to pasture and livestock production in this year***. Figure 5.13 shows a summary of the calculated Departmental payouts or pure loss costs (as a % of TSI) for 2008-09 for a 1 in 10 year payout frequency (month by month basis). The highest losses in 2008-09 in excess of 40% of departmental TSI were incurred in Flores, Florida and San Jose Departments in the south and south west of Uruguay and high losses were also recorded in Colonia, Durazno and Soriano. Conversely, the northern departments of Uruguay were relatively less affected by the drought. Overall the loss cost over all departments was 22.5% equivalent to a total loss of US$ 71 million. The analysis is remarkable for the fact that the NDVI rating model does not calculate any losses in Rivera Department (located on the northern frontier with Rio Grande do Sul Brazil) in 2008-09, the reason being that the NDVI values were above the opening trigger values for all Police Sections in all 7 months of the cover period. According to the local livestock specialists from MGAP, Rivera was unique in receiving timely rainfall in the spring/summer 2008/09 which meant that the quality of pasture and grazing was much better than surrounding Departments and for the country as a whole. This finding tends to validate the accuracy of the NDVI database and pasture index insurance rating model and cover design parameters.

5.50. ***The NDVI rating model has been made available to OPYPA-MGAP, the Superintendent of Financial Services and interest insurance companies*** to enable them to further test the model payout parameters and to validate the model at Police Section level.

**Figure 5.13. Analysis of 2008-09 Calculated Losses by Department for NDVI Policy with 1 in 10 year payout frequency (Loss Costs as Percentage of Departmental TSI)**




Source: Author's NDVI Rating Model.

## Indicative Commercial Premium Rates

5.51. ***The NDVI Rating Model is also programmed to enable users to estimate indicative commercial premium rates: it is stressed, however that final rating decisions lie with the Uruguayan public and private insurance companies and their reinsurers.*** For the purpose of providing Government policy makers in Uruguay with guidance on the possible financial costs of the proposed macro-level NDVI program for cattle producers in Uruguay, some indicative commercial premiums have been calculated. It is stressed, however, that in practice the Uruguayan Insurance Companies that agree to underwrite this program will be responsible for deciding on the final commercial premium rates that are charged on this NDVI program. In deriving commercial premium rates the factors that need to be taken into account include: (i) business acquisition costs or the service usually provided by a retail broker in Uruguay; (ii) the insurance company's administration and operating (A&O) expenses including internal costs and external operating costs, for example the appointment of a third party operator to manage the access to and analysis of NDVI data for the Insured Police Sections, (iii) The Insurer's reasonable profit expectations, (iv) reinsurer's expenses and finally (v) local stamp duty and Value Added Taxes (termed IVA in Spanish) on insurance premiums. Under the proposed macro-level NDVI insurance program where Federal and or Provincial Government is the proposed insured, there should be no need to incur business acquisition costs and therefore brokerage costs can be saved. The Insurers' A&O expenses will also be reduced on a macro policy where a single policy is issued to government and where there are no marketing costs. The Insurers' main start-up A&O costs will include the contracting of a third party NDVI operator and in establishing registers of the final recipients of the compensations and in establishing procedures for making payouts to them. In Uruguay, the rate of Value Added Tax (IVA) on insurance premiums can be very high with a standard rate of 22% which is added to the insurance premium. Some insurance policies are exempted from IVA including death and old age, disability and illness cover. In addition, agricultural insurance premiums are specifically exempted from IVA and this will result in major cost savings to the Insured (GoU).

5.52. ***For the purposes of this illustrative analysis a simple load factor of 1.25 has been applied to the calculated NDVI technical premium rates to generate illustrative commercial premium rates.*** The results of this analysis are summarized in Table 5.15 for different monthly payout frequencies of 1 in 7, 10, 12 and 15 years for the whole Uruguay national breeding cow portfolio with 3.87 million head of insured animals and TSI of US$ 315 million. For an NDVI program with a high frequency of monthly payouts of 1 in 7 years, the indicative commercial premium rate is extremely high at 11.33% (commercial premium of US$ 35.7 million) assuming benefits of portfolio diversification and pooling of risk. If the monthly payout frequency is amended to 1 in 15 years, the indicative commercial premium rate would be reduced to 6.42% (diversification included) and the annual commercial premium would be in the order of US$ 20.1 million. While the 1 in 15 year option may appear attractive to Government from a fiscal viewpoint because of the much lower premium, such a low frequency of payouts may not necessarily meet the pasture risk transfer requirements of the cattle producers in Uruguay. As such there is a trade-off between the premium costs of the NDVI index cover and the level of financial protection against drought afforded to livestock producers in Uruguay. As noted above, final commercial premium rates will be set by local insurers and their reinsurers.

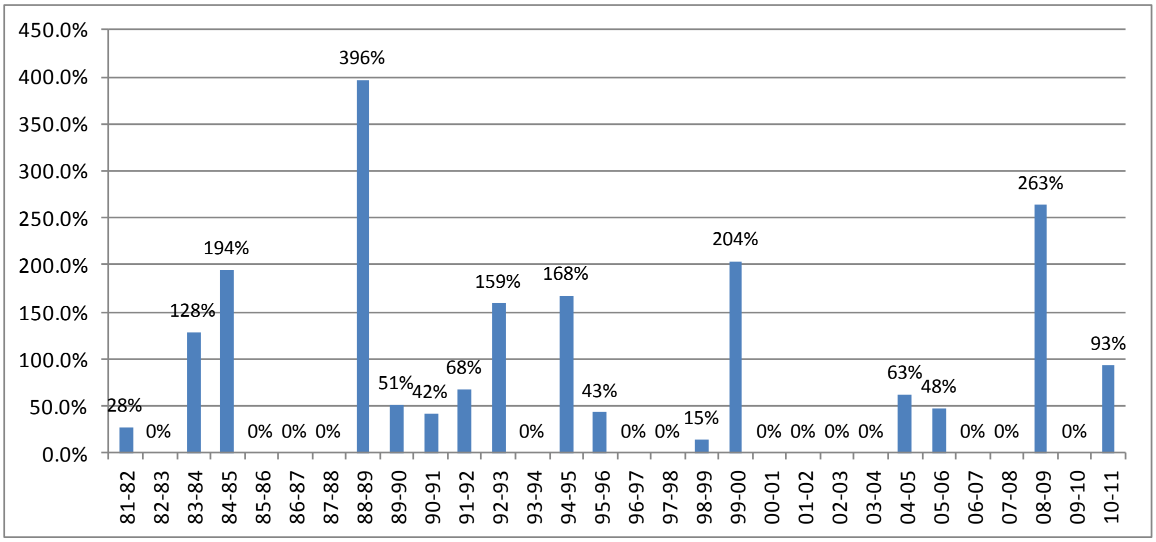
**Table 5.16. Uruguay NDVI Insurance Program: Indicative Commercial Premium Rates (Calculated Technical Rate Plus loading 25% to derive Commercial Rate)**

| Payout Frequency (Years) | Pure Risk Rate (%) | Pure Risk Premium (US$) | Technical Rate (%)[1] | Technical Premium (US$)[1] | Indicative Commercial Rate (%)[2] | Indicative Commercial Premium (US$)[2] |
|---|---|---|---|---|---|---|
| 1 in 7 | 7.59% | 23,813,877 | 9.32% | 28,525,588 | 11.33% | 35,656,985 |
| 1 in 10 | 5.59% | 17,605,714 | 6.84% | 21,528,294 | 8.55% | 26,910,367 |
| 1 in 12 | 4.89% | 15,390,096 | 6.02% | 18,947,976 | 7.52% | 23,684,971 |
| 1 in 15 | 4.12% | 12,974,799 | 5.13% | 16,156,834 | 6.42% | 20,196,042 |

Source: Authors' NDVI Rating Model
Notes:
[1] Technical rates in each Police Section calculated as pure loss cost rate + uncertainty load of 15% of the standard deviation of the pure loss cost rate
[2] Illustrative Commercial Premium Rates calculated as Technical Premium Rate + Simple Load of 25%

5.53. ***An "As If analysis" has been conducted on the loss ratios on the NDVI program over the past 30 years by comparing the calculated claims payouts with the indicative commercial premiums.*** The results of this analysis are presented in Figure 5.14 for the 1 in 10 year payout option (month by month basis). There would have been three major losses over this period with loss ratios exceeding 200% (in 1988-89 with loss ratio of 396%, in 2008-09 with loss ratio of 263% and finally in 1999-2000 with loss ratio of 204%); and with an overall long-term average loss ratio of 65%. The loss ratios for the other payback options are almost identical to the 1 in 10 year option on account of the model construction where higher payout frequencies and values are matched by corresponding rate increases. The corresponding long-term average loss ratios are 67% (1 in 7 year payouts), 65% (1 in 12 year payouts) and 64% (1 in 15 year's payouts).

**Figure 5.14. "As if" Historical Annual Loss Ratio, NDVI Program for 1 in 10 year payout Option**




Source: Authors' NDVI Rating Model

## Probable Maximum Loss Estimation for Uruguay NDVI Program

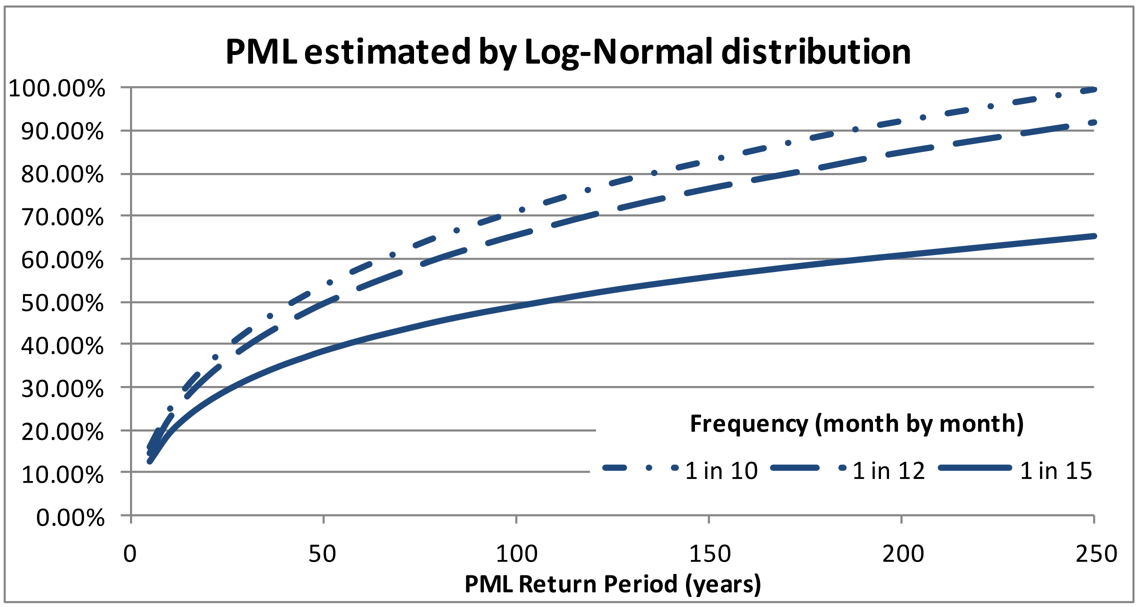
5.54. ***For the purposes of risk layering and deciding on the prudent risk retention and risk transfer/reinsurance strategy it is very important to calculate the Maximum Probable Loss (PML) that could be expected for a defined return period.*** The worst loss experienced over the 30 years for which NDVI data is available was in 1988-89 with a 33.9% loss cost for a payout frequency of 1 in 10 years (month by month basis) equivalent to an insured payout of US$ 107 million on the TSI of US$ 315 million. While 1988-89 was a very severe loss year, it is possible that considerably higher losses which have not been experienced over the past 30 years, may occur in future. In order to assess their maximum expected losses and to set their risk retention and risk transfer and reinsurance strategies, it is common for underwriters to use appropriate calculations of the Maximum Probable Loss (PML) that they might incur for a given return period of say 1 in 100 years or 1 in 250 years if it is necessary to be more conservative.

5.55. ***In order to estimate the PML, the data of the worst historical losses have been fitted to different parametric probability distribution functions, namely: Log-Normal, Log-Logistic and Inverse Gaussan. Then, 10,000 simulated losses (years) have been generated using the best fit and the PML was calculated from the simulated distribution.*** Although a Normal distribution has been proposed to estimate the average historical loss cost rate (see Annex 3), this parametric distribution was not used to estimate the PML because the aim is fitting the tail of the distribution, and a Normal distribution would underestimate the extreme loss values. Because the objective is to fit the tail of the distribution, only the worst 50% of years were used to calibrate the parametric functions. The steps followed to estimate the PML were: (i) to calculate the historical payouts, (ii) to discard the lower payouts, preserving only the 15 years with major losses, (iii) to fit this data to the four parametric distribution functions mentioned above using the Monte Carlo simulation software @Risk, (iv) to perform 10,000 simulations (years) of losses, and (v) to estimate the PML according to the return period selected as a percentile of the simulated values. The Log-Normal distribution function generated the best fit and was used to simulate the losses and to estimate the PML.

5.56. ***The PML estimated through a Log-Normal distribution fitted to the losses calculated using the assumptions from Table 5.7 (i.e. payout frequency 1 in 10 years -month by month-) and considering a return period of 100 years is US$ 223 million, or 71% of the Total Sum Insured (TSI).*** This high value of PML shows the high risk exposure that is faced by the NDVI insurance program.

5.57. ***The PML is very sensitive to the payout frequency (month by month) selected to calculate the threshold triggers.*** A reduction in the frequency (month by month) of payouts is accompanied by an increase in the threshold triggers, which in turns generates a decrease in the payouts of the NDVI insurance. If the Triggers are calculated using a payout frequency (month by month) of 1 in 12 years, then the PML is estimated at 66% of the TSI or US$ 206 million, and with a 1 in 15 years frequency (month by month) the PML is reduced to US$ 154 million or 49% of TSI. Figure 5.15 shows the PML as a function of the return period of the event, and for threshold triggers calculated assuming several payout frequencies (month by month).

**Figure 5.15. Estimated PML for different payout frequencies, in function of Year Return Period (% of TSI)**




Source: Author's NDVI Rating Model

5.58. ***The PML analysis above has been performed by considering the whole portfolio of 3.9 million breeding cows for Uruguay. If the stakeholders decide to start with a pilot program in selected departments of Uruguay, the PML as a percentage of the Sum Insured for the selected departments would be higher than the figures presented for the whole portfolio.*** As previously mentioned, by pooling the risks some benefits from diversification can be achieved and the PML's presented in Figure 5.15 which considers Uruguay as a whole takes advantage from these benefits. Conversely, if each department is considered in isolation, the individual PML of each one could be as high as 100% of the Department's Sum Insured. This point is important if the stakeholders wish to start the NDVI program with a pilot in selected Departments, in which case the PMLs would be considerable higher than those presented above (see Chapter 7 for further discussion of the possible NDVI Pilot program).

## Conclusions on NDVI Contract Design and Rating Study

5.59. ***On the basis of this study the following points are highlighted in regard to the NDVI pasture index contract and rating exercise:***

- A prototype NDVI contract has been designed and tested with the livestock industry in Uruguay and refined on the basis of the feedback provided. The prototype NDVI cover provides comprehensive protection for breeding cattle (cows and heifers) over 7 months of the year. The sum insured has been carefully related to the nutritional requirements of cows on a daily and monthly basis during the 7-month cover period and then valued accordingly using a ration made of sunflower flour and wheat bran as a reference supplementary feed.

- An Excel based NDVI Rating Model has been developed by the actuarial consultant under this study. The Rating Model is programmed to permit the end user a high degree of flexibility in setting the both the threshold NDVI trigger leading to an insurance payout and the exit trigger in each of the 195 Insured Units (Police Sections). The rating tool is designed to generate pure loss costs rates, technical rates and indicative commercial premium rates. The user can also modify the sums insured and the three qualifying franchise levels.

- Under this study a User's Technical Manual has been drawn up which is attached as Annex 3. This manual sets out the full details of the NDVI Rating methodology and can be used to form the basis of any Technical Note (*Nota Tecnica*) that the Insurance Companies may be required to submit to the Superintendent of Insurance and other key stakeholders.

- The NDVI product has been tested to compare the calculated pasture-drought payouts with past major drought events and losses as quantified by or remembered by the insurance industry. There appears to be a very high degree of correlation between modelled payouts per Department and by year and actual historical losses experienced by the livestock sector in Uruguay. The NDVI prototype insurance product therefore appears to offer potential as a catastrophe drought insurance policy for GoU to use to protect the livestock insurance sector going forward.

- The rating exercise has clearly shown the very high drought risk exposures in pasture and this is reflected in the relatively high technical premium rates which have been presented in this Section. The main way of controlling the underlying pure rates and technical rates is by amending the frequency of payouts from 1 in 10 years to 1 in 12 years or 1 in 15 years.

- The Insurance companies and Government (the Insured) will need to work closely with the livestock sector in deciding on the optimum frequency of payouts (return period) for this NDVI product. If the payout frequency is set to a purely catastrophe product (for example 1 in 15 years or greater) the product may look very attractive in terms of its pricing, but the cover may incur major contract design basis risk namely that the policy does not trigger payouts although livestock producers in Uruguay have incurred major pasture drought losses.

- A separate Monte Carlo simulation analysis has been conducted to analyze the expected PML's on the NDVI program for all 18 qualifying Departments in Uruguay. This analysis shows there are considerable benefits of pooling of risk on the overall PML for Uruguay as a whole. The PML analysis is designed to assist the local insurers to assess their prudent risk retention and reinsurance purchasing requirements and to layer the reinsurance program. The estimated PMLs are very high on this pasture NDVI program reflecting the high drought risk exposure in pasture in Uruguay.

- The results of the pricing analysis and PML analysis will help insurance companies to design a strategy for retention and risk transfer (reinsurance) on this NDVI pasture index insurance program for livestock producers in Uruguay. It is stressed, however, that the commercial premium rates presented in this section are purely illustrative and that final rating decisions will be taken by the local insurers and their reinsurers.

# 6. Legal, Institutional, Operational and Financial Considerations for NDVI Pasture Insurance

6.1. ***This Chapter deals with the Legal, Institutional, Operational and Financial options and requirements for the implementation of the proposed Macro-level NDVI pasture insurance program for cattle producers in Uruguay***. Over the past two years of the implementation of this study, OPYPA-MGAP have indicated their willingness to support a macro-level pasture-livestock NDVI insurance program which would complement or even substitute the existing Agricultural Emergency Fund (FAE). To date, however, neither MGAP nor GoU have formally confirmed their intention to purchase this NDVI cover on behalf of breeding cattle producers in Uruguay, as they have been awaiting the final report and recommendations prior to taking decisions to implement this ex-ante drought index insurance program. There are obviously major financial implications to GoU if it were to approve the macro-level NDVI insurance option under which it would be the Insured and would be responsible for the payment of premium and for agreeing the payout rules to livestock producers in Insured Units where the NDVI-pasture drought index program is triggered. This Chapter therefore aims to set out the legal, institutional, operational and financial issues and options for the NDVI-pasture drought program which will need to be agreed between Government and the Insurance Companies, and then approved by the Insurance Regulator.

## Legal Considerations for NDVI Insurance

6.2. ***Index insurance as a mechanism to insure adverse weather risk and other natural perils in agriculture is a very new class of insurance and to date little attention has been focused on the legal and regulatory aspects of index insurance.*** Under this GIIF funded NDVI Feasibility study for Uruguay technical assistance has been allocated both for the technical design and rating of the pasture NDVI cover and also to cover the legal and regulatory aspects.

### Insurance Market, Regulator and Insurance Law

6.3. ***Uruguay has a Civil Law legal system based on the Spanish legal system* (or European Continental system, of law)**. Although Uruguay has adopted the Civil Law system, sentences issued by jurisdictional justice (Courts of the first instance, Higher Courts and the Supreme Court of Justice) are used as a guide only and they are not binding (do not constitute a legal precedent) and this is one of the main distinguishing features from a Common Law legal system. Key insurance legislation which regulates the insurance activity in the country date back to 1861 with the enactment of the Commercial Code authorizing three classes of insurance including fire, agriculture (crop-hail) and life insurance. In 1911 legislation was introduced to establish the state insurer, Banco de Seguros del Estado (BSE) which at the time enjoyed near monopoly status over insurance. In 1993 the Insurance Law No 16.426 was enacted to eliminate the monopoly status of BSE and to open up the market to competition by private insurers (AXCO 2012). The market is regulated by the Superintendent of Financial Services (Superintendencia de Servicios Financeiros – SFS) of the Central Bank of Uruguay (BCU). The SFS is responsible for setting the legal and regulatory framework governing the insurance activity, monitoring compliance of the insurance companies and the insurance agents and for disseminating market information. There is also an Insurance Association, the Asociacion Uruguaya de Empresas Aseguradoras (AUDEA) which represents the interests of the private insurance companies including the 12-non-life companies that operate in Uruguay.

6.4. ***Uruguay, in common with most countries does not have specific agricultural insurance legislation either for traditional indemnity-based insurance products or new index based products.*** Very few countries with private sector agricultural insurance have specific agricultural insurance laws and Uruguay is no exception although it has underwritten crop hail insurance for more than a hundred years. The Insurance Law No 16,426 of 1993 and subsequent Laws and Decrees make no reference either to (i) agricultural insurance which is treated as a miscellaneous class of Non-Life business, or (ii) index insurance (including weather index insurance for agriculture). The Law does, however require any insurer that wishes to introduce any new insurance product or policy into the market to first present the new product to the SFS for formal approval. In other words, index insurance would currently be permitted under existing legislation if this is first approved by the SFS and secondly if insurers and reinsurers are willing to underwrite such index covers as an insurance policy (as opposed to treating these covers as derivate or financial risk transfer products). AXCO 2012 reports that some Uruguayan insurance companies complain about the lack of adequate legislation and especially the need for a new insurance law and regulations governing mediation as existing legislation is open to different interpretation.

## NDVI Index Insurance in Uruguay and Legal Considerations

6.5. ***NDVI 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 a satellite measured vegetative reflective NDVI index which is designed to approximate as accurately as possible the loss of pasture production and grazing quality that occurs in years of extreme weather, especially droughts. Secondly a central feature of any standard insurance policy is that the insured good or object must be subject to physical loss or damage which can be measured and quantified, and an indemnity is paid according to the actual amount of loss suffered/incurred by the insured object. Under an index insurance cover, there is no measurement of actual physical loss or damage suffered by the Insured, but rather an insurance payment is made according to a pre-agreed payout procedure once the index threshold leading to a payout has been triggered. Such a payout may be a single lump sum payment or a scaled payout subject to a maximum. An additional key difference between index and indemnity 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. Since the core principle of an insurance contract is to compensate the Insured for a real loss only, regulators have occasionally challenged the legal status of index contracts and even blocked the establishment of the index contracts on the basis that the index cannot be insurance (GlobalAgRisk 2011)[31].

6.6. ***Under the proposal to issue a macro-level NDVI insurance policy whereby the Government of Uruguay or its appointed representative such as MGAP would be the Insured, it will be important for the participating Insurance Companies to confirm the legal requirements***

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[31] In their State Knowledge Report GlobalAgRisk present a very useful overview on the differences between traditional indemnity based agricultural insurance products and weather index insurance covers and identify key legal and regulatory issues which should be carefully taken into consideration in the planning and design of any new index insurance program

***and procedures for issuing such a cover, with the Superintendent of Financial Services (SFS)***. Under this proposal, the GoU or its appointed representative such as MGAP would be the Insured on behalf of the estimated 38,000 "qualifying breeding cattle producers" located in the 195 Police Sections in the 18 (out of 19) Departments of Uruguay, each of whom would be registered with the government according to their number of cattle in each Insured Unit (as verified by SNIG/DICOSE's national livestock date-base). Under this assumption, all "breeding cattle" livestock producers in Uruguay would be automatically enrolled and protected under the NDVI scheme as "recipients" in the event of a triggered payout. The Insured (GoU) would receive an NDVI Master Policy document and special conditions attaching and would be responsible for payment of premium on the agreed TSI.

6.7. ***One of the key reasons for recommending a macro-level policy NDVI pasture-drought index insurance cover is to ensure that Government and not individual livestock producers is the Insured named in the Policy and is also responsible for the payment of premium.*** By adopting the macro-level approach, individual livestock producers would not have any insurable interest in the pasture NDVI contract or legal rights to make a claim on this policy. If, however, individual livestock producers were to be named in the policy as the Insured (and or to participate in the payment of premium), in the event that individual producers incur localized drought (or any other peril) related losses in their pasture, but the policy does not make any payouts as these losses are not triggered by the NDVI policy at the Insured Unit (Police Section) level, the individual livestock producer might then make a claim in the Courts against the Insurer. It is very important to avoid such situations of litigation in the start-up phase of a new index insurance program. Finally as stressed throughout this report, the design team do not believe that the low resolution of the NDVI database is appropriate to an individual livestock producer pasture insurance program because of the issue of Basis Risk. Conversely Basis Risk is much less of an issue under a Macro-level policy issued to GoU.

6.8. ***In the conduct of the NDVI Livestock Pasture Index Technical Design and Rating Study the World Bank-OPYPA team has briefed the SFS at each stage of development of the program and SFS has expressed its agreement in principle to this new index program.*** During the study the team has regularly met with SFS to present the NDVI prototype product, rating tool and Manual of Instructions. The SFS has confirmed its agreement, in principle, with the proposed macro-level policy, which would be issued to GoU, which would be the Insured, and the proposed basis of insurance and indemnity payouts using the SNIG-DICOSE livestock data-base in each Seccion Policial. SFS has also indicated its "no objections", in principle, to the concept of forming a local Co-insurance pool agreement for the pasture NDVI Insurance Program (discussed further below). In due course it will be the responsibility of the local insurers (either operating singly or under some form of coinsurance agreement) to present their Technical Note (Nota Técnica) for the pasture NDVI insurance product to SFS for registration and approval purposes.

6.9. ***The World Bank-OPYPA team has been committed to providing technical assistance both to the SFS and to interested insurers in the form of (1) an Excel-based NDVI premium rating and PML estimation Model; and (2) a Manual of Instructions for the use of the NDVI Rating Model*** (see Annex 3). During the November/December 2012 Mission to Uruguay, the Excel-based NDVI rating tool and draft final User's manual was demonstrated to OPYPA-MGAP, the SFS and Agricultural Insurance Companies and other key stakeholders and electronic copies of the rating tool were provided to OPYPA to distribute to the interested parties[32]. The

[32] Final updated copies of the rating tool and manual were provided to OPYPA to distribute to interested parties at the World Bank's May 2013 final Mission to Uruguay.

Users' Manual provides full details of the NDVI product design and terms and conditions of cover, and instructions for the use of the Excel-based NDVI rating model which is programmed to provide calculations of the pure risk premium rates, technical rates and indicative commercial premium rates for all Insured Units in each Department and in total and for any pre-defined sum insured and payout frequency. As such, the Insurance Companies now have all the information they require on the NDVI pasture index insurance cover to prepare a contract wording and their Technical Note (*Nota Técnica*) and to finalise their technical and commercial premium rates for each Police Section and Department and to then present this information to the SFS for final approval.

6.10. ***If the proposed Macro-level NDVI pasture-insurance product is confirmed it will be necessary to review the legal status and operations of the Government's Emergency Fund for Agriculture (FAE), in order to avoid overlap and duplication of compensation payments by the two programs.*** Chapter 2 noted that the FAE was established by GoU after the catastrophe droughts of 2008/09 which severely impacted on the livestock industry, as an instrument to compensate affected crop and livestock producers and to enable them to rehabilitate their enterprises after a major climatic or natural disaster. The FAE is administered by MGAP. Under the present NDVI Feasibility study OPYPA-MGAP agreed that it will be important to establish the conditions under which NDVI insurance program and the FAE disaster relief compensation scheme will operate in future in order to avoid potential duplication and overlap of the two programs and situations of double-indemnity / compensation payments being made. A key insurance principle is that the Insured should not be over-compensated for the actual financial loss incurred. The legal and regulatory conditions for both programs should therefore be carefully studied with the SFS and those organizations responsible for implementation of the FAE.

## Institutional Considerations for NDVI Insurance

6.11. ***Since the beginning of this pasture NDVI insurance initiative every effort has been made to involve the group of leading agricultural crop and /or livestock insurance companies in Uruguay in the development of this program.*** In each of the previous Missions the World Bank-OPYPA team has met with Uruguay's specialist agricultural insurers including Banco de Seguros del Estado, BSE, the state insurance company and four private insurance companies, Sancor Seguros S.A., MAPFRE Uruguay Compania de Seguros S.A, Cooperativa de Seguros Surco and Berkley International Seguros S.A.

6.12. ***The local agricultural insurance companies have indicated their strong preference for a macro-level NDVI pasture index insurance product for the livestock sector in Uruguay which would be offered as an aggregate policy to GoU as opposed to marketing micro-level insurance cover to individual livestock producers***. In addition to issues of the prohibitively high costs of marketing voluntary NDVI cover to individual farmers, the Insurers noted their concerns over moral hazard namely, the potential under this pasture NDVI cover for individual farmers in small Insured Units (Police Sections) to influence the NDVI payouts by overstocking and over-grazing their pasture lands. The NDVI signature of over-grazing is equal to that of a severe drought.

6.13. ***The interested insurance companies will in due course need to decide whether to agree to a single company insuring the NDVI program for livestock producers in Uruguay, or whether they wish to collaborate under a suitable form of "Pool" coinsurance structure[33].*** If a

[33] Currently there are no Pools in Uruguay (Axco 2012).

single company is appointed to underwrite the NDVI program, a decision will need to be taken whether to do this through a tender process or not. Coinsurance Pools are fairly common features of major national or regional Public Private Partnership (PPP) agricultural insurance programs including the Agroseguro Program in Spain, the Tarsim Pool program in Turkey and various regional coinsurance pools in China. 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, (iii) ability for each company to select a share according to its risk appetite, and (iv) major cost savings in purchasing pooled reinsurance (common account) protection (Mahul & Stutley 2010). Further information on the advantages and disadvantages of Coinsurance Pools are contained in Box 6.1. The SFS has advised its agreement, in principle, to the Uruguay NDVI Program being coinsured under a Pool agreement if this is the preferred structure by the specialist public and private agricultural insurance companies. It is important to note, however, that to date none of the insurance companies has formally committed to participating in a coinsurance agreement or Pool.

**Box 6.1. Benefits and Limitations of Coinsurance Pool Arrangements**

**Benefits**

**Economies of scale through operating as a single entity with shared (pooled) administration and operating functions leading to costs savings due to:**
* Reduced staffing requirements (fixed costs);
* Shared costs of product research and development, actuarial and rating;
* Reduced costs of underwriting and claims control and loss adjustment.

**Cost advantages in purchasing common account (pooled) reinsurance protection rather than each company trying to place its own reinsurance program. Advantages due to:**
* Stronger negotiating position with reinsurers;
* Larger and more balanced portfolio and better spread of risk;
* Reduced costs of reinsurance due to pooled risk exposure;
* Reduced transaction costs (reinsurance brokerage, etc).

**No competition on rates in a soft market and ability to maintain technically set rates.** Most pools operate as the sole insurance provided or monopoly (e.g. Austria, Senegal, Spain, Turkey), and there is therefore no competition on pricing.

**Ability to maintain underwriting and loss adjustment standards.** Under a pool monopoly arrangement, the pool manager can ensure that common and high standards are maintained in the underwriting of crop and livestock insurance and in the adjusting of claims. Where companies are competing against each other for standard crop insurance business, there is often a problem of varying loss adjustment standards between companies.

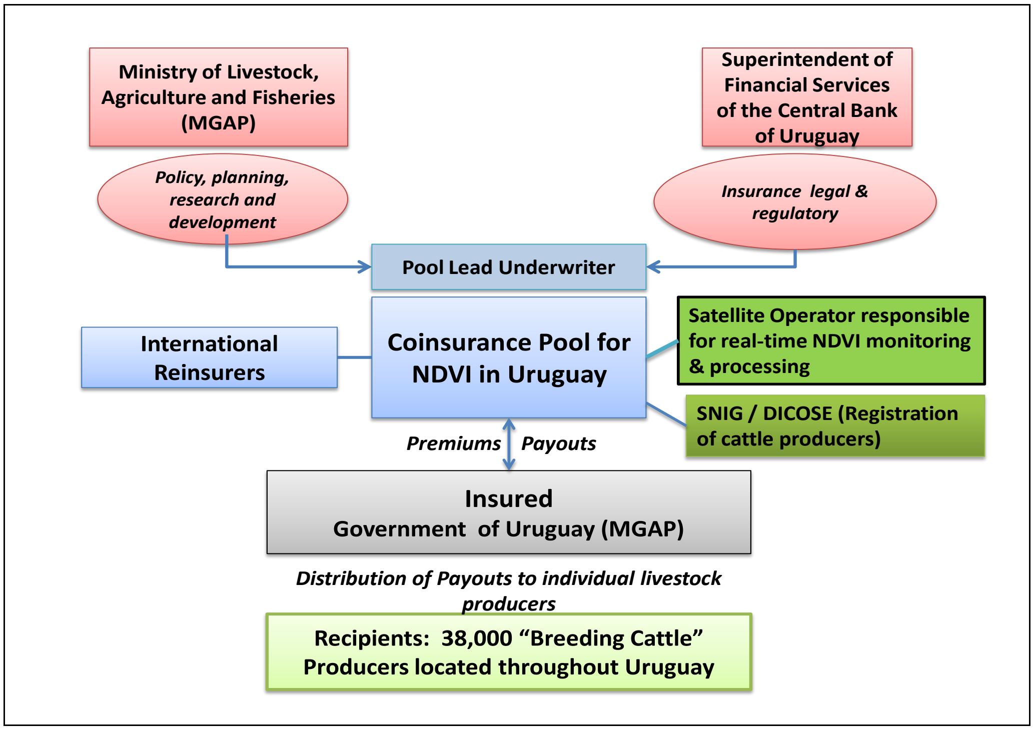
**Limitations**

**A Pool may act as the sole agricultural insurer, resulting in lack of competition in the market in terms of the:**
* Range of products and services offered by the monopoly pool underwriter;
* Restrictions on the range of perils which are insured;
* Restrictions on the regions where agricultural insurance is offered or the type of farmer insured;
* Lack of competitiveness in premium rates charged by the pool.

*Source:* Mahul & Stutley 2010

6.14. ***An outline Institutional framework for the suggested NDVI coinsurance Pool is shown in Figure 6.1.*** Under the Coinsurance option it is assumed that one of the participating companies will act as the Pool leader with regard to issuing a single insurance Policy to the Insured (GoU or its representative, MGAP) and for ensuring that a schedule is annexed to the Policy containing for each Department and Police Section (Insured Unit) in Uruguay details of the total number of insured breeding cattle and the sum insured per Police Section. As noted, however, from a legal standpoint the Schedule should not include the names of any individual breeding cattle producers (the intended beneficiaries) or their livestock holdings (number of cattle) and the corresponding sum insured per producer as this could confer an insurable interest to each individual livestock producer. The GoU would be responsible for payment of premium to the Pool leader. The Pool coinsurers would purchase common account reinsurance protection from international reinsurers. The Pool would need to enter into a contractual agreement with a third party remote sensing operator to provide regular reporting throughout the cover period of the actual monthly average NDVI values in each Insured Unit and on which basis claims payouts will be triggered if the thresholds are exceeded (discussed further below).

**Figure 6.1. Outline Institutional Framework for Macro-Level Livestock NDVI Insurance for Government in Uruguay**




Source: Authors

<u>**Linkages with the Agricultural Crop and Livestock Emergency or Disaster Program**</u>

6.15. ***If Government does decide to introduce the macro-level NDVI pasture-drought index insurance program into Uruguay in the near future, it is very important to analyze the linkages of this ex-ante insurance program with the ex-post Agricultural Emergency Fund (FAE).*** This is needed to avoid potential duplication of effort and situations where livestock producers potentially receive double indemnities from both programs. In this context, if Government elects to purchase purely catastrophe-level pasture NDVI insurance cover with a payout frequency of say 1 in 15 years, one option government may wish to consider is whether to back up this “top layer insurance protection” by use of emergency funds for the more frequent but smaller payout pasture-drought events in Uruguay. A two layered program which is structured in this way would reduce the problem of basis risk associated with the NDVI product.

## Operational Considerations for NDVI Insurance

**Registration and allocation of livestock to each Seccion Policial (Insured Unit) to establish the Sum Insured and to effect NDVI insurance payouts**

6.16. ***For the purposes of the NDVI insurance program will be necessary to register all livestock cattle owners according to the location of their animals by Insured Unit in Uruguay***. The need to register all cattle owners according to the number of cattle they own and which are located in each Insured Unit includes: (i) it is necessary to calculate the sum insured in each Insured Unit; (ii) premium will be paid on the basis of the sum insured and the calculated premium rate that applies to each Insured Unit; and (iii) for insurance compensation payout purposes it is necessary to know exactly which livestock producers are located in each Insured Unit and their individual herd (breeding cows) sums insured.

6.17. ***Uruguay has one of the World's most comprehensive livestock registration database system which is managed by the National Livestock Information Service (SNIG) in conjunction with the Division of Livestock Control (DICOSE).*** SNIG-DICOSE are involved twice yearly in updating cattle numbers as part of Uruguay's national Foot and Mouth Disease (FMD) prevention and vaccination program. For the purposes of the NDVI study in Uruguay SNIG-DICOSE have kindly made available their full cattle database for all Departments in Uruguay: this data has been provided for 2011 and to maintain confidentiality of information, the only identification provided is a unique registration code number and the Police Section of each livestock producer and the current numbers of cattle they each hold by category of animal. The World Bank-OPYPA team has used the SNIG-DICOSE 2011 livestock holding data to allocate all 3.9 million head of breeding cattle owned by approximately 38,000 breeding cattle producers into the 195 insurable Police Sections (Insured Units) across the 18 Departments and to estimate the total sum insured of US$ 315 million.

6.18. ***The SNIG Database of livestock producers and their current livestock holdings by class of insured animal will be used to establish the sums insured per Police Section and the total sum insured for the macro-level NDVI policy and in the event of losses being triggered to make payouts***. At the start of each insurance campaign, the Insurance Companies will need access to SNIG-DICOSE's livestock data-base to verify the numbers of livestock held by and the sum insured attaching to each livestock producer (recipient) and their location by Insured Unit (Police Section). In the event of a payout being triggered in any Insured Unit the payouts will be estimated for each and every livestock producer within the affected Police Section.

6.19. ***It is anticipated that the Insurance Companies will need to enter into a formal agreement with SNIG -DICOSE to provide updated livestock (cattle) holding data each year***. This will permit the Insurers to update the total sum insured on an annual basis as well as the livestock holding details of each livestock producer.

**Third Party NDVI Operator**

6.20. ***For the operation of this NDVI policy and to ensure timely payouts in the event the NDVI policy is triggered in any Insured Unit(s), the Insurance Companies will need to appoint a third party operator who will be responsible for downloading and processing MODIS imagery on a 16-day basis for Uruguay and in providing the processed monthly NDVI data for each 2,500 Ha pixel to the Insurers.*** The third party operator will be responsible for providing the appointed Insurer (or Pool leader) with the calculated monthly average MODIS NDVI values in each forage pixel during the cover period, and it is also recommended that the monthly NDVI data and reports should be made available to the Insured (GoU). The third party operator must be capable of demonstrating complete independence and impartiality in the processing of the monthly satellite NDVI data and to be accepted and trusted by all parties including the Insured, the Insurance Company(ies) and the lead Reinsurer(s). It is extremely important that the processing of the NDVI results is conducted by the Insurer within the shortest possible period, especially if NDVI index payouts have been triggered in the current month. The Insurer (or Pool) and its reinsurers will be ultimately responsible for checking the index payouts and in settling the payment to the Insured (GoU).

6.21. ***The 3rd Party operator will need to be an independent remote sensing specialist which will be contracted to provide NDVI monitoring, interpretation and reporting to the Insurers of the Uruguay pasture-livestock NDVI insurance program.*** One option which is currently being considered would be for LART-FAUBA from Buenos Aires, in conjunction with the National Institute of Agricultural Research (INEA), Uruguay, to act as the NDVI operator. At the World Bank-OPYPA's request LART-FAUBA have provided indicative costings for providing this 3rd party NDVI processing and reporting service to the Insurance Companies. Their services would include accessing and splicing SPOT and NOAA with MODIS satellite data in order to provide a back-up to the MODIS real-time monthly NDVI database in case of the MODIS satellite breaking down or being closed down. LART-FAUBA would provide monthly updates of the NDVI database for each pixel and annual generation of land use coverage maps: the company would charge an indicative annual fee of about US$ 160,000 for providing this NDVI database service to Insurers in both Uruguay and South West Buenos Aires (LART-FAUBA 2012). Alternatively, this service could be performed by an international remote sensing specialist appointed by the Insurer and its lead reinsurer. The costs of this remote sensing / NDVI service will have to be included in the final commercial premium rates that are charged on the NDVI insurance program.

6.22. ***The operation of the NDVI pasture index insurance program is totally dependent on the effective functioning of the MODIS satellite throughout the coverage period, and back-up systems in the case MODIS is not functioning at any stage need to be carefully considered. These back-up procedures need to be specified in the Policy Wording*** which is provided to the Insured. In the wider context, it should be recognized that MODIS has now been operating considerably longer than originally planned and when in due course it is shut-down it will then be necessary to re-estimate the NDVI database for Uruguay using a new and more up to date and higher resolution NDVI remote sensor (i.e. SPOT 4, SPOT 5 or AVHRR). It is therefore positive to note that LART-FAUBA, if appointed to provide the 3rd party NDVI monthly update service, would seek to calibrate and splice SPOT NDVI imagery which can be obtained at a very high resolution with the MODIS data in order to have an alternative source of monthly real-time NDVI data as soon as MODIS ceases to operate.

## Payout Mechanism to Individual Cattle producers

6.23. ***The third major operating requirement is to design a system of ensuring in times of drought in pasture when the NDVI policy is triggered, that livestock owners in each affected Insured Unit receive timely insurance payouts, either in cash or in kind.*** Under this NDVI program there are two options for making the compensation payouts to individual cattle producers in Police Sections where a payout has been triggered namely, in the form of (i) a cash payment or (ii) coupons or vouchers with the stated value of the payment due to each cattle owner which are redeemable at authorized local animal feed suppliers or finally (iii) the equivalent value in livestock feed rations ("in kind").

6.24. ***In the panel discussions with Uruguayan livestock producers, some cattle owners expressed their preferences to receive payouts in the form of cash or cheques paid directly into their accounts which they would then use to purchase feed rations for their livestock.*** These livestock producers felt this was the most rapid and transparent system for receiving NDVI compensation payouts. However, other livestock producers noted that cash payouts would be of little use to them in acute drought situations when animal feed stocks would be very hard to access and what they needed was for MGAP to arrange to deliver animal feed rations to municipality-level collection points, or preferably directly to their farms.

6.25. ***The voucher approach to making compensation payments to farmers has been adopted under some agricultural insurance programs***. The rationale of issuing vouchers which carry a stated monetary value rather than cash payouts is that cash can be diverted into any form of expenditure, while the vouchers can only be redeemed for inputs in kind - in this case animal feed rations. Each cattle producer due an NDVI payout would receive a coupon for that month with a value calculated on the basis of their number of breeding cows which they could then redeem at their nearest animal feed supplier.

6.26. ***MGAP and the regional research and extension services strongly felt that it was more cost-effective and practical in a major drought emergency situation for MGAP to access feed supplements and rations in bulk (including both domestic supplies and imported grains) and to then distribute these supplies to livestock producers in the triggered Police Sections***. It is noted that MGAP already has transport and storage infrastructure in place as well as accumulated experience in distributing livestock feed rations in times of major droughts, gained during the 2008-09 drought relief program and subsequently under the FAE program which it operates. If MGAP were to assume responsibility for distributing NDVI payouts in kind, it would be necessary to consider how to cover the distributional costs (staff, transport, fuel etc). It is noted that the costs of distributing the payouts in the form of animal feed rations has not been taken into account in the pricing of the NDVI product to date. Under the seven month cover period there is a potential that MGAP would be involved in distributing the animal feed rations over the full 7-month period and its operating costs could be substantial and if these costs were to be built into the commercial premium rate this could significantly increase the premium costs. In addition to the issue of the high costs of distributing the NDVI payouts in kind, this is likely to be the slowest of the three methods for delivering payouts to cattle producers suffering from drought and who urgently need these payments.

6.27. ***The Insurance Companies have pointed out that while they could possibly implement a system of direct payments by cheque to livestock producers in the event of the NDVI policy being triggered, they do not have the regional operating infrastructure or expertise to get directly involved in the distribution of animal feed rations***. If requested by the Insured (GoU) the appointed Insurer (or Pool Insurance Companies) could make automatic payments to the accounts of each registered cattle owner in the Insured Units where a payout has been triggered according to their individual livestock holdings and sums insured in each triggered Insured Unit. However, the Insurance Companies have made it clear they would only be able to operate financial settlements to each recipient as they do not have a rural network to effect purchases of livestock feed rations and to then distribute these to individual livestock producers. Under this option, it would be very important for the Insurers in conjunction with SFS to examine the legal position of the Insurers making direct payments to the livestock producers and specifically to confirm whether this would be deemed to amount to an insurance obligation between the Insurance Companies and the recipients of the payouts.

6.28. ***On the basis of this study it would appear that the most cost-effective way of distributing NDVI compensation payouts to livestock producers is for the Insurer to make a lump sum payout to GoU and then for GoU through its appointed representative MGAP to purchase animal feed rations in bulk and to distribute the rations to the eligible recipients in each affected Police Section.*** This compensation method would involve the Insurers paying a lump sum amount to the Insured (GoU) which would then be responsible, through MGAP, for distributing the payouts to the affected cattle producers. This would require that the Insurer(s) provide MGAP with a detailed schedule of the affected (triggered) Departments and Police Sections, and a listing of each breeding cattle owner along with his/her individual sum insured and amount of compensation payment due to each livestock producer.

6.29. ***It is noted that there is a price-risk exposure on this NDVI pasture insurance product.*** At the time of calculating the sum insured prior to policy inception the current market prices are used to value the wheat bran and sunflower flour animal feed rations. In the event of a major drought which impacts on both pasture and ceareal crop production in Uruguay it is likely that the costs of wheat, sunflower and any other feed grains will increase significantly. This means that a cattle producer who has received a cash or voucher payment and who takes it to purchase animal rations would not be able to puchase the originally calculated ration amount on account of the price increases. The same problem could also apply to the Option 3 procedure whereby government would use the lump sum payout to puchase bulk food stocks and to deitribute this as rations to the intended recipients. Most agricultural crop and livestock insurance programs do not, however, provide price risk protection.[34]

## Financial and Reinsurance Considerations for NDVI Insurance

### Premium financing

6.30. ***Chapter 5 presented full details of the rating methodology and the calculated technical rates and indicative commercial premium for an automatic insurance program covering all eligible cattle producers and their insurable cattle (breeding cows) in Uruguay*** under a series of assumptions including the sums insured which were set at 50% of the feed requirements of the cattle over the 7 month cover period and under a series of assumed payout return periods varying from 1 in 7 years to 1 in 15 years. The calculated indicative commercial premiums are reproduced in Table 6.1 and vary from a low of about US$ 20.2 million for a 1 in 15 year payout option to a high of US$ 35.7 million for the 1 in 7 year payout option.

[34] One exception is Malawi where Government purchases both a macro-level rainfall-deficit WII cover for maize to cover shortfall in nation maize crop production and to use the payouts to purchase maize imports, but in the recognition that a major drought could lead to increased maize prices throughout the region, it also places a put/call option on the Johannesburg Stock Market to hedge against maize import price increases.

**Table 6.1. Indicative Commercial Premium Rates (Calculated Technical Rate Plus loading 25% to derive Commercial Rate)**

| Payout Frequency (Years) | Pure Risk Rate (%) | Pure Risk Premium (US$) | Technical Rate (%)[1] | Technical Premium (US$)[1] | Indicative Commercial Rate (%)[2] | Indicative Commercial Premium (US$)[2] |
|---|---|---|---|---|---|---|
| 1 in 7 | 7.59% | 23,813,877 | 9.32% | 28,525,588 | 11.33% | 35,656,985 |
| 1 in 10 | 5.59% | 17,605,714 | 6.84% | 21,528,294 | 8.55% | 26,910,367 |
| 1 in 12 | 4.89% | 15,390,096 | 6.02% | 18,947,976 | 7.52% | 23,684,971 |
| 1 in 15 | 4.12% | 12,974,799 | 5.13% | 16,156,834 | 6.42% | 20,196,042 |

Source: Authors' NDVI Rating Model
Notes:
[1] Technical rates in each Police Section calculated as pure loss cost rate + uncertainty load of 15% of the standard deviation of the pure loss cost rate

[2] Illustrative Commercial Premium Rates calculated as Technical Premium Rate + Simple Load of 25%

6.31. ***Under the proposed macro-level policy, the GoU would be responsible for settling the due premium to the Pool Insurers.*** As part of this feasibility study it had been intended to conduct a comparative cost-benefit analysis for Government of the costs of NDVI Insurance premiums and the financial payouts that would have resulted over the past 10 years with the costs of compensation payments made by the FAE to livestock producers in Uruguay for the same years. It has not been possible to access FAE data to make this comparative analysis: however, some figures are set out below.

6.32. ***A comparison of the premiums Government would have paid out over the past 30 years and the benefits it would have received in terms of NDVI compensation payouts in catastrophe years is shown in Table 6.2.*** This analysis is presented for the 12 year pay-back period and with an annual commercial premium payment of US$ 23.7 million. Over the 30-year period, the program has been rated to achieve a 65% loss ratio or in other words for every US$ 1.0 of premium paid by Government it would have received payouts of US$ 0.65. The margin of surplus over this period is required to finance insurers and third party operator expenses and to provide a reasonable level of profit to the Insurer and its reinsurers. The value of the cover is seen in catastrophe drought years: in 1988-89 which is the worst payout year in the past 30 years, the GoU would have received a payout of US$ 96.3 million or 4.06 times higher than the US$ 23.7 million annual premium it would have paid. In the second worst year 2008-09, GoU would have received a payout of US$ 64.2 million to purchase animal feed rations to distribute to affected breeding cattle owners. It is noticeable that the 2008-09 NDVI insurance policy modelled payout value of US$ 64.2 million is identical to the additional costs of feed rations for beef and dairy cattle reported by the Rural Association of Uruguay (See analysis of 2008-09 drought losses in Table 2.6).

6.33. ***It is noted that under this feasibility study, it has not been possible to estimate the additional benefits of the NDVI program in terms of the reduction in consequential losses due to providing timely supplementary feed rations to the breeding cows*** during the up to 7 months drought cover period. The provision of the rations would save many livestock owners from having to sell their breeding cows and to avoid decapitalizing their cattle enterprises, by maintaining the cows nutritional status and health, mortality rates of the cows would be reduced, abortion rates in calves would be reduced and there would be an improved chance of suckling the calves up to the point of weaning and in the following year all these factors would enable the beef cattle sector to recover from the drought much more quickly than if no insurance program had been in place.

**Table 6.2. "As if" Analysis of NDVI Benefit to Cost Ratio for Government (12 year payback option)**

| Year | Premium (US$) [1] | NDVI Payout (US$) | Loss Ratio (%) |
|---|---|---|---|
| 1988/89 | 23,684,971 | 96,271,018 | 406% |
| 2008/09 | 23,684,971 | 64,174,365 | 271% |
| 1984/85 | 23,684,971 | 47,896,104 | 202% |
| 1999/00 | 23,684,971 | 47,041,440 | 199% |
| 94-95 | 23,684,971 | 45,021,861 | 190% |
| **all 30 years** | **710,549,119** | **461,702,870** | **65%** |

Source: Authors' analysis, NDVI Rating Model
Note: Premium assuming discounts for the effect of risk diversification.

6.34. ***The Government of Uruguay will need to decide whether it will cover 100% of the NDVI program commercial premium by itself,*** or to seek a premium cost-sharing formula with the livestock industry and local associations and the cattle producers (the recipients), who will be automatically protected under the proposed macro-level NDVI policy. It would, however, potentially be much harder to implement an automatic NDVI product if livestock producers in Uruguay are required to contribute to the costs of premiums and possibly this program would have to then revert to a voluntary insurance scheme, which is unlikely to be financially and operationally viable nor attractive to the Uruguayan insurance companies and their reinsurers. Moreover, if the livestock producers contribute to the costs of premiums thereby being an insured under the policy, an issue related to basis risk will arise: if a voluntary NDVI insurance scheme is implemented with the current pixel and Insured Unit spatial resolution, it is technically improbable that the underlying index (NDVI) will show a satisfactory correlation with farmers´ actual loss. Under this circumstance, therefore, livestock producers would have the right to sue the insurer in case they have incurred a loss and the NDVI insurance policy has not triggered any payment (see Chapter 3 for earlier discussion of the issue of basis risk).

**Probable Maximum Loss**

6.35. ***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 methodology for calculating the PML was detailed in Chapter 5.

6.36. ***The PML estimates on this scheme are high which is a reflection both of the systemic nature of drought risk exposure in Uruguay and the nature of a parametric index insurance cover which is designed to trigger payouts up to 100% of the total sum insured (liability) in the worst loss scenario.*** Table 6.3 shows the PMLs associated with 1 in 100 year, 1 in 50 year and 1 in 25 year return periods for the 1 in 7 up to 1 in 15 year payout frequencies any month during the seven month NDVI insurance cover period. The 1 in 100 year PML is often used by insurers and reinsurers to set their capital requirements for covering a worst loss scenario. For the 1 in 7 year payout frequency, and 1 in 100 years PML, the expected PML payout is equivalent to 96% of the

Total Sum Insured or US$ 302 million: this would be equivalent to a 1 in 100 year PML loss ratio of 848%. For a 1 in 15 year payout frequency the 1 in 100 year PML is estimated at 49% of total liability or AR$ 154 million. On account of the considerably lower premium for this option, however, the corresponding PML loss ratio would still be high at 762%.

6.37. ***The very high PML estimates on this NDVI livestock-pasture index insurance program and therefore capacity requirements indicate that the local insurance sector will need actively to involve the international specialist agricultural reinsurers in this program.*** Issues relating to reinsurance options and structuring are discussed in the next section below.

**Table 6.3. Pooled Risk PML Estimates for Different Payout Frequencies**

| Payout Option | Total Sum Insured | Total Premium | 1 in 100 Year PML | | PML Loss Ratio |
|---|---|---|---|---|---|
| | (US$) | (US$) | % of TSI | US$ | (%) |
| 1 in 7 years | 314,765,742 | 35,656,985 | 96.1% | 302,366,647 | 848% |
| 1 in 10 years | | 26,910,367 | 71.0% | 223,518,041 | 831% |
| 1 in 12 years | | 23,684,971 | 65.5% | 206,210,487 | 871% |
| 1 in 15 years | | 20,196,042 | 48.9% | 153,812,321 | 762% |
| **Payout Option** | **Total Sum Insured** | **Total Premium** | **1 in 50 Year PML** | | **PML Loss Ratio** |
| | (US$) | (US$) | % of TSI | US$ | (%) |
| 1 in 7 years | 314,765,742 | 35,656,985 | 70.5% | 222,022,049 | 623% |
| 1 in 10 years | | 26,910,367 | 53.7% | 168,954,968 | 628% |
| 1 in 12 years | | 23,684,971 | 49.4% | 155,566,665 | 657% |
| 1 in 15 years | | 20,196,042 | 38.5% | 121,050,792 | 599% |
| **Payout Option** | **Total Sum Insured** | **Total Premium** | **1 in 25 Year PML** | | **PML Loss Ratio** |
| | (US$) | (US$) | % of TSI | US$ | (%) |
| 1 in 7 years | 314,765,742 | 35,656,985 | 50.4% | 158,491,240 | 444% |
| 1 in 10 years | | 26,910,367 | 39.3% | 123,651,236 | 459% |
| 1 in 12 years | | 23,684,971 | 36.1% | 113,782,688 | 480% |
| 1 in 15 years | | 20,196,042 | 29.3% | 92,252,787 | 457% |

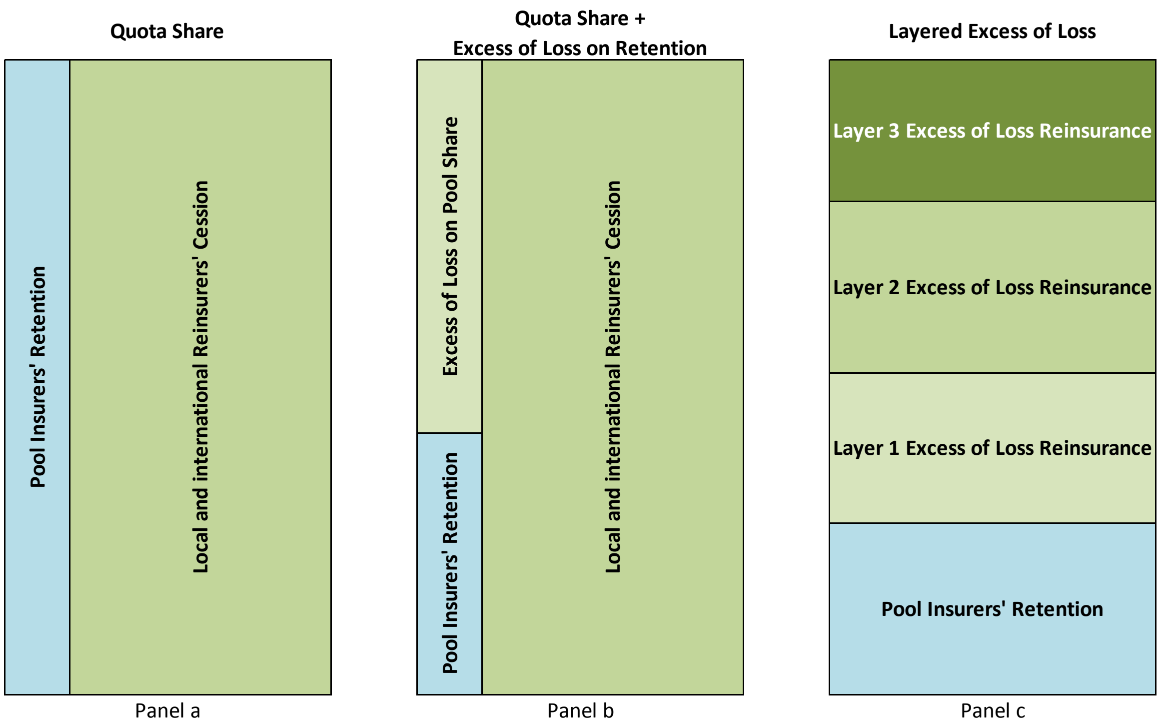
Source: Authors' based on NDVI Rating Model for Uruguay

## Risk Layering and Reinsurance

6.38. ***There are several options for the Uruguayan lead Insurer or Pool Coinsurers to consider for reinsuring the pasture NDVI program.*** The first option would be to purchase facultative proportional or quota share reinsurance under which the single appointed Insurer (or Pool) would decide on the share of risk it (they) could prudently retain, for example 10% of the risk which on a total sum insured basis would amount to US$ 31.5 million, and to then seek to cede the remaining 90% of the risk (US$AR$ 283.3 million) to international reinsurers (Figure 6.2, Panel a). The Insurer (Pool) may also decide to purchase facultative Excess of Loss Reinsurance (XOL) on its retention, for example for losses excess of 100% of Gross Net Premium Income (GNPI) (Figure 6.2, 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 6.2, panel c). It is not possible to predict at this stage if international reinsurers would agree to provide unlimited liability to the Pool on any XOL program, or whether they would only provide cover up to an agreed limit (e.g. 1 in 50 year PML) beyond which liability would revert to the local cedant (Pool).

**Figure 6.2. Examples of Proportional Quota Share and Non-Proportional Excess of Loss Reinsurance open to the Pool Insurers**




Source: Authors

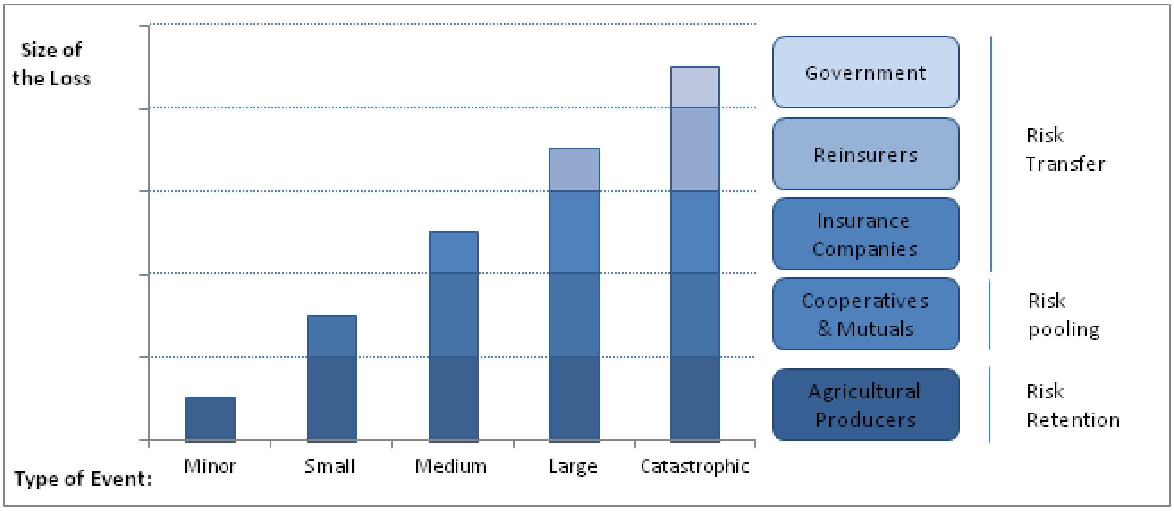
6.39. ***In many countries with public-private partnerships for agricultural insurance, government acts as a catastrophe reinsurer*** as illustrated in Figure 6.3. Major programs where governments actively participate in agricultural reinsurance financing include the USA and Canada, Spain, Portugal, India, China and in Latin America, Brazil and Mexico. In Uruguay, there is a very competitive private-sector agricultural insurance market actively supported by local and international reinsurers. At this stage it is envisaged that 100% of the livestock-pasture NDVI Index reinsurance program would be passed on to international reinsurers and that GoU would not participate as a catastrophe reinsurer of last resort.

6.40. ***There will be a need to involve international reinsurers at an early stage in the negotiations over the final cover design and rating and sums insured for this NDVI program.*** The specialist international agricultural reinsurers[35] are familiar with NDVI insurance and their

[35] In Uruguay insurers are free to place their business with any reinsurer so long as it has a credit rating of A- or better (AXCO 2012). The main reinsurers include Swiss Re, Munich Re, MAPFRE RE, Transatlantic Re Hannover Re, SCOR and Lloyd's.

support will be critical to the implementation of this new pasture NDVI program in Uruguay. 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 international reinsurers.

**Figure 6.3. Example of Agricultural Risk Layering**




Source: Mahul and Stutley 2010.

# 7. Conclusions, Recommendations and Next Steps for Pasture NDVI Insurance Program in Uruguay

## Next Steps - Moving Ahead

7.1. ***In the first instance, GoU will need to confirm whether it plans to purchase a macro-level NDVI pasture index insurance contract.*** This report has clearly indicated that because of the limitations on the satellite spatial resolution used by the World Bank-OPYPA team for the design of this insurance program, the NDVI cover is not suited to individual farmer insurance and furthermore that the Insurance Companies are currently not willing to underwrite a voluntary individual farmer scheme. As such the proposed NDVI program is designed as an ex-ante financial contingency product for government to use to provide timely payouts to small and medium livestock (cattle) producers located in Uruguay in years of extreme drought or other major events affecting natural pasture.

7.2. ***The new Macro-level NDVI pasture insurance program should be seen as part of the Government's natural disaster risk management strategy and will need to be carefully coordinated with the existing MGAP managed Fund for Agricultural Emergencies (FAE).*** If government elects to introduce NDVI pasture cover for livestock (cattle) producers in Uruguay, it will be necessary to decide on the future role of the FAE program as it would not be logical to continue operating two natural disaster compensations programs with overlapping objectives. However, if Government elects to purchase a top-layer catastrophe NDVI insurance protection only, it could be both possible and desirable to structure the two programs together, with the NDVI policy insuring catastrophe drought losses in pasture and the FAE continuing to compensate smaller frequency losses in pasture, or any other type of risk that impacts on livestock production in Uruguay for example disease resulting in mortality of the cattle.

7.3. ***The implementation of a pilot NDVI program in selected Departments of Uruguay may be attractive to the interested parties in order to test and validate the product before moving to full scale implementation.*** On the basis of the sum insured and rating calculations presented in Chapter 5, a full-scale program for all 3.9 million insurable breeding cows in the 18 eligible Departments of Uruguay would amount to a very significant new insurance program with TSI (liability) of US$ 315 million and for a payout frequency of 1 in 12 years, and with a 1 in 100 year estimated PML of US$ 206 million the capacity requirements from the local Insurer (or Pool coinsurers) and international Reinsurers would be very significant. Similarly the indicative commercial premium costs which would have to be borne by the Insured (GoU, under the proposed macro-level cover) would also be significant and in the order of US$ 23.7 million for the 1 in 12 year payout frequency option assuming the benefits of risk diversification (Table 7.1.).

7.4. ***If GoU approves the implementation of a macro-level NDVI pasture insurance program, OPYPA-MGAP has indicated that it plans to start with a Pilot Program in seven selected Departments located in two regions, four Departments in the Basalto region in northern Uruguay and three more in south eastern Uruguay.*** This pilot NDVI pasture insurance program would be linked to the Fund for Adaptation to Climate Change under the Kyoto Agreement[36] and would be implemented in 30 selected Police Sections located in Artigas, Salto,

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[36] *Fondo de Adaptación de Protocolo de Kyoto (Proyecto del GoU).*

Paysandu and Tacuarembo Departments in the Basalto Region and Lavelleja, Rocha and Maldonado Departments in south-eastern Uruguay. OPYPA advises that the pilot project would be targeted at small and medium breeding cattle owners with less than 750 hectares of land and on this basis it would insure a total of 326,427 breeding cattle (8.4% of the national herd) with TSI of US$ 26.6 million and illustrative commercial premium costs of US$ 2.2 million (1 in 10 year month by month payout frequency option). Lavalleja Department would have the highest share of liability at US$ 7.3 million or 28% of TSI and 23% of premium, followed by Rocha Department with sum insured of US$ 5.7 million (22% of TSI) and 21% of premium (Table 7.1 and Figure 7.1).

7.5. ***The World Bank team fully endorses this prudent approach of starting with a pilot NDVI pasture project*** as this will (i) reduce the insurance and reinsurance capacity requirements to a manageable level, (ii) reduce the costs to GoU of the premium to a more fundable level, (iii) permit all parties to test the cover design parameters of the NDVI product and the operating systems and procedures and to strengthen these if required over time and (iv) enable all parties to gain experience with the NDVI product and to evaluate its cost-effectiveness and on which basis to take decisions to scale the program up to full national coverage over time. The only drawback of starting with a pilot project is that there will be reduced benefits from pooling of risk and the PML as a percentage of TSI would be higher.

**Table 7.1. Pilot NDVI Insurance Project for Breeding Cattle Farms < 750 Ha, located in selected Police Sections of 7 Departments: No. of Insured Breeding Cows, Sum Insured and Premium**

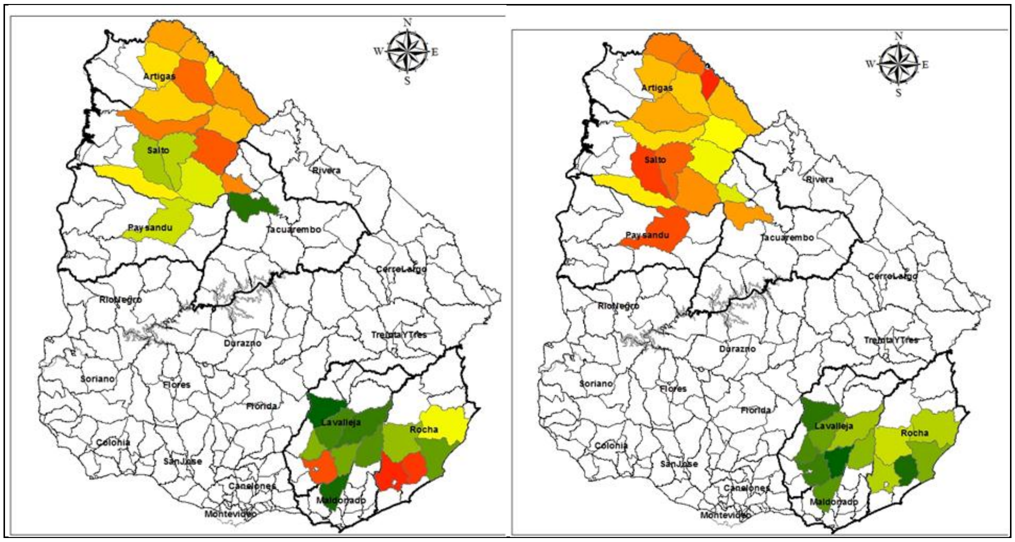
| Department | No. of Police Sections | No. Insured Breeding Cows | Sum Insured (US$) | Pure Risk Premium | | Technical Premium | |
|---|---|---|---|---|---|---|---|
| | | | | % Rate | US$ | % Rate | US$ |
| Artigas | 7 | 56,429 | 4,591,910 | 6.53% | 299,700 | 7.86% | 360,716 |
| Lavalleja | 6 | 90,001 | 7,323,831 | 4.52% | 331,138 | 5.85% | 428,557 |
| Maldonado | 2 | 30,177 | 2,455,653 | 5.08% | 124,727 | 6.38% | 156,715 |
| Paysandú | 1 | 5,274 | 429,172 | 6.82% | 29,249 | 8.65% | 37,116 |
| Rocha | 5 | 70,415 | 5,730,021 | 5.24% | 300,431 | 6.52% | 373,749 |
| Salto | 7 | 51,042 | 4,153,543 | 6.28% | 260,660 | 7.71% | 320,392 |
| Tacuarembo | 2 | 23,089 | 1,878,867 | 6.21% | 116,657 | 7.85% | 147,498 |
| **TOTAL** | **30** | **326,427** | **26,562,997** | **5.47%** | **1,453,160** | **6.67%** | **1,771,041** |
| **Indicative Commercial Premium (Technical premium with 25% loading for A&O expenses, underwriting profit etc)** | | | | | | **8.33%** | **2,213,802** |

Source: Authors NDVI Rating Model

7.6. ***At an early stage, the Uruguayan public and private insurance companies will need to decide how they wish to underwrite the NDVI program and the option of forming a coinsurance pool has been identified as one strategy to follow.*** Under the proposed macro-level option where a single policy is issued to government, there appear to be two insurance institutional options (i) for GoU (in conjunction with the SFS) to adopt a tender approach whereby interested companies would submit their proposals for underwriting and managing the NDVI program and the successful company would assume sole responsibility for underwriting the NDVI pasture-drought insurance program, or (ii) that the interested agricultural insurance companies elect to establish some form of coinsurance or Pool agreement and to share in the costs of implementing this program. In both cases the program would need to be backed up by international reinsurance protection.

**Figure 7.1. NDVI Pilot Project Departments and Police Sections**

(a) Sum Insured (US$) (b) Pure Risk Premium Rates




Source: Authors

7.7. ***From a technical viewpoint it is recommended that the Pool Insurers contract a Remote Sensing Specialist to update the Uruguay NDVI Data-base for 2011-12 and 2012-13.*** The LART-FAUBA NDVI Data-base study was conducted between 2011/12 and has provided a 30 year NDVI time series from 1981/82 to 2010/11. If the NDVI Pilot project is approved, it will be necessary for the Pool Insurers contract a local specialist to update the NDVI data-base to include the most recent years 2011-12 and to 2012-13. Following this the World Bank NDVI-Rating Model for Uruguay will need to be updated to include the two years of new NDVI data and the pure rates and the technical rates and commercial premium rates recalculated.

7.8. ***The insurance companies will now need to obtain formal approval from the SFS to implement the new NDVI product / program.*** Throughout the conduct of this feasibility study the World Bank team has regularly briefed the SFS on the technical design characteristics and rating model for the proposed index-based Pasture NDVI insurance program for livestock producers in Uruguay. The SFS has been very supportive of the NDVI Feasibility study. Now that the Feasibility study has been completed and the NDVI Rating Manual and NDVI Rating Tools have been finalized, the insurance companies are now in a position to prepare their Technical Note and formally to submit these documents and rating tools to the SFS for formal approval.

7.9. ***It will be necessary to involve international reinsurers at an early stage in the negotiations over the final cover design and rating and sums insured for this NDVI program.*** The capacity requirements for this program are very large and inevitably the local insurers will need to seek the support of specialist international reinsurers of this class of agricultural index-based insurance. International reinsures will need to have access to the NDVI database, cover design and rating model in order to conduct their own analyses and to validate the threshold and exit triggers and payout scales, and to then validate the technical rates and to determine the final commercial premium rates they require to support this program.

7.10. ***A third party NDVI Operator will also need to be identified and approved by all stakeholders in the implementation planning phase.*** It is essential that the third party operator is able to operate independently in monitoring the NDVI values for each pixel and Insured Unit during the Insurance Cover Period and for providing these data to the key stakeholders (including the Insured, the insurance companies and their reinsurers) on a regular monthly basis. In 2012 the World Bank requested LART-FAUBA to draw up technical specifications and a financial budget for the requirements of such a third party NDVI operator for the insurance program in Uruguay (and in Argentina). Details of LART-FAUBA's proposals have been made available to OPYPA-MGAP and in the next stage would need to be shared with the local insurers and their reinsurers. There is, however, no obligation for the local insurers to use LART-FAUBA's services and if the Insurers prefer they could hire an alternative international NDVI specialist.

7.11. ***The most critical operational aspect of the proposed NDVI pasture index insurance program is to ensure that, in the event of payments being triggered, livestock producers in the affected Insured Units (Police Section) will receive their payouts in a timely fashion.*** This report has shown that SNIG-DICOSE can provide accurate information for each and every livestock producer on the number of beef cattle they hold by Police Section and by Department in Uruguay for the purposes of (i) registering these producers as the recipients of the macro-level program and (ii) for the purposes of establishing the sums insured per recipient and by Police Section and Department and in total. The options for making payouts in cash or in kind (feed rations) has firmly concluded that it will be most practical for GoU to use MGAP to make bulk purchases of livestock rations and to then distribute these rations using MGAP's existing infrastructure and procedures for the FAE program. .

7.12. ***Government in conjunction with the Insurance Companies will need to decide on the level of livestock producer awareness and promotion it wishes to provide in the start-up phase of the NDVI pasture index insurance program in Uruguay.*** Under the proposed automatic insurance program where government is responsible for paying premium, the most important training topics that will need to be addressed include explaining to livestock producers located in the insured Police Sections and Departments the basis of insurance and compensation payouts of the NDVI pasture index product in order to ensure that they understand that the cover provided is not based on individual farmer's own farms and pasture, but on the NDVI measure of pasture productivity at the Police Section level. Equally the training should emphasize that cover is provided according to the estimated nutritional requirements of only breeding cows, and that the amount of compensation per head of cattle is on a fixed amount basis each month that the policy payouts are triggered, and does not cover the full estimated costs of providing supplementary feeds to breeding cows during periods of severe drought when natural pasture and grazing resources are depleted.

7.13. ***It is recommended that the key interested parties in this NDVI-pasture-drought insurance initiative consider forming a Working Group which would meet on a regular basis to review the key implementation planning tasks and issues which need to be resolved in order to launch the Pilot NDVI scheme***. The composition of the Working Group should include key stakeholders such as OPYPA-MGAP, the Ministry of Economy, INIA, the Superintendent of Financial Services and representatives of the livestock associations

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# Annex 1. Livestock (Cattle) Production Systems in Uruguay

This annex is aimed to provide a general description of the livestock sector in Uruguay. The annex starts with the description of the main agricultural activities in Uruguay, and then it provides a brief description of the predominant livestock production systems. The annex also provides a description of the main livestock production systems in the country and the main fodder supplies. Last, but not least the annex provides an economic analysis of the livestock production systems in each region of the country.

## *Description of the Agricultural Sector in Uruguay*

Uruguay is characterized by a wide range of productive activities in temperate climates. In terms of area, we find that livestock for meat, milk and wool, occupies more than 80% of the country, followed by extensive agriculture (rainfed crops and irrigated rice) which currently holds more than one million hectares, forestry with 950,000 hectares, and finally intensive crop production (deciduous fruit, citrus, vineyards and in-field and protected horticulture) with more than 40,000 hectares. Table A1.1 summarizes the main figures for the distribution of agricultural activities in the country.

**Table A1.1. Agricultural production general characterization**

| Type of product | Nº of farmers | Surface (miles of ha.) |
|---|---|---|
| Livestock (cattle and sheep) | 41,136 | 12,256 |
| Dairy | 4,507 | 800 |
| Extensive Agriculture | 7,567 | 3,293 |
| Wheat | | 553 |
| Malting barley | | 141 |
| Corn | | 96 |
| Sunflower | | 35 |
| Sorghum | | 35 |
| Rice | 523 | 162 |
| Soy | | 863 |
| Deciduous Fruit Orchard | | 7,6 |
| Vineyard | | 8,1 |
| Citrus | | 16,2 |
| In-field horticulture | 2,34 | 9,5 |
| Protected horticulture (1) | 690 | 0,6 |
| Forestry | | 951 |

*Source: Agricultural Statistical Yearbook 2010*. DIEA - MGAP

### *Characterization of the major production regions in Uruguay*

Agricultural production regions in Uruguay are grouped into agro-ecological zones with different patterns in terms of natural resources and technology applied, among others. Based on these criteria and following the classification established by (Ferreira 2001), the country can be divided into seven Agro-ecological regions as described below, and as shown in Map A1.1.

**Zone 1-Basalto**

The Basalto zone is the most important livestock production area in Uruguay. The area has 5,100 farms occupying 3.3 million hectares. The area is predominantly characterized by extensive livestock production systems, with low productivity and investment, where cattle and sheep graze freely together throughout the year. Natural grassland represents the 93% of the total area and annual sown pasture occupies 4.1 %. The extensive production system in this zone is highly dependent on weather conditions. The technology levels in the region are, in general, very low and most of the farmers in the zone are usually very risk averse.

**Zone 2-Eastern Sierra**

The Eastern Sierra zone has area of 1.555 million hectares holding 5,000 farms. Natural grassland represents 87% of the area and cropping and improved pasture represents 8.3%. The area is featured by the presence of shallow or medium deep soil with high presence of rocks. The water holding capacity of the soils in sierra region is low.

**Zone 3- Eastern plains.**

The Eastern Plains extends over approximately 850,000 hectares out of which about 130,000 hectares (30% of the area) being the only major crop. Cattle breeding activities are taken place in the areas where rice production, mainly owing to drainage and irrigation problems, is not possible. In recent years the rangelands in this zone have been improved through the use of aerial seeding of pastures. This practice allows the development of more intensive livestock activities like beef cattle fattening with daily gains between 400 to 600 grams per animal per day.

**Zone 4- Cristalino (4A) and Sierras del Este (4B).**

The zone 4 is divided into two sub-zones namely: (i) Cristalino, and (ii) Sierras del Este. There are 6,900 farms occupying an area of 2,469,000 hectares in the granitic soils of the centre in the Cristalino sub-zone. The Cristalino medium to deep soils are suitable for agriculture. Rangelands accounts for 69% of the area and cultivated pastures for 22% of the area. The Sierras del Este subzone has 4,700 farms distributed over 1.3 million hectares. The landscape is characterized by hills with slopes between 2 and 12%, where rocky areas (in patches) are rare. Natural grassland accounts for 80% of the area and cultivated, improved annual pastures, account for 14%.

**Zone 5 - Sandy soils (5A) and Northeast (5B)**

The zone 5 is divided into two sub-zones namely: (i) Sandy Soils, and (ii) Northeast. There are 3,210 farms occupying an area of 1.3 million hectares ha in the sandy soils sub-zone. The landscape is featured by hills, with deep soils of low fertility. The sources of fodder for the cattle are rangelands (accounting for 79% of the area) and cultivated pastures (8% of the total area). Pasture production in terms of dry matter is high, mainly during the spring and summer, but of low quality. The herd productivity performance in this sub-zone is very poor. The Northeast subzone has 3,500 farms distributed over 1.5 million hectares. The area is characterized by heterogeneous soil types and a hilly landscape. The main source of fodder for livestock production is mainly based in natural grasslands (87% of the area) and cultivated pastures (10% of the area).

**Zone 6 - Deep soils, crops, intensive livestock and dairy production.**

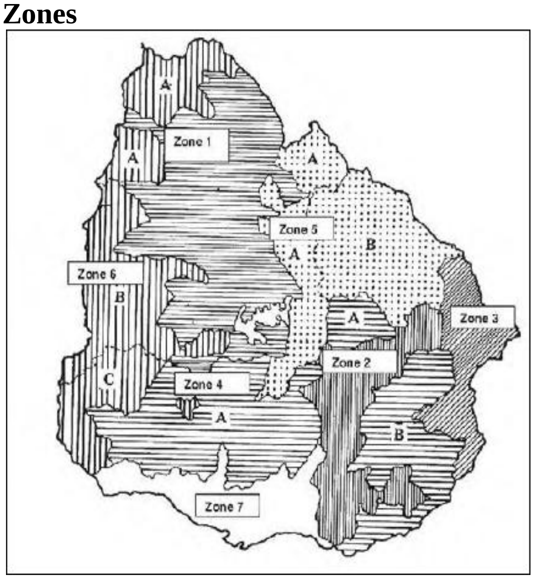
This zone has been divided into three subzones. Subzone 6A is in the north of the country and has 1,460 farms occupying 846,000 hectares dedicated to extensive livestock production. Natural pastures accounts for 90% of the area and cultivated, improved and annual pastures for 6% of the total area. Livestock production in the area is close linked with rice production. Current technologies improve the overall system efficiency of rice-pasture rotation. The land which is not suitable for handling the rotation remains in extensive livestock production. Subzones 6 B and 6C have the more intensive livestock production and agriculture systems of the country and a high proportion of cultivated pastures with the use of silage and hay for fodder conservation. The subzone B has 2,861 farms and covers 1.3 million hectares and 2,861 farms. Cultivated pastures account for 24% of the area. Crops and natural grassland account for 8% and 58%, respectively. Cultivated pastures, account for 38% of the total area, crops cover 21% of the area, and only 40% corresponds to natural pasture. In this area, beef and dairy cattle are 558,000, sheep are 221,000 and horses are 14,500.

**Zone 7 - Deep soils.**

The main production systems in Zone 7 are intensive dairy production and fruit and vegetable production. There are 10,500 farms distributed in 886,000 hectares. Natural grassland represents 48% of the total area and cultivated, improved and annual pastures, 40% of the total area. In 2001, the zones had 792,000 heads dairy and beef cattle, 161,000 sheep heads, and 21,600 horses were declared.

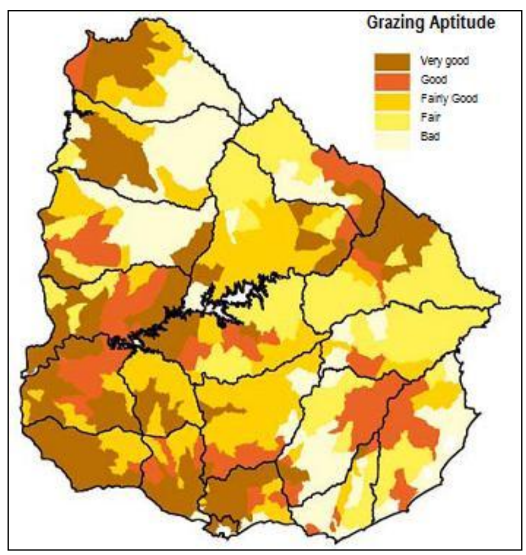
Map A1.1. shows the distribution of the seven agro-ecological zones in Uruguay and then Map A1.2 shows the distribution of land in Uruguay according to its suitability for livestock grazing (ranked from very good to bad), according to the information gathered in the General Agricultural Census, 2000. The cattle production distribution is related to the grazing aptitude of the land, which can be observed in map A1.2.

**Map A1.1 Uruguay: Agro-ecological Zones**




Source: (Ferreira, 2001)

**Map A1.2 Uruguay: Grazing Aptitude**




Source: General Agricultural Census, 2000

***Characterization of the beef cattle production systems in Uruguay***

Beef cattle stocks in Uruguay are relatively stable. The beef cattle stock has remained almost constant at 11.1 million head of animals during the period 2002 up to 2010. The stock figures indicate a relative stability in the number of heads, whose average for the period is 11.7 million, with a coefficient of variation of only 2.6%. The same applies to the demand expressed in Livestock Units, the average being 9,000 million LU[37], with a coefficient of variation of 1.6%. Table A1.2 presents the stock information for different categories of cattle and their evolution from the period starting in 2002 up to and including 2010 according on the information provided by the Division of Livestock Control (DICOSE), based on affidavits.

**Table A1.2. Trends of cattle stocks and livestock units, by agricultural year (1), and by category (thousands of heads).**

| YEAR | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|
| Total Stock | 11,268 | 11,708 | 11,958 | 11,950 | 11,709 | 11,625 | 11,913 | 11,750 | 11,092 |
| Bulls | 166 | 173 | 177 | 179 | 172 | 171 | 170 | 163 | 154 |
| Breeding cows | 4,159 | 4,149 | 4,130 | 4,143 | 4,044 | 4,132 | 4,231 | 3,903 | 3,874 |
| Fattening Cows | 457 | 524 | 473 | 432 | 441 | 389 | 373 | 483 | 361 |
| Steers of more than 3 years | 664 | 640 | 598 | 577 | 531 | 498 | 478 | 516 | 509 |
| Steers of 2 to 3 years | 856 | 833 | 911 | 968 | 892 | 845 | 865 | 854 | 897 |
| Steers of 1 to 2 years | 979 | 1,135 | 1,213 | 1,197 | 1,172 | 1,171 | 1,176 | 1,216 | 1,178 |
| Heifers of more than 2 years | 427 | 438 | 559 | 615 | 584 | 527 | 535 | 591 | 576 |
| Heifers of 1 to 2 years | 1,015 | 1,187 | 1,283 | 1,254 | 1,215 | 1,218 | 1,246 | 1,273 | 1,232 |
| Steers / Calves | 2,545 | 2,629 | 2,615 | 2,584 | 2,658 | 2,674 | 2,838 | 2,750 | 2,306 |
| Livestock Units | 8,964 | 9,132 | 9,381 | 9,377 | 9,147 | 9,081 | 9,267 | 9,108 | N/A |

Source: MGAP-DICOSE

Cattle production in Uruguay takes place under three different production systems: (i) cattle rearing (breeding) system (relation 2-year old or older steers[38] to cows bigger lower than 0.4); (ii) Complete cycle system (relation 2-year old or older steer[39] to cows bigger between 0.4 and 1.2); and (iii) fattening production systems (relation 2-year old or older steers[40] to cows bigger than 1.2). According to the production system, three regions can be distinguished for Uruguay. The first region is the breeding region. The breeding region occupies 6.44 million hectares and has 1.44 million cows, which accounts for 47% of total non-dairy breeding cows in the country. The cow loading factor is 0.24 heads per hectare. The steers over two years amounts to 370,000 heads, accounting for 26% of the total number of steers in the country. The second region in terms of cattle production in Uruguay is the “complete cycle” region. The "complete cycle" region occupies 8.58 million hectares and has 1.55 million of cows (50% of the total), meaning 0.2 head / hectare. This shows that the breeding, in terms of heads, is regionally associated with re-breeding. The stock of steers in the region amounts to 900,000 heads (64% of the total). The third region is the fattening region. The "fattening"

[37] Livestock Units: In the present document we assume a consumption of 2,774 kg of dry matter / year.

[38] Extracted from Pereyra et al. 2004

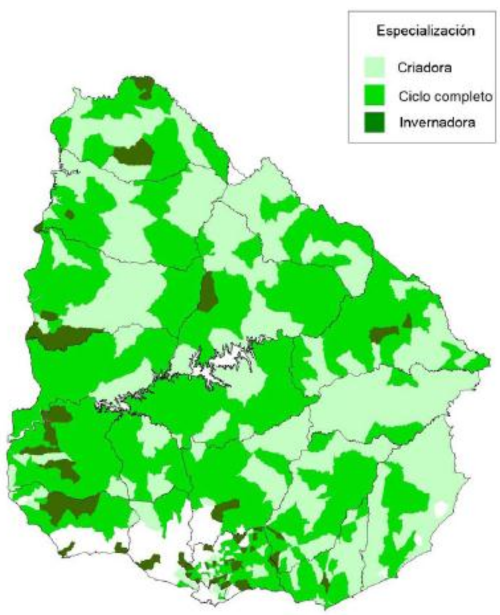
[39] Ibid[2]

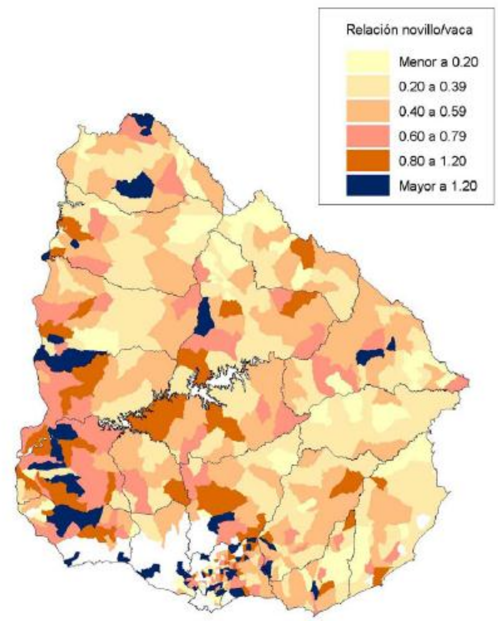
[40] Ibid[3]

region occupies 0.78 million hectares and has 130,000 steers over 2 years (9% of total), so at the spatial level, there is not hold a great specialization in fattening. Thus the fattening region usually appears surrounded by the highest values of the relationship steers / breeding cows that correspond to the complete cycle group, which also tend to be deficient in calves.

Map A1.3 and Map A1.4 show the distribution of the livestock production systems in Uruguay and the distribution of the steer/cow coefficient in Uruguay.

**Map A1.3. Beef Cattle Production Systems** **Map A1.4. Relation Steers (>2 years)/ cows**



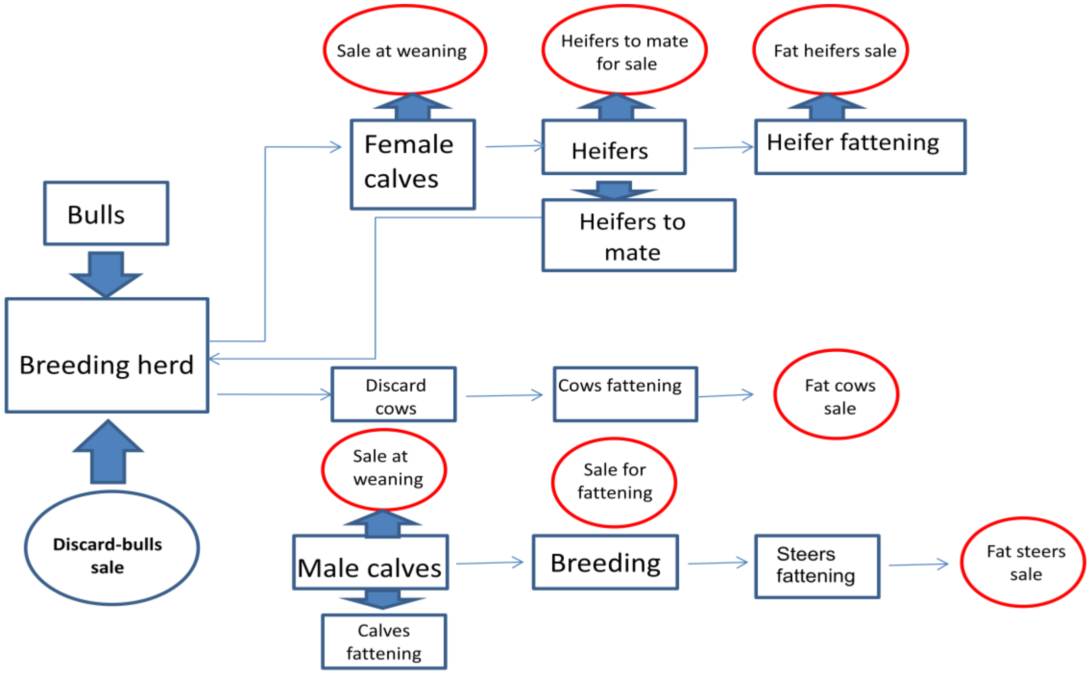




Source: Pereira et al. 2004, based on MGAP-DIEA General Agricultural Census, 2000

Diagram A1.1 and Diagram A1.2 summarize the main features of the breeding and the full cycle production systems in terms of structure and management of the herd.

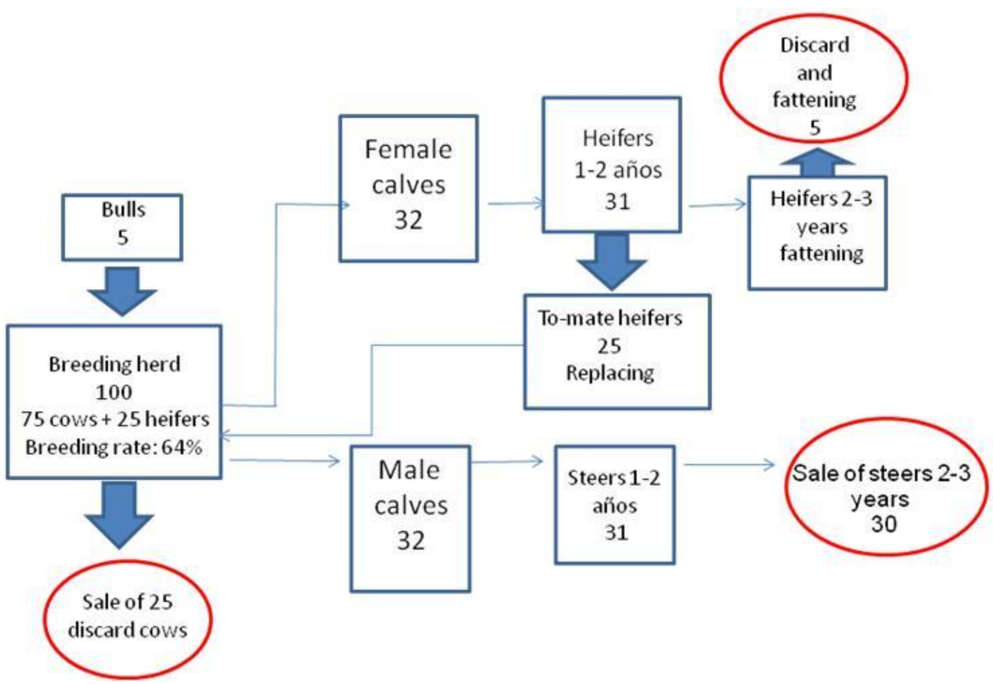
The cattle herd in Uruguay is not evenly distributed. Almost 93% of the farms have less than 1,000 hectares, and considering them all together they account only for 50% of the cattle surface area. The remaining 50% of the livestock area is in the hands of the 7% of big farmers. Table A1.3 shows the profile of pure livestock farms in Uruguay.

**Diagram A1.1 Management and Structure of a cattle breeding herd**




Source: Rivera et. al. 2005.

**Diagram A1.2. Management and Structure of a Complete Cycle herd**




Source: Rivera et. al. 2005.

**Table A1.3 Number of pure cattle farms, total area and area with improvements (thousand ha)**

| Surface strata (ha) | Number of. Farms | Area ('000 hectares) | | Area of Improvements (Hectares) | |
|---|---|---|---|---|---|
| | | Hectares ('000) | % | Hectares ('000) | % |
| **Total** | **41,136** | **12,256** | **100** | **1,362** | **14%** |
| < 50 | 17,570 | 316 | 3 | 44 | 13% |
| 50-100 | 5,359 | 393 | 3 | 53 | 11% |
| 100-200 | 5,474 | 798 | 7 | 90 | 10% |
| 200-500 | 6,397 | 2,072 | 17 | 212 | 11% |
| 500-1,000 | 3,440 | 2,444 | 20 | 266 | 11% |
| 1,000-3,000 | 2,400 | 3,795 | 31 | 435 | 10% |
| 3,000-5,000 | 354 | 1,350 | 11 | 131 | 12% |
| > 5,000 | 142 | 1,088 | 9 | 130 | 14% |

Source: MGAP-DIEA based on DICOSE affidavits, Crop year 2008/09.

***Fodder availability and pasture improvements***

Natural grasslands used as extensive livestock systems with a low degree of modification correspond to the principal soil types of each region and to the agro-ecological zoning previously defined (by Ferreira, 2001). The floristic characterization depends on the soil type, its physical and chemical properties, and to a small extent, on topography and sun radiation exposure. There are four different types of pasture: (i) permanent pastures or natural grassland; (ii) fertilized natural grassland; (iii) improved grassland; and (iv) cropping pastures or perennial ones.

Forage production shows a seasonal pattern. The lower dry matter values correspond to the winter period and the higher dry matter values to the summer season. The north-east region has the smaller value range while the sandy soils have the largest one. During autumn and winter, deep soils are the ones that have higher dry matter productivity, because of their ability to store water.

Cattle and sheep production systems are more intensive in the western region, which has highly fertile soils. Due to its high production potential this area has a long intensive cropping tradition that resulted in the substitution of the best species of native pasture grasses and weeds that invaded (mainly Cynodon dactylon) and adversely affected the physical and chemical properties of soils. In the 1970 decade started the adoption of crop rotation and cropping pastures (production systems with grassland). Because cropping pastures had high production potential, it was possible to overcome the difficulties of low annual and winter production and forage quality of degraded native vegetation, resulting in improvements in the efficiency of the breeding and fattening processes for cattle and sheep. Since the introduction of cultivated pastures it has been an intensification of the processes of breeding and fattening in a context that ensures bio-economical sustainability of the predominant production systems (Carámbula, 1991, cited by Berretta 2003).

Table A1.4 presents the productivity of different types of grasslands, measured in daily growing rate (DGR) (kg dry matter/ha/day) with its standard deviation and the seasonal distribution (SD) in the main Agro-ecological zones in the county.

**Table A1.4 Grassland Productivity according to Agro-Ecological Zone, soil type and season**

| Agro-Ecological Zone | Soil Type | Variable | Season | | | |
|---|---|---|---|---|---|---|
| | | | Summer | Autumn | Winter | Spring |
| Basalt (Zone 1) | SBR(1) | DGR | 10.1 +/- 4.9 | 6.8 +/- 2.9 | 4.9 +/- 2.5 | 9.9 +/- 3.9 |
| | | SD | 31.4 | 21.2 | 15.7 | 31.7 |
| | SB(2) | DGR | 13.6 +/- 5.9 | 8.8 +/- 3.9 | 6.1 +/-2.4 | 13.0 +/-4.3 |
| | | SD | 32.1 | 21.0 | 14.9 | 32.0 |
| | Deep(3) | DGR | 17.2 +/- 7.8 | 10.9 +/- 4.2 | 7.3 +/- 3.1 | 14.8 +/-4.4 |
| | | SD | 33.3 | 21.5 | 15.1 | 30.1 |
| Eastern sierra (Zone 2) | | DGR | 9.6 +/- 6.7 | 6.3 +/- 3.1 | 1.1 +/- 1.0 | 6.0 +/- 2.4 |
| | | SD | 41.5 | 27.6 | 5.0 | 25.9 |
| Granite of the center (Zone 4A) | Deep | DGR | 13.1 +/- 7.3 | 8.6 +/- 3.3 | 6.5 +/- 3.2 | 17.0 +/- 6.8 |
| | | SD | 28.6 | 19.3 | 14.5 | 37.6 |
| Eastern Hills ( Zone4B) | | DGR | 15.3 | 9.2 | 3.8 | 11.5 |
| | | SD | 38.0 | 23.4 | 9.7 | 28.9 |
| Sandy soils (Zone 5A) | High hillside | DGR | 27.2 +/- 5.6 | 7.3 +/- 4.2 | 4.1 +/- 2.3 | 17.6 +/- 3.3 |
| | | SD | 48.5 | 13.1 | 7.3 | 31.1 |
| | Low hillside | DGR | 27,3 +/- 8.4 | 7.5 +/- 4.4 | 3.7 +/- 1.5 | 22.2 +/- 4.1 |
| | | SD | 44.5 | 13.6 | 6.1 | 36.8 |
| Northeast (Zone 5B) | | DGR | 5.1 | 6.9 | 4.7 | 11.0 |
| | | SD | 18.3 | 25.0 | 17.1 | 39.6 |

1: Superficial brownish red soil; 2: superficial black soils; 3: Deep soils.
Source: Berreta, 2003.

Natural grasslands have limitations that prevent adequate animal production throughout the year like seasonality, with very low winter growth due to the predominance of summer-growing species. This situation results in the animal`s weight loss that farmers try to alleviate with different ways of forage conservation (pasture hay, silo of cultivated pasture, improved grassland, annual fodder and humid corn and sorghum grains). Another important limitation is the low nutritive values of natural pasture with variable crude protein values between 5 and 15 percent, depending on the season, the highest values recorded in winter and spring, irrespective of the growth cycle of plants, and the lowest ones in summer. The generalized deficiency of nutrients such as phosphorus also causes reductions in the pasture yield.

The use of annual forage species to complement the forage supply deficit during winter and autumn are of common use in Uruguay. Intensive and semi-intensive cattle production systems for meat and milk have adopted annual forage species (oats, wheat, ryegrass, moha, corn and sorghum for pasture and silage, among others) in order to buffer the effect of the seasonality of the production of natural grasslands. In 2000 the cultivated pasture area (1,287,245 hectares) is greater than the improved pasture area (487,082 hectares) and all of them are under intensive systems (General Agricultural Census, 2000).

Many farmers have implemented improved forage managements practices in their farms. The farmers have increased the number of paddocks of their farms allowing them to use productivity enhancing practices such as alternating grassing loadings according to season, vegetation type and animal category. In the last two decades, farmers have increased the divisions of the grassland through the use of electrical wiring, which allows a flexible management of the cattle in the field. Farmers have also increased the pasture productivity in a safe and sustainable framework. Farmers are applying fertilizers to remove the deficiencies of phosphorus and nitrogen present in most of the soils; ones through inorganic fertilizer application, others through the introduction of legumes with no-tillage sowing and phosphorus fertilization.

Because there is no available estimation of the forage supply for now, we would use indirect indicators such as breeding and pregnancy rates, over which events like drought have particular impact due to the adverse affect it has on fodder supply.

***Technical indicators of the herd in Uruguay***

In Uruguay, farmers have historically weaned an average of 64 calves for each 100 cows. It is important to note that most of the cattle farms have a great variation between years in these indicators. The breeding process carried out over natural grassland is conditioned by its total production and, above all, by the low winter forage production, time at which cows are in late gestation or early lactation period. The low rate of weaning that characterizes domestic livestock, is due to the poor nutritional status of cows at labour and at the beginning of the mating period, determining a long period of postpartum and low probability of pregnancy. Pregnancy indicators presented in this report are derived from surveys conducted by DIEA to Veterinarians across the country.

Cattle herd pregnancy and breeding indicators are affected every time there is an event affecting grassland production. In the last 13 years the country has been affected by severe droughts on three occasions. In 2000/1, the pregnancy rates were down from 73% to 67%t, almost (10% reduction). In 2004/5, the pregnancy rates were down from 71.6% to 69.8%, almost (5% reduction). In 2009/10, the pregnancy rates were down more than 15%, from 77% to 65%. Table A1.5 shows the historical evolution of the pregnancy rate and the breeding rate for the period 1998-2010 indicating the years on which pasture production has been affected by droughts.

**Table A1.5. Historical Evolution of Pregnancy and Breeding Rates.**

| Year | Pregnancy rate[41] | | Breeding rate[42] | |
|---|---|---|---|---|
| | % | Base 98/99=100 | % | Base 98/99=100 |
| 98/99 | 73.7 | 100 | 57.9 | 100 |
| 99/00 | 73.4 | 100 | 60.9 | 105 |
| 00/01 | 67.0 | 91 | 61.2 | 106 |
| 01/02 | 81.2 | 110 | 59.6 | 103 |
| 02/03 | 83.1 | 113 | 65.9 | 114 |
| 03/04 | 71.6 | 97 | 64.1 | 111 |
| 04/05 | 69.8 | 95 | 63.0 | 109 |
| 05/06 | 73.9 | 100 | 62.6 | 108 |
| 06/07 | 79.0 | 107 | 62.7 | 108 |
| 07/08 | 76.1 | 103 | 66.0 | 114 |
| 08/09 | 77.7 | 105 | 68.7 | 119 |
| 09/10 (*) | 64.3 | 87 | No data | No data |

Source: DIEA-MGAP (*) Preliminary data

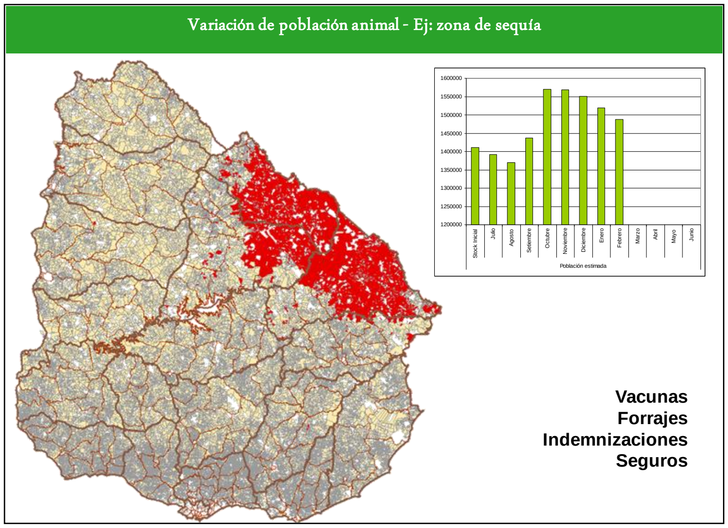
The Ministry of Livestock, Agriculture and Fisheries (MGAP) has since 2001 developed the National Livestock Information System (SNIG), which performs the livestock´s traceability through electronic devices and provides information about both stocks and animal movement along the territory. This system makes possible to know, in real time, livestock stocks movement and animal distribution in the rural area. Among other purposes, this system allows to identify holdings in a farm by farm basis, based on the affidavit (DICOSE), including their core business and stocks data. As an example of the practical usefulness of this information system to assess the impact of adverse events of great magnitude, such as drought, it allows the identification of the areas and number of heads by category that were either sold or transferred to other regions, due to the shortage of fodder. The map A1.5 below shows the trends of livestock transportation in a geographical area that suffered a drought during 2008-2009.

As we have seen throughout this document, the Agricultural and Livestock Census collects the data associated to the "Numbering Areas", the minimum census geographic unit, and the National Livestock Information System publishes the data using the "Police Section" (*Sección Policial)* geographical unit. The Police Section unit groups a set of Numbering Areas, being compatible and allowing the aggregation of the data at different scales. See Soil Moisture availability by *Police Section* in Map A1.6.

[41] T he **breeding rate** of each year is associated with the pregnancy rate of the previous year. This information comes from the Affidavits of DICOSE-MGAP.

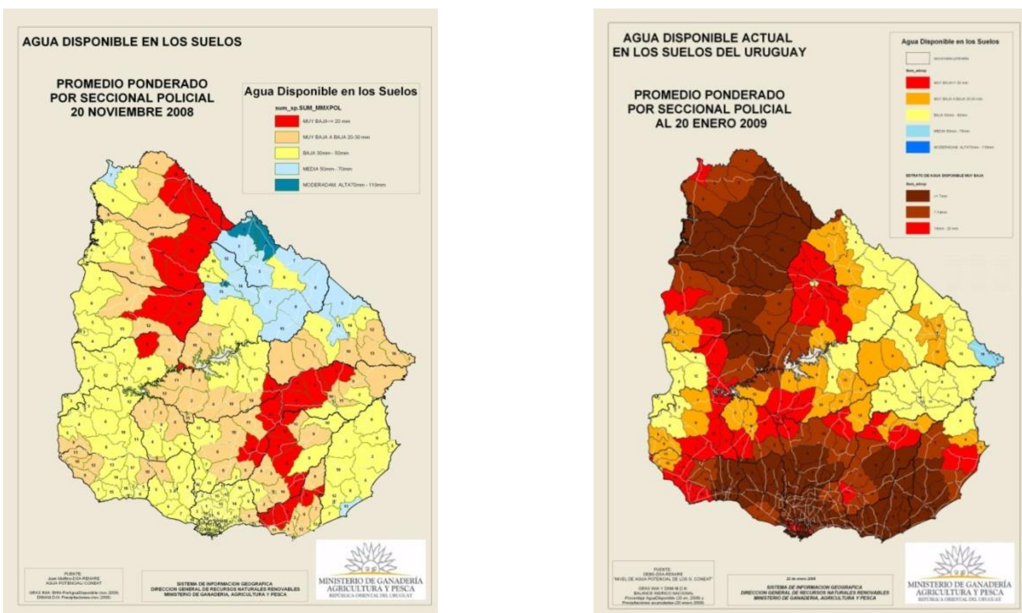
[42] Information from the Survey to Veterinarians of DIEA-MGAP.
**Pregnancy Rate** = pregnant cows / mated cows

**Map A1.5. Area with livestock transportation during a drought (2008-2009)**




Source: National Livestock Information System - SNIG

**Figure A1.6. Available soil moisture in the soils during the drought of 2008/09 in two dates**




Source: MGAP

# Annex 2. Development of a NDVI/fPAR Database for Uruguay

This annex introduces the methodology used by the technical team of the Laboratory for Regional Analysis and Remote Sensing, Faculty of Agronomy, University of Buenos Aires, Argentina (LART-FAUBA) for (i) the generation of a vegetation cover map and for (ii) the construction of a NDVI/fPAR database for Uruguay with a temporal coverage from 1982 to 2011. The methodology described in this Annex should be followed by the key stakeholders of Uruguay to update the series and, in the event an NDVI insurance policy is issued by (re) insurers, to monitor and operate the insurance program. It is worth mentioning, however, that it is expected that in the future new remote sensing technologies will be available for researches to better estimate land cover vegetation and / or to improve both the spatial and spectral resolution of satellite imagery. In the event the stakeholders decide to use such improved methodology, a new analysis should be conducted in order to guarantee data consistency; and a new risk and rating analysis should also be carried out.

### *Introduction*

Forage productivity has a direct impact on livestock production in rangelands, and is therefore an indicator of the whole system performance. To develop an insurance instrument for ranchers, it is needed to generate forage productivity estimates in order to assess trends and quantity, frequency and magnitude of extreme values in forage production.

Forage productivity is mainly controlled by environmental factors (precipitation, temperature, topography, soil type, structural characteristics of the dominant vegetation, etc) rather than management decisions of each particular farmer at landscape and regional scales. For this reason, estimates of vegetation productivity allow quantifying the frequency of anomalies associated with extreme weather events and establishing the probability of occurrence of these events.

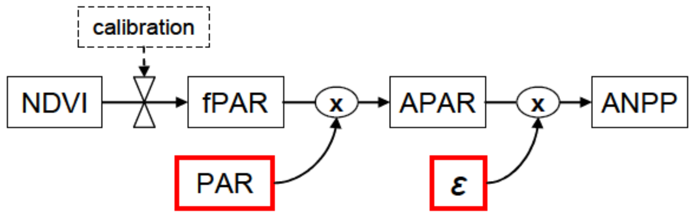
Currently, satellite technology allows indirect estimates of vegetation productivity in real time over large areas and at low cost. Reflected light by the earth's surface measured by sensors onboard satellites is closely associated with photosynthetic activity and therefore with growth or plant production. This relationship and the availability of satellite data from the 80's to the present allows scientist to generate long-term time series and spatially detailed estimates of forage production in ranches. The most widely spectral index designed to estimate forage productivity is the NDVI (Normalized Difference Vegetation Index). This index includes two key spectral aspects of photosynthetic tissues: its low reflectance in the red wavelength and a high reflectance in the near infrared.

The *NDVI* has been related to above ground net primary productivity of vegetation (*ANPP*), as well as leaf area index (*LAI*) and therefore to the fraction of photosynthetic active radiation intercepted by vegetation (*fPAR*). A strong empirical and theoretical relation exists between *NDVI* and *fPAR* allowing the estimation of the absorbed photosynthetically active radiation (*APAR*) by multiplying the *fPAR* (derived from *NDVI*) by the incident photosynthetically active radiation (*PAR*). Finally, forage production (the aboveground net primary production, *ANPP*) can be obtained by applying the Monteith model which states that:

$$ANPP = fPAR \cdot PAR \cdot \varepsilon$$

where $\varepsilon$ is the radiation use efficiency of plants (See Figure A2.1).

**Figure A2.1. Schematic representation of the general algorithm applied to obtain the aboveground net primary production (ANPP) from spectral information (NDVI), incident photosynthetically active radiation (PAR) and radiation use efficiency (ε). Black boxes represent satellite derived information whereas red boxes represent information measured/estimated in the field.**




Although *NDVI* (and other vegetation indexes) time series exist from different sensors onboard satellites since 1980, a complete and unified time-series up to the present is still lacking, mainly as a consequence of different spatial, temporal and spectral resolutions. The splicing of NDVI series obtained from different sensors is not exempt of physical and methodological problems, but it can be resolved using detailed satellite information and recently developed computational algorithms. Besides NDVI time-series, and because the radiation use efficiency (ε) varies between vegetation types, a detailed vegetation cover map was a key input to develop an ANPP database for Uruguay (See Figure A2.9). The vegetation cover map for Uruguay was constructed by combining high spatial resolution satellite imagery and field surveys.

### *Remote sensing data collection, processing, image splicing, and calibration of the relationship NDVI-fPAR*

Due to the lack of a continuous and unified recording of vegetation indices (as NDVI) in terms of temporal, spatial and spectral resolution, it was needed to splice spectral information from two satellite platforms with different characteristics (Table A2.1) in order to obtain a continuous series of fPAR (and then ANPP).

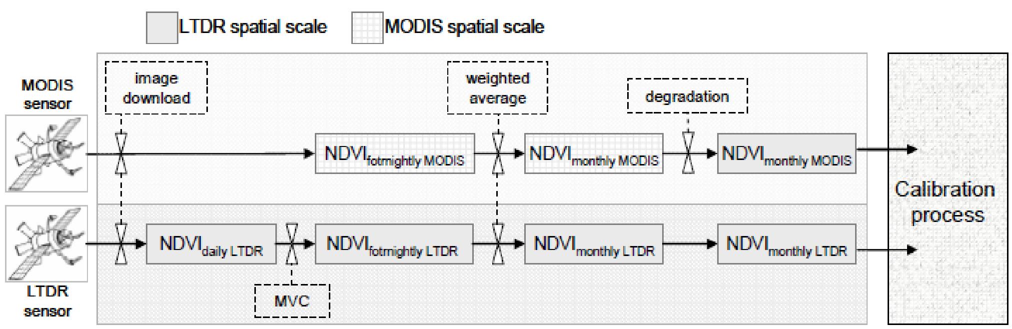
**Table A2.1. Satellite platforms used to obtain NDVI series and their most important characteristics**

| Platform | Spatial resolution | Temporal resolution | Operation period |
|---|---|---|---|
| LTDR series 2 | ≈2500 has | Daily | 1981 - 1999 |
| MODIS | 5 has | 16 Days | 2000 - present |

The LTDR platform ("Long Term Data Record") combines a high temporal resolution with a moderate spatial resolution. This platform also provides quality information that allows estimating the usefulness of the vegetation indices associated. The MODIS platform ("Moderate Resolution Imaging Spectro-radiometer") combines a high spatial resolution with a moderate temporal resolution, and as LTDR platform, provides additional quality information.

In order to obtain series of vegetation indices with a monthly temporal resolution the algorithm presented in Figure A2.2 was applied. In the case of LTDR, given that this platform provides a daily image of global coverage, first the image to the study area was clipped, and then applied the technique of 15-day maximum value composites (MVC). This technique selects as representative of the fortnight, the maximum NDVI daily value of the period. Then the monthly value was obtained as a weighted average of the fortnightly values. On the other hand, the MODIS platform provides an image each 16 days, for a grid of cells that encompass the whole earth surface. From this grid, the cell ("tile", in the MODIS terminology) that covers Uruguay was selected. In order to obtain monthly values of NDVI from MODIS, a weighted average on the fortnight NDVI values was applied. Once the monthly time series of NDVI from each satellite platform was obtained, the second step was to degrade MODIS monthly values to the LTDR spatial resolution. This was done by averaging the 400 MODIS pixels encompassed by each LTDR pixel. The NDVI series thus obtained are congruent in terms of temporal (one month) and spatial (2500 ha) resolutions.

**Figure A2.2. Schematic representation of the obtaining of monthly NDVI values derived from MODIS and LTDR satellite platforms. MVC stands for maximum value composite.**



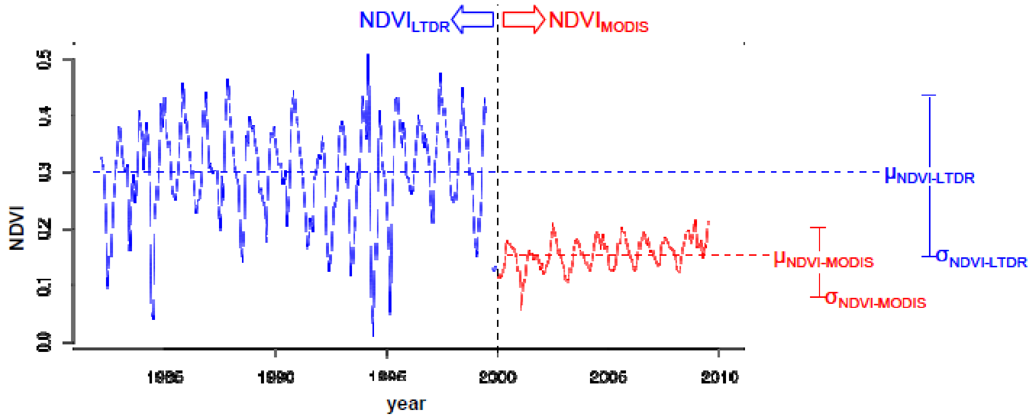

Given the differences in spatial, temporal and spectral resolution, differences of scale between monthly NDVI values from MODIS and LTDR are expected to be registered (i.e., differences in the mean and range of variation between NDVI from spatially degraded MODIS and LTDR for a given spatial location). In order to establish the existence of these inconsistencies between the NDVI series, the mean and standard deviation of LTDR and MODIS derived vegetation indices corresponding to each LTDR pixel (2500 has) were compared. As each LTDR pixel consists in approximately 400 MODIS pixels, a monthly value of NDVI derived from MODIS corresponds to the mean of the 400 values that fall inside the area corresponding to an LTDR pixel. With this information at hand the mean and standard deviation of the MODIS NDVI and the LTDR NDVI were calculated and compared (Figure A2.3). In order to compare the means of the series, the difference of means was calculated as follow:

$$diff_{MODIS-LTDR} = \mu_{NDVI-MODIS} - \mu_{NDVI-LTDR}$$

For comparing the variability, the quotient between the standard deviations of the series was calculated as follow:

$$\sigma_{NDVI-MODIS} / \sigma_{NDVI-LTDR}$$

**Figure A2.3. Illustration of calculation process of mean and standard deviation for NDVI series of each LTDR pixel and degraded MODIS pixels.**




These measures were calculated for the LTDR pixels encompassing Uruguay, and then categorized their values to generate a series of maps and statistics that summarize the spatial patterns of the match (mismatch) between NDVI from MODIS and LTDR, measured in scale [0-1]. In the case of **differences between means**, the minimum and maximum values were -0.501 ($\mu$*NDVI-LTDR*> $\mu$*NDVI-MODIS*) to 0.313 ($\mu$*NDVI-LTDR*< $\mu$*NDVI-MODIS*) respectively. Ninety one point nine percent (91.9%) of the differences exhibited differences in the range [-0.1, 0.1], whereas a 3.2% exhibited differences below -0.1 and 4.9% exhibited differences above 0.1. The differences in means as percent of the mean for indices from both satellite platforms can be expressed as

$$diff_{MODIS-LTDR}\% = 100 \cdot ((\mu_{NDVI-MODIS} - \mu_{NDVI-LTDR}) / \mu_{NDVI-MODIS-LTDR})$$

Around 97.2% of the pixels showed percent differences in the range of (-5%, 5%) of the general mean, whereas 97.7% of the pixels exhibited differences in the range (-10%, 10%). The conduction of this analysis indicates that the biggest differences are found in areas associated to waterways, coastlines and urban areas.

For the case of **the quotient between standard deviations**, the extreme values were 0.002 (which implies that the standard deviation of NDVI series from LTDR is more than 450 times bigger than the standard deviation from NDVI from MODIS) and 1.66 (which implies that the standard deviation of NDVI series from MODIS is most than a time and a half bigger than the standard deviation from NDVI from LTDR). The quotient between the standard deviations was categorized in eight intervals, from quotients ≤ 0.25 (standard deviation of NDVI from LTDR at least four times greater than standard deviation of NDVI from MODIS) to quotients ≤4 (standard deviation of NDVI from MODIS at least 4 times greater than standard deviation of NDVI from LTDR) in order to facilitate mapping and analysis. It was estimated that 64.5 % of the pixels are in the class "0.67≤σNDVI-MODIS/σNDVI-LTDR ≤1" (σNDVI-MODIS is at least a time and a half greater than σNDVI-LTDR), whereas 21.7 % of pixels are in the class "1≤σNDVI-MODIS/σNDVI-LTDR ≤1.5" (σNDVILTDR is at least a time and a half greater than σNDVI-MODIS). As in the case of the differences between means, the greater differences in standard deviations (the remaining 13.8%) are found around cities, coastlines and waterways. However these differences are not as evident as in the case of the differences in means. This result suggests that main differences between NDVI-MODIS and NDVI-LTDR are related to temporal variability in vegetation functioning rather than related to average values.

Although the congruence of the NDVI series from LTDR and MODIS platforms seems to be good, the LTDR NDVI was re-scaled to make its variability and mean identical to those from MODIS NDVI, given the quality assessments that are given by this platform, and make it more reliable. The LTDR derived NDVI series was re-scaled with the standard deviation of the MODIS NDVI from all the NDVI values and pixels encompassing Uruguay (excluding those pixels from urban areas, coastlines and water bodies), σNDVI-MODIS-ALL, according to:

$$NDVI^{M}{}_{LTDR} = z_{LTDR} \cdot \sigma_{NDVI_{MODIS}ALL} + \mu_{NDVI_{LTDR}ALL}$$

Where NDVI$^M$ LTDR is the value of the NDVI from LTDR re-scaled according to the standard deviation of the NDVI from MODIS platform and $Z_{LTDR}$ is the standardized value of NDVI derived from LTDR platform (considering the mean and standard deviation of LTDR NDVI values from all months and pixels from Uruguay, excluding those pixels from urban areas, coastlines and water bodies):

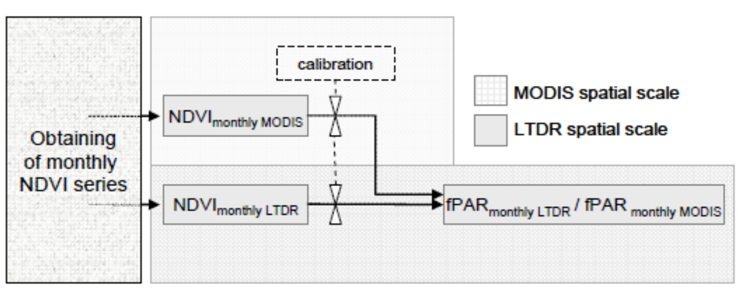
$$z_{LTDR} = \frac{NDVI_{LTDR} - \mu_{NDVI_{LTDR}ALL}}{\sigma_{NDVI_{LTDR}ALL}}$$

With the values of NDVI$^M$ LTDR and NDVI MODIS (both series in MODIS scale of variation) the relationship between NDVI and fPAR were calibrated with the parameters estimated by Grigera et al (2007, see below). The rescaling process was done in this way (with the mean and standard deviation from all NDVI monthly values from all pixels) and not pixel to pixel (with the mean and standard deviation from all NDVI monthly values from each pixel), in order to eliminate the differences in indices that could have arisen as an artifact of differences in sensors and, at the same time, not to lose the capacity to detect the effect on NDVI of possible changes in the land use of pixels between 1999-2000 (the last year of LTDR and the first year of MODIS). In previous versions of the generated database, the standardization was done pixel to pixel. The actual version of the database represents an improvement, given that it can detect changes in the dynamics of NDVI and fPAR associated to true changes in land use. The pixel to pixel standardization eliminates the effect of changes in land use change on the dynamics of NDVI and fPAR.

### *Calibration of the relationship between NDVI and fPAR and Database Development.*

The inputs and products of the calibration of the relationship between NDVI and fPAR are described in Figure A2.4.

**Figure A2.4. Schematic representation of the obtaining of monthly fPAR values from monthly NDVI.**

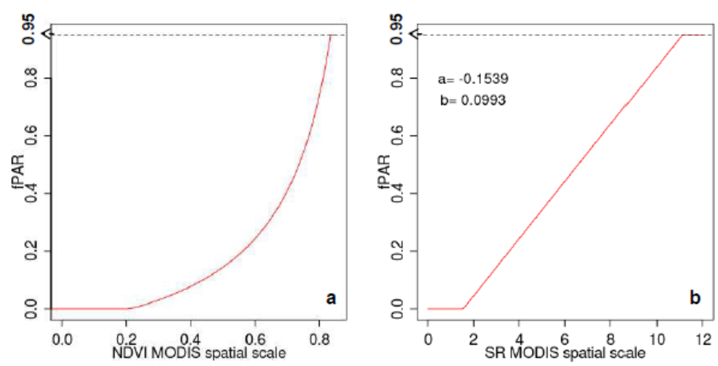


To estimate fPAR based on NDVI, it was used an empirical approximation that assumes a non-linear relationship between MODIS-NDVI and fPAR[43]. The non-linear relation between NDVI and fPAR accounts for the widely described saturation of NDVI at high Leaf Area Index (LAI) > 3, and implies a linear relation between the simple ratio index (SR = (1 + NDVI)/(1 - NDVI) = IR / NIR) and fPAR. The relation between SR/NDVI and fPAR was parameterized with local data assigning no absorption (fPAR = 0) to NDVI values corresponding to pixels that had no green vegetation (bare soil or senescent residues due to tillage) and maximum fPAR (fPAR = 0.95) to NDVI values corresponding to pixels with high amount of green biomass (sown pastures with LAI > 3 and high yielding wheat crops during anthesis, Grigera et al. 2007). The resultant equation was:

$$fPAR = \min\left[\frac{SR - SR_{\min}}{(SR_{\max} - SR_{\min})}, 0.95\right]$$

Where the extreme values of SR where extracted from Grigera et al. (2007): SRmin=1.55 and SRmax=11.62. The corresponding relationships are showed in Figure A2.5.

**Figure A2.5. Functions derived from the calibration of the relationship between NDVI and fPAR (a) and SR and fPAR (b). The numbers in the upper left corner of sub-figure (b), represents the intercept (a=-0.1539) and slope (b=0.0993) of the piecewise linear relationship defined by equation 8.**




A graphical summary of the whole process of NDVI splicing and fPAR generation on its base is shown on Figure A2.6. The NDVI/fPAR database for the whole country was then exported to text file in order to facilitate data analysis ("NDVI-fPAR database URUGUAY MAYO 2012.csv").

### *Results on test sites*

In this section it is shown some results for four test sites. These sites were extracted from a network of meteorological stations. In particular, the selected four sites (Queguay Chico, Melo, Trinidad and Cerro Colorado) have an extensive precipitation record (from 1948 to the present) which allows studying the relationship between the dynamics of carbon gains (estimated by fPAR) and precipitation.

[43] Los et. al 2000; Piñeiro et. al 2006; Grigera et. al 2007.

**Figure A2.6. A graphical summary of the process of NDVI splicing and fPAR generation.**

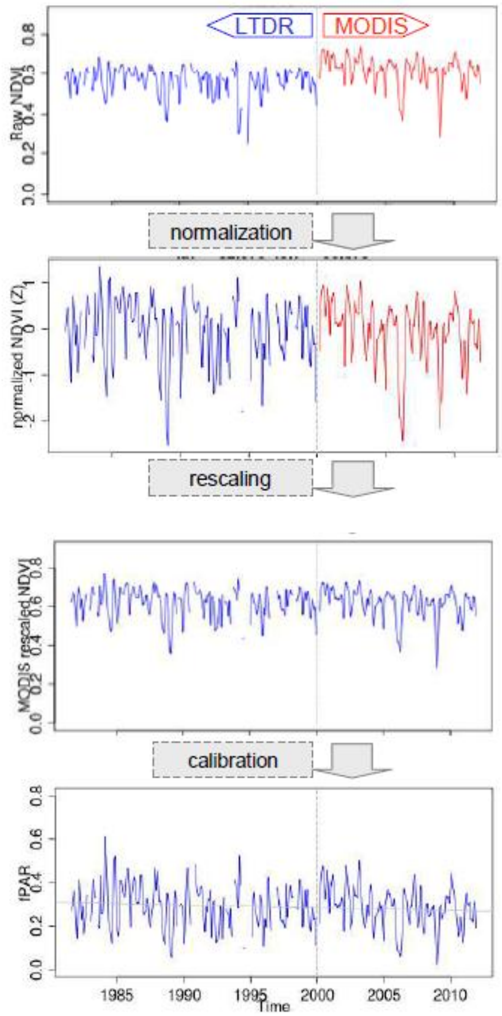
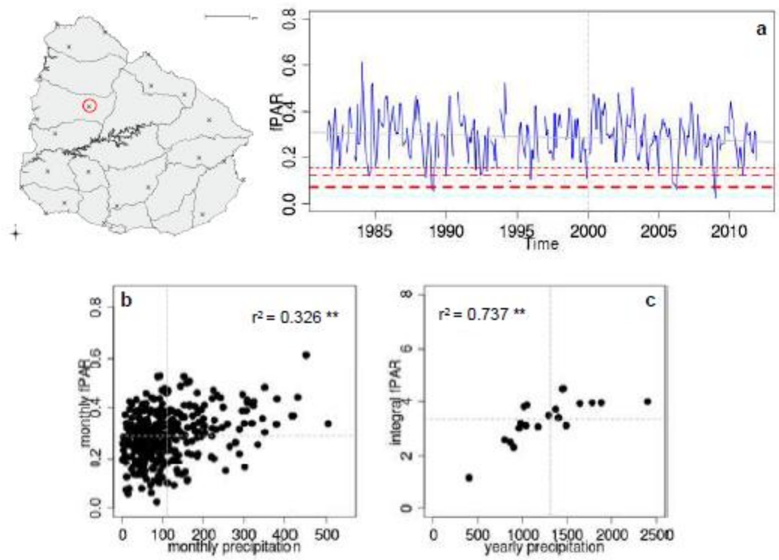



Figure A2.7 illustrate some of the questions that can be answered with the fPAR database for Queguay. One of the most important analysis that the database permits is exploring the incidence and frequency of extreme negative anomalies in carbon gains, as estimated by the percentiles 10%, 5% and 1% of fPAR empirical distribution (subgraph "a" in Figure A2.7), or existence of temporal trends in the fPAR.

On the other hand, the weak relationship between monthly fPAR and precipitation (subgraph "b" in Figure A2.7) shows an "instantaneous" response of vegetation to precipitation. This relationship is stronger when we consider annual integrated fPAR and annual precipitation (subgraphs "c" in Figure A2.7). The kind of analyses performed here can be repeated on a quarterly or biannual basis and considering temporal lags in the response of fPAR to precipitation. Moreover, the existence of a satellite platform that estimates precipitation rates that can be easily converted in monthly precipitation from 1998 to the present (TRMM, http://trmm.gsfc.nasa.gov/) and validated for the previously mentioned meteorological stations for Uruguay, could allow to repeat the exemplified analyses and others for the whole country.

**Figure A2.7. (a) fPAR time series for the Queguay Chico locality. The horizontal red doted lines progressively thicker, represents the percentiles 10%, 5% and 1% of the fPAR empirical distribution. The gray line represents the significant (α= 0.05) negative trend in fPAR. (b) The relationship between monthly fPAR and monthly precipitation. (c) The relationship between annual integral of fPAR and yearly precipitation. The values of correlation are both significant at α= 0.01. The gray doted lines in subgraphs (b) and (c) represents the mean values of fPAR (y axis) and precipitation (x axis).**




## *Land cover characterization for Uruguay using remote sensing data and field trips*

A land cover characterization was generated for the whole country using high spatial resolution LANDSAT images and field observations, following the methodology proposed by Baeza et al (2011) (Figure A2.8). Based on this characterization, for each of the LTDR pixels that encompass the whole country it was estimated the proportion of the pixel occupied by the following six land cover classes: Summer crops, Winter-Summer crops, implanted and native Forests, Forage, Water bodies and Urban areas (Figure A2.9). MODIS product MOD13Q1 was used to characterize different types of land covers. This product provides two spectral indices: (i) Normalized Difference Vegetation Index (NDVI) and (ii) Enhanced Vegetation Index (EVI), both associated positively with interception of photosynthetically active radiation by green tissues. The behavior of the NDVI and EVI for a given pixel over a growing season is called "phenological signature", since it describes the seasonal dynamic of vegetation. In this case, each signature describes the dynamics of photosynthetic light interception by each land cover type. In order to realize this, it was necessary to observe land covers during field trips because ground control points were needed to generate “phenological signatures” and also for validating the precision of the land cover classification. Then, knowing the “signature” of each cover observed in field (forage, crops, forestation, etc.), it was possible to determine what cover may be associated with that spectral signature and therefore identify the coverage for the whole territory. Since there is some spatial and temporal variability, resulting from the different management practices, climate, topography, etc., phenological signature of the same coverage tends to vary in space and time. It is therefore crucial to have large number of firms to meet the phenological variability within each cover type and between different land cover. From different “phonological signatures”, a "spectral library" was constructed. The map generated showed the known patterns of main land cover types in Uruguay, where forest areas are in practically all country except in the Basalto Region, crop areas dominating the west and east regions and the rest of the country dominated by forage resources (Figure A2.9). The map has a global precision of 91%.

**Figure A2.8: Field trips conducted during 2011 and 2012 to construct phonological signatures used in the characterization of land cover for Uruguay. In each point land cover was registered and then used to the classification of the whole country using remote sensing data (see Methods).**

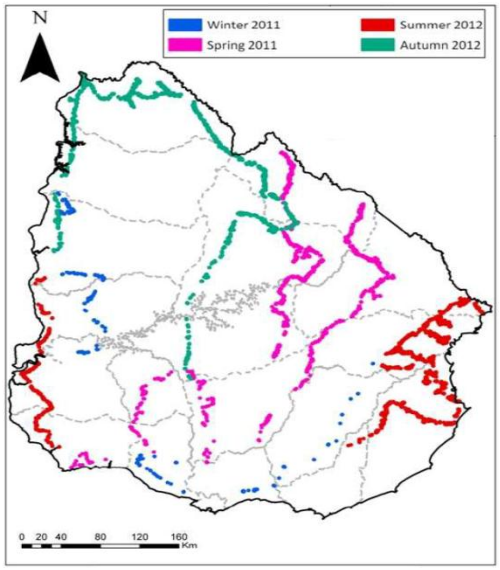
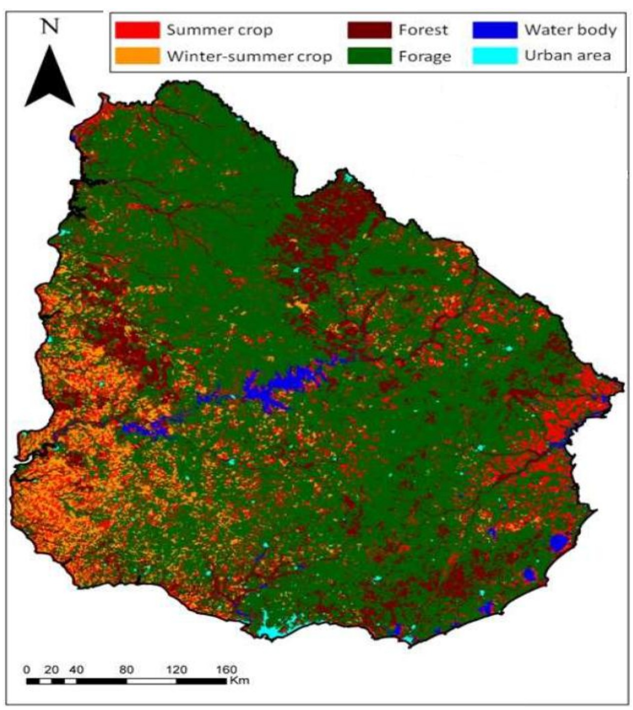



**Figure A2.9: Land cover characterization of the Uruguay based on remote sensing data and field observations, as proposed by Baeza et al. (2011).**



### *Development of ANPP estimates for forage areas*

ANPP was calculated according to Monteith´s model (Figure A2.1). As it was explained, this model asserts that aboveground net primary production of a particular vegetation cover is proportional to the amount of incident photosynthetically active radiation (PAR), to the fraction of photosynthetic active radiation intercepted by vegetation (fPAR) and to the radiation use efficiency ($\varepsilon$) (Monteith 1972):

$$ANPP(g \cdot m^2 \cdot month^{-1}) = fPAR \cdot PAR(MJ \cdot m^2 \cdot month^{-1}) \cdot \varepsilon(g \cdot MJ^{-1})$$

Monthly values of fPAR for the period from mid-1981 to 2011 were estimated as described in the first part of this Annex, whereas monthly values of PAR were estimated as the mean monthly values from a PAR series for the period 1975-2000, recorded by the weather station from INTA Concepción del Uruguay, Argentina (32º48' S, 58º23' W). PAR estimations can be applied from this weather station, given that is located in a similar latitudinal position respect to the mean latitude of Uruguay and exhibit a comparable altitude above sea level respect to Uruguay (as fPAR varies regionally related to latitude and elevation and slope). As the radiation use efficiency depends on the specific vegetation cover[44], and because regions mainly devoted to forage production are the main interest of this study, to estimate this parameter the land cover characterization of the previous section was filtered by those LTDR pixels with >80% of are covered by forage resources. To obtain ANPP estimations for these pixels, an estimation of radiation use efficiency (RUE) that comes from an average of RUE from different pastures of the region was applied (Oyarzabal et. al 2011). As a result of all this study, a database of NDVI/fPAR was developed for the whole country, with a temporal coverage from 1982 to 2011 ("Base Final NDVI-PPNA Uruguay JUNIO 2012.txt").

[44] Piñeiro et al. 2006; Grigera et al. 2007; Baeza et al. 2011b

# Annex 3. Normalized Difference Vegetation Index (NDVI) Pasture Index-based Insurance Rating Manual for Uruguay

## 1. Introduction

This annex describes the methodology used in the design of the macro-level NDVI Index Insurance for livestock producers in Uruguay and the rating tool built in Excel developed by the World Bank team, which performs the ratemaking of the product. The rating tool contains nineteen (19) Excel files linked each other. The main file, from which the user can manage all the calculation, is ***NDVI_IndexInsurance_Uruguay_MasterFile.xlsm***, and the remaining eighteen (18) files correspond to each one of the Departments under analysis in Uruguay (see Table A3.1).

| File name | Department |
|---|---|
| Dpto02_Artigas | Artigas |
| Dpto03_Canelones | Canelones |
| Dpto04_CerroLargo | Cerro Largo |
| Dpto05_Colonia | Coloni |
| Dpto06_Durazno | Durazno |
| Dpto07_Flores | Flores |
| Dpto08_Florida | Florida |
| Dpto09_Lavalleja | Lavalleja |
| Dpto10_Maldonado | Maldonado |
| Dpto11_Paysandu | Paysandú |
| Dpto12_RioNegro | Rio Negro |
| Dpto13_Rivera | Rivera |
| Dpto14_Rocha | Rocha |
| Dpto15_Salto | Salto |
| Dpto16_SanJose | San José |
| Dpto17_Soriano | Soriano |
| Dpto18_Tacuarembo | Tacuarembó |
| Dpto19_TreintaYTres | Treinta y Tres |
| ***NDVI_IndexInsurance_Uruguay_MasterFile*** | NA* |

**Table A3.1: Files of the Rating Tool**
*** NA: Not Applicable**

The Rating Tool allows calculating the main parameter of the Index Insurance (Trigger and Exit), calculating the Sum Insured, estimating premiums based on burn analysis methodology, calculating historical payments according to the parameters chosen, and estimating the Probable Maximum Loss in an individual basis[45].

The main file, ***NDVI_IndexInsurance_Uruguay_MasterFile.xlsm***, besides to allow the modification of the parameters, summarizes the Sum Insured, Premium and historical payments of the NDVI insurance program. The sheet “Parametros” shows the main summary for the whole country and at Department level, and the sheets called after the Departments expose the Sum Insured, Premium and historical payments with a per Police Section detail. Finally, in each one of the Departments’ files there is one sheet per cluster (Homogeneous Risk Zone) [46], in which is shown the Trigger and Exit for each one, as well as the historical payouts.

[45] See Chapter 5 of the main report for the details of the product design.

[46] See Section 3.2 of this annex.

## 2. Excel version and macro configuration

The rating tool has been developed completely in Microsoft Excel® 2007, and the developers do not guarantee the adequate working of it in another version of Microsoft Excel or in any other spreadsheet software.

For an adequate working of the rating tool all the Excel files mentioned in Section 1 of this annex (***NDVI_IndexInsurance_Uruguay_MasterFile.xlsm*** and the eighteen files corresponding to each one of the Departments in Uruguay) must be located in the same folder of the PC. In case that the files are located in different folders, some links could be damaged and the rating tool could work wrongly.

The rating tool includes code developed in Visual Basic for Applications (VBA), therefore the "Macros" have to be enabled by users for correct functioning of the tool.

**Macros Settings**

In order to enable macros, the user have to access to the Trust Center in Excel. The procedure is illustrated in Figure A3.1 in next page, and the steps are as follows:

(a) Click the Microsoft Office Button,
(b) Click Excel Options,
(c) Click Trust Center and the click Trust Center Settings,
(d) Once in the Trust Center, click Macro Settings and then choose "Disable all macros with notification".

By this setting Excel disables all macros of any file, but with a notification to the user, so that the user could choose to enable it, in case the developer is trusty. Once this setting was done in Excel, the user should open the master file and enable macros.

## 3. Insurance description and features of the rating model

### 3.1. Database

In order to design the insurance and to develop the rating methodology, it has been used NDVI monthly data from August 1981 to December 2011. NDVI data corresponds to the eighteen Departments mentioned in Table A3.1 and it is disaggregated in pixels whose spatial resolution is 2,500 Ha each one. Ownership of the NDVI Database resides with the World Bank and OPYPA-MGAP. The database was developed by the Remote Sensing and Regional Analysis Laboratory – Faculty of Agronomy, University of Buenos Aires (LART-FAUBA) at the request of the World Bank.

**Pixels considered**

It is worth mentioning that there were zones in Uruguay discarded because they did not show adequate forage coverage in land surface. The rating model was developed including only those pixels with at least 60% of forage coverage, according to the classification of land coverage performed by LART-FAUBA, and with less than 6.7% of missing data. Finally, through visual inspection, it were excluded some pixels because of the specific location of their centroids (i.e. urban zones, rivers, lagoons, tubes, etc.).

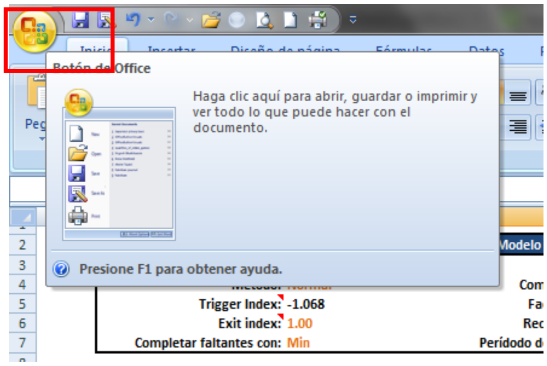
## Filling data gaps

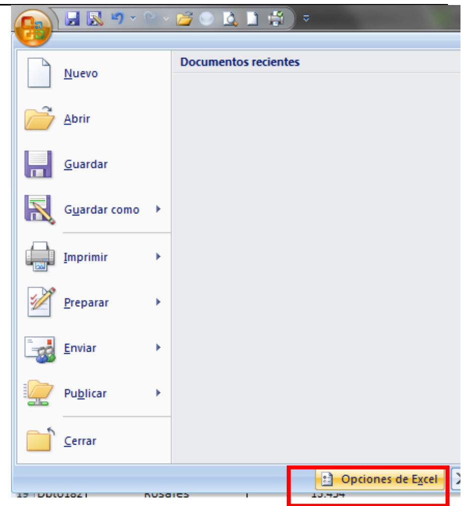
It is important to notice that in all and each one of the pixels in the Database there is 6.6% of missing data, which correspond to the months in Table A3.2

| Año | 1982 | 1982 | 1983 | 1983 | 1989 | 1990 | 1990 | 1990 | 1993 | 1993 | 1993 | 1994 | 1994 | 1994 | 1994 | 1996 | 1996 | 1996 | 1996 | 1996 | 1998 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mes | 11 | 12 | 6 | 7 | 8 | 8 | 9 | 10 | 2 | 9 | 10 | 9 | 10 | 11 | 12 | 8 | 9 | 10 | 11 | 12 | 4 | 5 |

**Tabla A3.2: Meses con datos faltantes en la Base de Datos.**

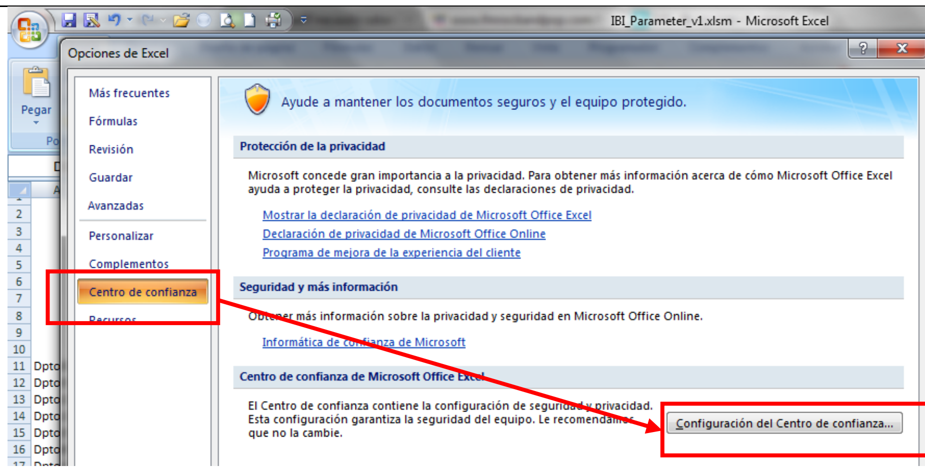
Because the database has missing values, it was necessary to fill the gaps by means of interpolation techniques. The filling was made on a “pixel base”, using the historical average NDVI value in the pixel, *corresponding to the month* in which the datum is missed. For example, if in a pixel the datum of June 2000 is missed, the filling was made using the historical *June average* (by averaging all the years in which there is data in June). Table A3.2 shows that there are missing data in November 1982, 1994 and 1996, which were filled in with the average on November of the remaining 28 years, and consequently the three years have the same NDVI value in November.



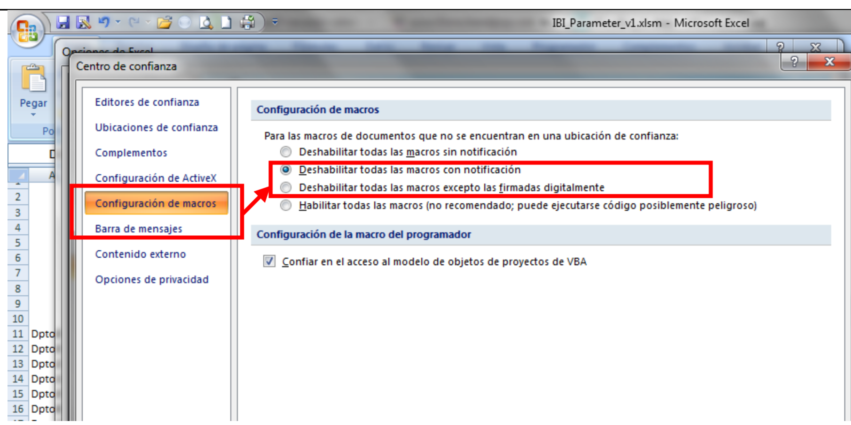




(a) Office Button

(b) Excel Options




(c) Trust Center




(d) Macro Settings => Disable all macros with notification

**Figure A3.1: Enabling Macros in Excel® 2007.**

### 3.2. Homogeneous Risk Zones (HRZ), Insured Units and underlying Index

In order to calculate the main parameters of the model, and to perform the ratemaking, the zones in Uruguay have been clustered according to the similarity in NDVI time series. The statistical technique of Cluster Analysis has been applied to the data, particularly the procedure of Hierarchical Cluster Analysis allowed to analyze the homogeneity of the pixels in each Police Section inside each one of the 18 Departments analyzed in Uruguay. As result, it has been found heterogeneity between pixels belonging to the same Police Section, and the Police Sections have been divided in Homogeneous Risk Zones (HRZ). See Chapter 5 of the main report for further details.

Besides the Cluster Analysis has shown heterogeneity inside each Police Section, **the Insured Units are the Police Sections** (administrative units), because in a macro-level scheme, from an operational point of view, it is more convenient to make the insurance payouts using a political-administrative division, instead of a division obtained by statistical techniques.

In the rating model, the underlying Index used in each Police Section (Insured Unit) was the average NDVI of the pixels belonging to the more representative cluster (HRZ). For instance, if one "Police Section" has two "HRZ", one with 5 pixels and the other one with 2 pixels, for purposes of product design and ratemaking of the insurance, the average of the 5 pixels belonging to the first groups was used.

### 3.3. Cover period and Sum Insured allocation

The cover period in a policy-year includes seven months in spring and summer (September to March). Besides this definition, the rating tool developed allows the user to change the cover period.

The annual Total Sum Insured (TSI) is calculated considering (i) the cost of feeding one Livestock Unit, (ii) the coverage period and (iii) the percentage of the cost of feeding that is covered through the insurance, and (iv) the number of breeding cows in each Police Section included in the insurance. The allocation of the TSI to each one of the months in the coverage period was made equally (i.e. a seventh to each month), but this could be changed for the user of the rating tool by fixing different percentages of coverage to each month.

Section 3.8 of this annex describes the methodology followed to calculate the TSI; and Section 5.3 of this annex exposes an example of the calculation of the Total Annual Sum Insured, and its allocation to each month of the coverage.

### 3.4. Payouts rules: Trigger and Exit

The payouts of the insurance for each Police Section are triggered when the Index (average NDVI of the pixels belonging to the more representative cluster) in any month of the cover period, $I_m$, falls below a predetermined value for that month called Trigger Index ($TI_m$). In case the Index is lower than another monthly predetermined value called Exit Index ($EI_m$), the total Sum Insured of the Police Section allocated to that month ($SI_m$) is paid out. In case the observed Index value is between Trigger and Exit, there is a proportional payout. To avoid minimal payments, the insurance has a Police Section qualifying franchise (non deductible).

Therefore, the loss in a Police Section, in any month of the cover period, is calculated as follows[47]:

$$L_m = \begin{cases} 0 & \text{if } I_m > TI_m \\ \dfrac{TI_m - I_m}{TI_m - EI_m} \times SI_m & \text{if } EI_m < I_m \le TI_m \\ SI_m & \text{if } I_m \le EI_m \end{cases}$$

The actual payout in the Police Section, including the franchise, is:

$$Payout_m = \begin{cases} 0 & \text{if } L_m < Franchise \\ L_m & \text{if } L_m \ge Franchise \end{cases}$$

Note that the franchise is "non-deductible": in case the loss is greater than the franchise, the full loss is paid out.

Figure A3.2 illustrates the payout rule in a Police Section and Section 5.4 of this Annex exposes an example.

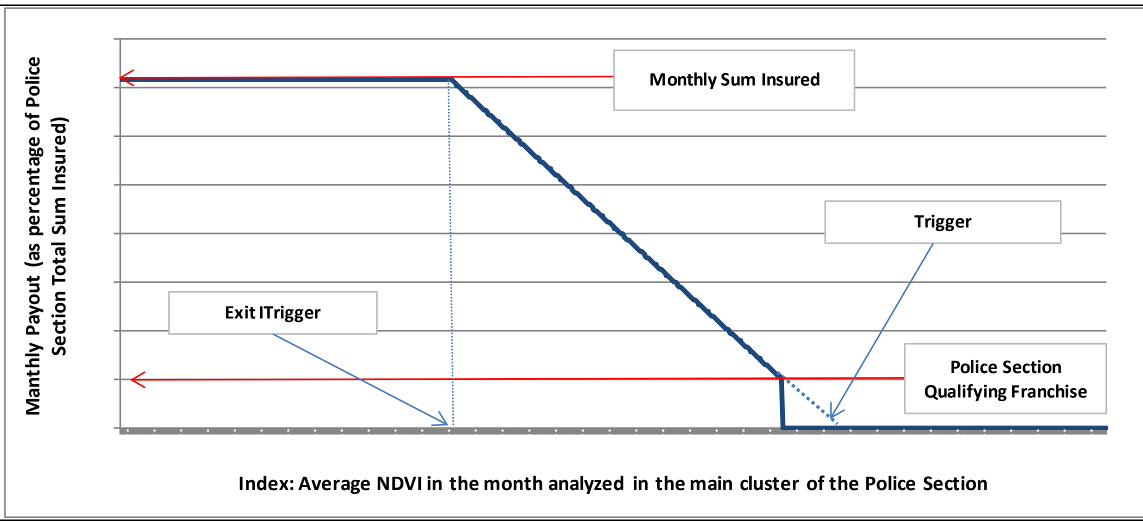



**Figure A3.2. Payout Rule**.

Besides the franchise at a Police Section (PS) level described above, the product includes (i) a **per department franchise** (non-deductible): if the sum of all the payouts of the Police Sections

[47] Notice that the product is an Index Insurance, and the "Loss" is measured indirectly through the index, and could be different to the actual damage suffered by an individual producer or a region as a consequence of deterioration in pastures.

belonging to the same department are lower than the department franchise, then there is no payment at all, otherwise the full payouts of the Police Sections are made; and (ii) a **global franchise** (non-deductible): if the sum of all the payouts of the Departments are less than this franchise, then there is no payment at all, otherwise the full payment is made. Notice that the three franchises (per Police Section, per Department, and Global) are applied in a sequential fashion: first the per PS franchise is analyzed to define if there should be a payment there; after the potential payouts of the PSs in one department were calculated, the per Department franchise is applied to identify if the total payout of the department is higher than it; and finally, after all the potentials payments in each department were calculated, the Global franchise is applied to define if there should be a payout or not.

**Trigger Index (TI)**

The Trigger Index for each month and in each cluster is calculated from the monthly Index probability distribution and according to the expected frequency of the payments, called Return Period (RP). For instance, if the Return Period is 10 years, the TI is calculated so that it triggers a payout each ten years in average (in each month and in each Police Section), i.e. it will be calculated as the tenth percentile of the Index probability distribution. If the Return Period is set to be 7 years, there is expected for each month in the cover period one payout each seven years, i.e. approximately in the 14% of the cases, so that the TI will be the fourteenth percentile of the probability distribution. And so on. Note that in each Police Section for each month there will be one TI. Mathematically, the trigger for each month has been calculated implicitly as follow:

$$P\left(I_m < TI_m\right) = 1/RP$$

It is worth to mention that the PR is referred to each month and to each cluster, and consequently the total frequency of payout (considering all the months in the cover period and all the Police Sections) will be much higher than the PR chosen.

TI can be calculated by one out two methods, namely: by using the historical probability distribution (Método = Hist.)[48], or by fitting a Normal distribution function (Método = Normal). If historical method is chosen, the TI is set to be the percentile of the historical distribution function (of the month under analysis). If Normal method is chosen, the TI is calculated as follows:

$$P\left(I_m < TI_m^{Método=Normal}\right) = 1/RP \qquad \Rightarrow \qquad TI_m^{Método=Normal} = \mu_m + z_{1/RP}\sigma_m$$

where $\mu_m$ and $\sigma_m$ are the historical average and standard deviation of the observed values of the Index in the month "*m*" under analysis, and $z_{1/RP}$ is the value that accumulate a probability of 1/RP in a Normal Standard distribution

**Exit Index (TI)**

The Exit is set to be a chosen number of standard deviations below the Trigger, i.e.: $EI_m = TI_m - k_{EI}\sigma_m$, where the parameter $k_{EI}$ sets the slope of the line in Figure A3.2. For instance,

48 This expression refers to the setting in the Excel Rating Tool.

if $k_{EI} = 0$ then $EI_m = TI_m$, and the insurance payouts are "all or nothing"; and, for higher values of $k_{EI}$, the line becomes flatter. Figure A3.3 shows different payout rules according to different values of $k_{EI}$.

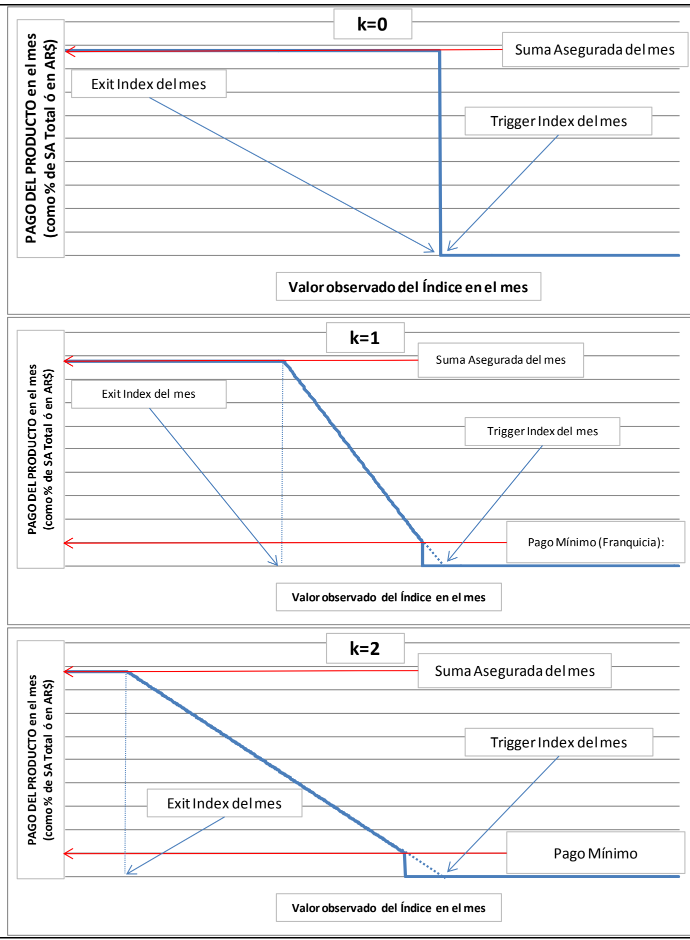



**Figure A3.3. Payout rules for different values of parameter "k", which determines the *Exit Index*.**

### 3.5. Risk Premium estimation (burn analysis) and Technical Premium

In order to estimate the Risk Premium of the NDVI Index Insurance a ***burn analysis*** has been carried out.

Once the Sum Insured for each month of the cover period (see Section 3.8 of this annex), the Return Period (that allows setting the Trigger for each month and for each cluster) and the parameter k (that allows setting the Exit) have been set, an "as if" analysis is performed to calculate what would have been the payment in each one of the 30 years of the database (see Section 3.1 of this Annex). The average payout, as percentage of the Annual Sum Insured, is the Risk Premium rate for each Police Section.

The Risk Premium rate for each Department is the average historical loss cost in the Department, which is calculated as the weighted average (by sum insured) of the loss cost in each Police section, provided this weighted loss is higher than the Department Franchise.

Likewise, the Risk Premium for the whole program is the average total loss cost in the 30 years analyzed; and the loss cost in each year is the weighted average (by sum insured) of the loss costs of the Departments, provided this weighted average is greater than the Global Franchise.

Section 5.5 of this Annex illustrates a step by step example of the calculation of the historical payouts for a specific Police Section, from which is also calculated the Risk Premium Rate for that Police Section. In turn, Section 5.6 of this Annex shows the calculations for a complete Department, and for all Uruguay.

The ***Technical Premium*** (TP) is the Risk Premium plus a technical risk loading (TRL); which compensates the inherent sample errors in the estimation of the Risk Premium and allows constituting a fund to catastrophic events as measured by the Probable Maximum Loss. In the rating model, the security loading is calculated as a percentage of standard deviation of the historical loss costs, i.e. $TRL = \sigma_{Payouts} \times \gamma_{TRL}$. In this report, this was set to $\gamma_{TRL}$ = 15%. Therefore, the Technical Premium is calculated as follows:

$$PT = PP + TRL$$

The methodology to estimate the TRL is consistent with actuarial good practices used in the insurance industry. In the insurance industry is also common to calculate risk loading as a percentage of the Probable Maximum Loss.

### 3.6. Technical and Commercial Premium

The Commercial Premium that should be paid for the policyholder can be disaggregated as follows:

$$CP = RP + TRL + \alpha_{A\&O} CP + \alpha_P CP$$

where CP is the Commercial Premium, RP is the Risk Premium, TRL is a technical risk loading (due to estimations error in calculating the RP and to constitute a fund for catastrophic events – PML-), $\alpha_{A\&O}$ is the percentage of the CP associated to the Administration and Operational expenses that should incur the insurer to operate the coverage, and $\alpha_P$ is the percentage of the CP that is loaded by the insurer as a Profit margin in order to accept the risk.

In the Rating Tool developed by the World Bank Team, the Commercial Premiums have been estimated by applying a fixed factor of 1.25 to the Technical Premiums, which is supposed to include all the loadings (besides the "Risk Loading" that is included in the Technical Premium) charged by the insurer.

The calculations carried out by the Rating Tool are indicatives for all the stakeholders, and the final premiums charged to the NDVI-insurance should be determined by the insurers (and their reinsurers).

### 3.7. Probable Maximum Loss (PML) Estimation

The Rating Tool developed in Excel does NOT include the calculation of the PML, because such calculation require the development of a separate analysis that involve parametric distribution fitting to the loss data and Monte Carlo Simulation using At Risk software, and this cannot be carried out automatically in the NDVI Rating Tool.

The methodology used to estimate the PML was presented in Chapter 5 of the main report. The reader is referred to that section for further details.

### 3.8. Sum Insured calculation

The Sum Insured is calculated based on the following inputs: (i) the number of breeding cows insured, , (ii) the cost of feeding each cow during the months in the cover period and (iii) the period of coverage. The cost of feeding in this report and in the rating tool was calculated on the basis of a ration made of 75 % of wheat bran and 25% of sunflower flour, which was distributed for MGAP to the small livestock producers in the drought in 2008. However, the cost of feeding could be calculated on the basis of different rations.

According to MGAP, four kilos of the ration could cover the Nutritional Requirements of one livestock unit (breeding cow). Under the assumption that a metric ton of wheat bran costs US$ 180 and a metric ton of sunflower flour costs US$ 235, the cost of feeding one breeding cow is US$ 0.775 per day. That is, for the seven months included in the cover period (September to March) the total amount needed is US$ 162.75 per breeding cow. However, it is advisable that the coverage does not assure the full amount to avoid moral hazard, and it is proposed in this report to cover the 50% of the feeding requirements, i.e. to use a sum insured of US$ 81.375 per cow. Table A3.3 shows the basis used in calculating the sum insured per breeding cow.

| Cattle supplementary feed based on 2008 drought rations | Sunflower flour | | Wheat bran | | Feed per day per LU | Cost per day per LU (US$) | Cost per month per LU (US$) |
|---|---|---|---|---|---|---|---|
| | % of ration | Price(US$/MT) | % of ration | Price(US$/MT) | | | |
| | 25% | 235.00 | 75% | 180.00 | 4 kg. | **0.775** | **23.250** |

| | Sep | Oct | Nov | Dec | Jan | Feb | Mar |
|---|---|---|---|---|---|---|---|
| Cover % | 50% | 50% | 50% | 50% | 50% | 50% | 50% |
| **Monthly Sum Insured per LU (US$)** | 11.625 | 11.625 | 11.625 | 11.625 | 11.625 | 11.625 | 11.625 |

| | |
|---|---|
| **Total Sum Insured per Breeding Cow (LU) for 7 month cover period (US$)** | **81.375** |

Table A3.3: Basis for the calculation of the sum insured per livestock unit (breeding cow).

In all the insurable regions of Uruguay, according to DICOSE data processed by OPYPA and World Bank specialists, there are 3,868,089 breeding cows. Therefore, the Total Sum Insured (TSI) for all Uruguay would be US$ 314,765,742.

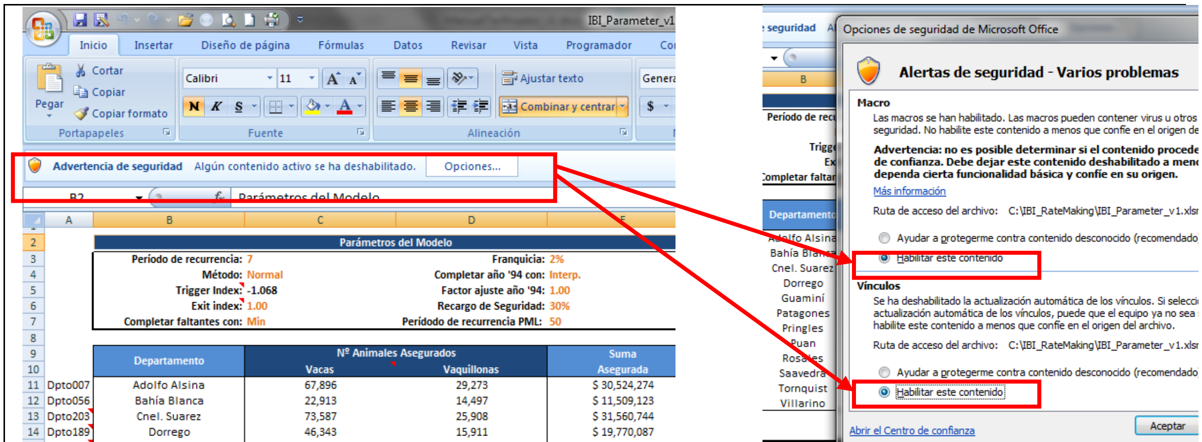
The allocation of this TSI to each month in the cover period will be done equally: one seventh of the TSI is allocated to each one of the seven months included in the cover period. Section 5.3 of this annex illustrates the calculation of the sum insured for a Police Section and its allocation to each month.

The values exposed so far are just a proposal and could be modified by the stakeholders. The Excel Rating Tool developed by the World Bank team allows performing all the calculations with different specifications for the Sum Insured. For further details, see Section 4.3 of this Annex.

# 4. Using the Software Rating Tool

### 4.1. Start-up the Rating Tool

In order to use the Rating Tool, the main file ***NDVI_IndexInsurance_Uruguay_MasterFile.xlsm*** should be opened. On opening, if the macro setting is as indicated in Section 2 of this Annex, Excel will show a "Security Warning". To allow the software functioning correctly, user should press the button "Options" in the "Security Warning", which will open the window "Microsoft Office Security Options". On this window, both the external links and the macros should be enabled by selecting the ***two option buttons "Enable this content"*** (See Figure A3.4).




Excel Secutity Warning => Enable Macros and External Links

**Figure A3.4: MS Excel® 2007 Security Warning.**

By enabling the macros and external links, the rating tool will ask the user permission to open the eighteen (18) files with the information of each one of the Departments in Uruguay (see Figure A3.5). Press the button "OK" to open the eighteen linked files and to perform calculations with the Rating Tool. The load of these files could take a moment, depending on the PC's hardware.

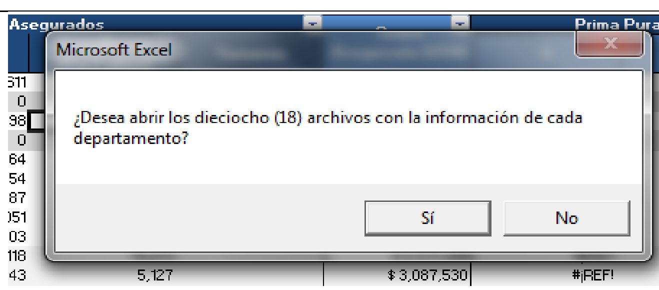



**Figure A3.5. Excel window shown when opening the maste file, asking permission to open the remaining files of the Rating Tool.**

In case the user refuse to open all the files by pressing “No”, modifications in parameter values will not be shown in the spreadsheet. **<u>For the changes in parameters to take effect in calculations, it is indispensable that the nineteen (19) files mentioned in Section 1 of this Annex are open simultaneously</u>**.

### 4.2. Model Parameter changes

In the main file, ***NDVI_IndexInsurance_Uruguay_MasterFile.xlsm***, the cells with font color red are parameters that the user can modify. In Figure A3.6 is shown a screen shot of the main spreadsheet.

| Parámetros del Modelo | | | |
|---|---|---|---|
| Recurrencia: | 15 | Franq. x SP x mes: | 2.00% |
| Método: | Normal | Franq. x Dpto: | 2.00% |
| Disparador (d.e.) | -1.501 | Franq. País: | 0.86% |
| Salida (d.e.) | 1.000 | Rec. Seg.: | 15% |
| Per. Cobertura: | CicloCrec. | Recurrencia PML: | 100 |

Figure A3.6. Parameters in file NDVI_IndexInsurance_Uruguay_MasterFile.xlsm

The parameters that the user can set are[49]:

- ***<u>Recurrencia</u>*** (RP, Return Period): indicates the frequency (years) of the payouts that is expected in each month of the cover period. The value of this parameter is used to calculate the Trigger and Exit.

- ***<u>Método</u>*** (Method): it can be chosen between a fitting of the historical data to a Normal distribution (Método = “Normal”) or to use the historical distribution (Método = “Hist.”). According to this choice, and using the Return Period, the Triggers are calculated for each one of the Police Sections in each one of the Departments.

- **<u>Disparador (d.e.)</u>** (deviation for Trigger, $z_{1/RP}$): is not a parameter modifiable by the user. In case “Método = Normal” is chosen, this cell shows the number of standard deviation below the mean in which the Trigger is set, according to the RP. Specifically, the Trigger in each Cluster and in each month of the cover period, $TI_{C;m}$, is calculated as follows:

  $$TI_{C;m} = \mu_{C;m} + z_{1/RP} \times \sigma_{C;m}$$

  where $\mu_{C;m}$ and $\sigma_{C;m}$ are the mean and standard deviation, respectively, of the time series of the Index in Cluster “C” and month “m”.

[49] The names of the parameters in the spreadsheet are in Spanish because the Rating Tool was developed to be shared with the stakeholders in Argentina.

In case "Método = Hist." is chosen, this cells shows the value NC (Not Applicable, - in Spanish: *No Corresponde*), because is not necessary for the calculations.

- **<u>Salida (d.e.)</u>** (Deviation for Exit, $k_{EI}$): allows determining the quantity of standard deviations below the Trigger in which is set the Exit, from which is paid out the full Sum Insured of the Police Section allocated to the month. Specifically, for each month in each Cluster, the Exit Index is:

$$EI_{C;mes} = TI_{C;mes} - \sigma_{C;mes} \times k_{EI}$$

- **<u>Franq. x SP x mes</u>** (Monthly Franchise per Police Section): is the minimum loss, as percentage of the Annual Police Section Sum Insured, from which the insurance is actually triggered and a payout is triggered in each Police Section (see Section 3.4 of this Annex).

- **<u>Franq. x Dpto</u>** (Franchise per Department): is the minimum loss in a Department, as percentage of the Department Sum Insured, from which a payout is triggered in each Department (see Section 3.4 of this Annex).

- **<u>Franq. País</u>** (Global Franchise): is the minimum total loss, as percentage of the Total Sum Insured in the whole country, from which a payout is actually made (see Section 3.4 of this Annex).

- **<u>Rec. Seg.</u>** (Risk Loading, $\gamma_{RS}$): is the percentage of standard deviation of Historical Payouts that is load to the Risk Premium in order to get the Technical Premium (see Section 3.6 of this Annex).

The user could choose the months included in the cover period and the level of assurance in the Sheet *CalculoSumaAsegurada*, by entering a percentage of coverage (between 0 and 100% of the nutritional requirements) greater than zero. If the user chooses 0% of coverage in any month of the year (see Table A3.5 below), that month will automatically be excluded of the coverage.

The number of breeding cows should be entered by the user in the spreadsheet *Cabezas* of the main file.

### 4.3. Changing parameters for calculation of Sum Insured

In Section 3.8 of this annex was exposed the proposed Total Sum Insured. However, this can be modified by changing (i) the heads of cattle insured in each Police Section, (ii) the percentage of the feeding requirements covered by the insurance, and (iii) the cost of feeding per Cow Equivalent.

**<u>Heads of Cattle</u>**

To modify the heads of cattle insured, the user should change the number of breeding cows in the spreadsheet ***Cabezas*** of the master file. In Table A3.4 below is shown a screenshot of the sheet ***Cabezas***.

| Datos de VACA DE CRÍA (BD Access de DICOSE, DDJJ 2011) | | | | |
|---|---|---|---|---|
| Departamento | SecPol | PROPIAS_DENTRO | AJENAS_DENTRO | DENTRO |
| Artigas | 1 | 17 | 0 | **17** |
| Artigas | 2 | 47 | 16 | **63** |
| Artigas | 3 | 10,643 | 1,540 | **12,183** |
| Artigas | 4 | 20,193 | 4,443 | **24,636** |
| Artigas | 5 | 32,465 | 6,000 | **38,465** |
| Artigas | 6 | 18,565 | 1,142 | **19,707** |
| Artigas | 7 | 3,568 | 1,281 | **4,849** |
| Artigas | 8 | 33,988 | 9,448 | **43,436** |
| Artigas | 9 | 37,417 | 3,259 | **40,676** |
| Artigas | 10 | 28,850 | 4,306 | **33,156** |
| Artigas | 11 | 28,623 | 3,574 | **32,197** |
| Artigas | 12 | 13,869 | 3,492 | **17,361** |
| Canelones | 1 | 4,610 | 115 | **4,725** |
| Canelones | 2 | 6,431 | 440 | **6,871** |
| Canelones | 3 | 3,690 | 265 | **3,955** |
| Canelones | 4 | 162 | 0 | **162** |
| Canelones | 5 | 351 | 95 | **446** |
| Canelones | 6 | 3,053 | 227 | **3,280** |
| Canelones | 7 | 3,530 | 228 | **3,758** |
| Canelones | 8 | 6,882 | 638 | **7,520** |
| Canelones | 9 | 8,490 | 350 | **8,840** |
| Canelones | 10 | 11,971 | 546 | **12,517** |
| Canelones | 11 | 6,607 | 552 | **7,159** |
| Canelones | 12 | 5,314 | 340 | **5,654** |
| ... | ... | ... | ... | **...** |

Table A3.4. Heads of breeding cows in master file, sheet *Cabezas*.

## Percentage covered and cost of feeding per Cow Equivalent

Parameters related to percentage covered and cost of feeding are in main file, in the spreadsheet "***CalculoSumaAsegurada***". Table A3.5 shows the sheet in which the user can modify the price of the ration, and/or the quantity of ration needed to feed one livestock unit, and/or the percentage of feeding covered in each month included in the coverage period.

| *Parámetros para Cálculo de Suma Asegurada* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Alimentación en base a compuesto utilizado en última sequía | Harina de Girasol | | Afrechillo de Trigo | | Cant. x U.G. | Costo en US$ x U.G. x | Costo en US$ x U.G. x |
| | % en comp. | Precio | % en comp. | Precio | | | |
| | 25% | USD 235.00 | 75% | USD 180.00 | 4 kg. | **USD 0.7750** | **USD 23.250** |

| | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % de Cobertura | 0% | 50% | 50% | 50% | 50% | 50% | 50% | 50% | 0% | 0% | 0% | 0% |
| **SA x Mes x Vacas** | USD 0.000 | USD 11.625 | USD 11.625 | USD 11.625 | USD 11.625 | USD 11.625 | USD 11.625 | USD 11.625 | USD 0.000 | USD 0.000 | USD 0.000 | USD 0.000 |

Table A3.5. Percentage of coverage and cost of feeding.

It is worth to highlight that in order to exclude one month of the coverage, the percentage of coverage (in the row "% de Cobertura" shown in Table A3.4) should be set to zero. By doing this, the months excluded will not have any effect on the calculations performed by the rating tool.

### 4.4. Closing the Rating Tool and Saving Data

By closing the main file, ***NDVI_IndexInsurance_Uruguay_MasterFile.xlsm***, the software will ask the user about the closing of all the files of the 18 Departments (see Figure A3.7 below).

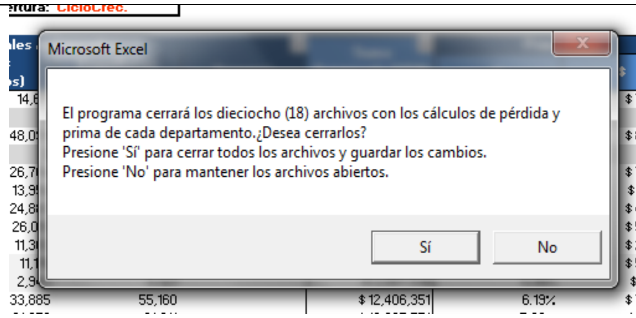



Figure A3.7. Excel window displayed by closing *NDVI_IndexInsurance_Uruguay_MasterFile.xlsm*, asking about the closing of the remaining 18 files of the Rating Tool.

By choosing "Sí" (Yes) all the files of the Departments will be closed by the software automatically, and **the changes carried out in them will be saved**. If "No" is chosen, the user should close each one of the files manually.

## 5. Example: illustration of the methodology and Rating Tool use

This section illustrates the complete methodology applied to Police Section 3 of Artigas Department. All the figures exposed here can be reproduced using the Ranting Tool software. Particularly, the data shown below were extracted from the files ***NDVI_IndexInsurance_Uruguay_MasterFile.xlsm*** and ***Dpto02_Artigas.xlsm***.

Furthermore, the aggregation of all the Police Sections belonging to the Department of Artigas is shown, and also the summary for all Uruguay.

### 5.1. Data, HRZ and Index

Police Section 3 has 14 pixels, and the cluster analysis separates it two homogeneous risk zones: SP3_1 with three pixels and SP3_2 with eleven pixels. Following methodology described in Section 3.2 of this annex, all the calculations will be made using the data in the main cluster, i.e. SP3_2, whose members are Pixels No. 196, 197, 198, 230, 231, 232, 263, 264, 265, 297 and 332.

**Filling data gaps**

Table A3.2 has shown the months in which there are missing data in the whole database. Following the methodology in Section 3.1 of this annex, data in November 1982, 1994 and 1996 in pixel Nº 196, for instance, will be fill in using the average of the November NDVI values in this pixel in all the remaining years in the sample. Table A3.6 below shows the calculation of the average in November in Pixel Nº 196. The data in November 1982, 1994 and 1996 will be filled in with this average, i.e. the three years will have a value of 0.59727 in November.

| *Año* | *Mes* | *NDVI* |
|---|---|---|
| 1981 | 11 | 0.57395 |
| 1983 | 11 | 0.52340 |
| 1984 | 11 | 0.63516 |
| 1985 | 11 | 0.59439 |
| 1986 | 11 | 0.60254 |
| 1987 | 11 | 0.64940 |
| 1988 | 11 | 0.58304 |
| 1989 | 11 | 0.50667 |
| 1990 | 11 | 0.66084 |
| 1991 | 11 | 0.59701 |
| 1992 | 11 | 0.57603 |
| 1993 | 11 | 0.64715 |
| 1995 | 11 | 0.55701 |
| 1997 | 11 | 0.65395 |
| 1998 | 11 | 0.59416 |
| 1999 | 11 | 0.51752 |
| 2000 | 11 | 0.63703 |
| 2001 | 11 | 0.64824 |
| 2002 | 11 | 0.65495 |
| 2003 | 11 | 0.62095 |
| 2004 | 11 | 0.59118 |
| 2005 | 11 | 0.60059 |
| 2006 | 11 | 0.57133 |
| 2007 | 11 | 0.65652 |
| 2008 | 11 | 0.58071 |
| 2009 | 11 | 0.59916 |
| 2010 | 11 | 0.45481 |
| 2011 | 11 | 0.63593 |
| **Promedio** | | **0.59727** |

Table A3.6. Calculation of the NDVI average value in November in pixel Nº 196, in Police Section 3 of Artigas Department, to fill in the missing data in November 1982, 1994 and 1996.

The filled in data of Police Section 3, Cluster 2, Artigas Department are shown in Table A3.7.

| año | mes | 196 | 197 | 198 | 230 | 231 | 232 | 263 | 264 | 265 | 297 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 11 | 0.59727 | 0.60725 | 0.62674 | 0.60802 | 0.61515 | 0.64538 | 0.58987 | 0.60740 | 0.61862 | 0.60654 |
| 1982 | 12 | 0.56572 | 0.58257 | 0.60502 | 0.57211 | 0.56906 | 0.61021 | 0.54878 | 0.56639 | 0.57556 | 0.56042 |
| 1983 | 6 | 0.56785 | 0.56223 | 0.56730 | 0.56671 | 0.57686 | 0.58972 | 0.56791 | 0.57638 | 0.58234 | 0.57821 |
| 1983 | 7 | 0.53890 | 0.53491 | 0.54294 | 0.54259 | 0.55792 | 0.56257 | 0.55012 | 0.55599 | 0.55792 | 0.55740 |
| 1989 | 8 | 0.52357 | 0.51856 | 0.53194 | 0.53212 | 0.54710 | 0.55443 | 0.53967 | 0.54478 | 0.54948 | 0.54691 |
| 1990 | 8 | 0.52357 | 0.51856 | 0.53194 | 0.53212 | 0.54710 | 0.55443 | 0.53967 | 0.54478 | 0.54948 | 0.54691 |
| 1990 | 9 | 0.55457 | 0.54942 | 0.55937 | 0.55739 | 0.57462 | 0.58610 | 0.56047 | 0.57345 | 0.58154 | 0.58039 |
| 1990 | 10 | 0.59413 | 0.59550 | 0.60372 | 0.60354 | 0.61900 | 0.63871 | 0.59657 | 0.61311 | 0.62203 | 0.61713 |
| 1993 | 2 | 0.57130 | 0.58957 | 0.61247 | 0.57479 | 0.57171 | 0.61062 | 0.55414 | 0.57111 | 0.58091 | 0.57586 |
| 1993 | 9 | 0.55457 | 0.54942 | 0.55937 | 0.55739 | 0.57462 | 0.58610 | 0.56047 | 0.57345 | 0.58154 | 0.58039 |
| 1993 | 10 | 0.59413 | 0.59550 | 0.60372 | 0.60354 | 0.61900 | 0.63871 | 0.59657 | 0.61311 | 0.62203 | 0.61713 |
| 1994 | 9 | 0.55457 | 0.54942 | 0.55937 | 0.55739 | 0.57462 | 0.58610 | 0.56047 | 0.57345 | 0.58154 | 0.58039 |
| 1994 | 10 | 0.59413 | 0.59550 | 0.60372 | 0.60354 | 0.61900 | 0.63871 | 0.59657 | 0.61311 | 0.62203 | 0.61713 |
| 1994 | 11 | 0.59727 | 0.60725 | 0.62674 | 0.60802 | 0.61515 | 0.64538 | 0.58987 | 0.60740 | 0.61862 | 0.60654 |
| 1994 | 12 | 0.56572 | 0.58257 | 0.60502 | 0.57211 | 0.56906 | 0.61021 | 0.54878 | 0.56639 | 0.57556 | 0.56042 |
| 1996 | 8 | 0.52357 | 0.51856 | 0.53194 | 0.53212 | 0.54710 | 0.55443 | 0.53967 | 0.54478 | 0.54948 | 0.54691 |
| 1996 | 9 | 0.55457 | 0.54942 | 0.55937 | 0.55739 | 0.57462 | 0.58610 | 0.56047 | 0.57345 | 0.58154 | 0.58039 |
| 1996 | 10 | 0.59413 | 0.59550 | 0.60372 | 0.60354 | 0.61900 | 0.63871 | 0.59657 | 0.61311 | 0.62203 | 0.61713 |
| 1996 | 11 | 0.59727 | 0.60725 | 0.62674 | 0.60802 | 0.61515 | 0.64538 | 0.58987 | 0.60740 | 0.61862 | 0.60654 |
| 1996 | 12 | 0.56572 | 0.58257 | 0.60502 | 0.57211 | 0.56906 | 0.61021 | 0.54878 | 0.56639 | 0.57556 | 0.56042 |
| 1998 | 4 | 0.61656 | 0.62207 | 0.62613 | 0.62057 | 0.62164 | 0.63924 | 0.60981 | 0.62331 | 0.62805 | 0.61730 |
| 1998 | 5 | 0.59441 | 0.59487 | 0.60250 | 0.59874 | 0.60339 | 0.61983 | 0.59569 | 0.60891 | 0.61042 | 0.60666 |
| 2000 | 1 | 0.53740 | 0.56429 | 0.59428 | 0.54624 | 0.54908 | 0.58349 | 0.51751 | 0.53895 | 0.54486 | 0.53950 |
| 2000 | 2 | 0.57130 | 0.58957 | 0.61247 | 0.57479 | 0.57171 | 0.61062 | 0.55414 | 0.57111 | 0.58091 | 0.57586 |

Tabla A3.7. Filled in data in the eleven pixels in cluster 2 in Police Sections 3 of Artigas Department.

Finally, using the complete NDVI time series for each pixel, the average in each month is calculated in order to get the time series for the **Index**. Table A3.8 illustrates the first data of the Index time series for Cluster SP3_2.

| año | mes | 196 | 197 | 198 | 230 | 231 | 232 | 263 | 264 | 265 | 297 | 332 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 8 | 0.52875 | 0.52240 | 0.53597 | 0.54194 | 0.55716 | 0.57336 | 0.54618 | 0.55315 | 0.56362 | 0.51308 | 0.56788 |
| 1981 | 9 | 0.55363 | 0.55396 | 0.55403 | 0.56704 | 0.57189 | 0.58035 | 0.56093 | 0.56808 | 0.58044 | 0.58021 | 0.57503 |
| 1981 | 10 | 0.54926 | 0.54843 | 0.54949 | 0.55074 | 0.55275 | 0.58730 | 0.54897 | 0.55708 | 0.56039 | 0.56445 | 0.57387 |
| 1981 | 11 | 0.57395 | 0.60223 | 0.63935 | 0.55719 | 0.57706 | 0.60091 | 0.58000 | 0.57809 | 0.57519 | 0.58190 | 0.59170 |
| 1981 | 12 | 0.55126 | 0.51704 | 0.55212 | 0.49559 | 0.49505 | 0.51770 | 0.49543 | 0.50687 | 0.49768 | 0.51898 | 0.52883 |
| 1982 | 1 | 0.58401 | 0.59467 | 0.61774 | 0.53771 | 0.55737 | 0.57076 | 0.56302 | 0.55036 | 0.54063 | 0.58163 | 0.58447 |
| 1982 | 2 | 0.52515 | 0.50990 | 0.53478 | 0.50442 | 0.52110 | 0.53828 | 0.50811 | 0.52072 | 0.54471 | 0.51152 | 0.53421 |
| 1982 | 3 | 0.59300 | 0.62728 | 0.65091 | 0.61896 | 0.61732 | 0.63766 | 0.58989 | 0.60933 | 0.62914 | 0.60081 | 0.61852 |
| 1982 | 4 | 0.58825 | 0.60113 | 0.61429 | 0.57047 | 0.57047 | 0.58154 | 0.56123 | 0.54436 | 0.54484 | 0.58697 | 0.55387 |
| 1982 | 5 | 0.57525 | 0.57737 | 0.58650 | 0.56387 | 0.56103 | 0.56401 | 0.56229 | 0.56473 | 0.56473 | 0.58529 | 0.56836 |
| 1982 | 6 | 0.56386 | 0.55045 | 0.55124 | 0.54344 | 0.53896 | 0.54928 | 0.54155 | 0.56190 | 0.58635 | 0.56553 | 0.55470 |
| 1982 | 7 | 0.51875 | 0.53006 | 0.53308 | 0.51081 | 0.52064 | 0.52508 | 0.52510 | 0.54951 | 0.56581 | 0.52630 | 0.52314 |
| 1982 | 8 | 0.55696 | 0.52345 | 0.52926 | 0.55061 | 0.54096 | 0.55779 | 0.55162 | 0.55550 | 0.58066 | 0.56594 | 0.56111 |
| 1982 | 9 | 0.60483 | 0.55206 | 0.53219 | 0.56652 | 0.57646 | 0.56707 | 0.56358 | 0.56720 | 0.58061 | 0.60212 | 0.55636 |
| 1982 | 10 | 0.60245 | 0.60455 | 0.60966 | 0.62034 | 0.63297 | 0.63988 | 0.61272 | 0.62002 | 0.62524 | 0.63183 | 0.63144 |
| 1982 | 11 | 0.59727 | 0.60725 | 0.62674 | 0.60802 | 0.61515 | 0.64538 | 0.58987 | 0.60740 | 0.61862 | 0.60654 | 0.61909 |
| 1982 | 12 | 0.56572 | 0.58257 | 0.60502 | 0.57211 | 0.56906 | 0.61021 | 0.54878 | 0.56639 | 0.57556 | 0.56042 | 0.57550 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |

Table A3.8. NDVI time series data of píxels 196, 197, 198, 230, 231, 232, 263, 264, 265, 297, 332, belonging to Cluster Nº 2 in Police Section 3 of Artigas Department, and Index calculated as the simple average of the NDVI values in each pixel.

## 5.2. Trigger and Exit Index calculation

The following illustrates the calculation of the Trigger and Exit Index for November, and then are shown the results for all the months of the cover period, namely: September, October, November, December, January, February and March. November Index data in each year of the database are shown in Table A3.9.

### Trigger Index (TI) for November

November TI for Police Section 3 (using data from Cluster 2) is calculated as a percentile of the distribution shown in Table A3.9, using the Return Period (RP) chosen. For instance, for a RP of 7 years, the Trigger is the Index value that accumulates a probability of 14.28% (≈1/7). In general, the Trigger is implied in the following relationship:

$$P\left(I_m < TI_m\right) = 1/RP$$

In order to calculate the TI two methods can be used, namely: historical frequencies ("Método = Hist."), or Normal distribution ("Método = Normal"). See Section 4.3 of this Annex for further details. If historical distribution is chosen, the percentile of the historical data in Table A3.9 is looked for, so the Trigger Index is:

$$P\left(Índice_{Artigas;SP3;Nov} < TI_{Artigas;SP3;Nov}^{Método=Hist.}\right) = 1/7 \cong 14.28\% \Rightarrow TI_{Artigas;SP3;Nov}^{Método=Hist.} = 0.57489$$

If Normal distribution is chosen ("Método = Normal"), then the Trigger Index is:

$$P\left(Índice_{Artigas;SP3;Nov} < TI^{Método=Normal}_{Artigas;SP3;Nov}\right) = 1/7 \cong 14.28\%$$

$$TI^{Método=Normal}_{Artigas;SP3;Nov} = \mu_{Artigas;SP3;Nov} + z_{0.1428}\sigma_{Artigas;SP3;Nov} = 0.61285 + (-1{,}068) \times 0.04103 = 0.56904$$

where $\mu_{Artigas;SP3;Nov}$ and $\sigma_{Artigas;SP3;Nov}$ are the historical average and standard deviation, respectively, of the observed Index data in November in Cluster SP3_2 of Artigas (see Table A3.9), and $z_{0.1428}$ is the value that accumulates a probability of 14.28% on a Normal Standard distribution.

| año | mes | ÍNDICE |
|---|---|---|
| 1981 | 11 | **0.58705** |
| 1982 | 11 | **0.61285** |
| 1983 | 11 | **0.59471** |
| 1984 | 11 | **0.63275** |
| 1985 | 11 | **0.61543** |
| 1986 | 11 | **0.64909** |
| 1987 | 11 | **0.65566** |
| 1988 | 11 | **0.60007** |
| 1989 | 11 | **0.54295** |
| 1990 | 11 | **0.65024** |
| 1991 | 11 | **0.57852** |
| 1992 | 11 | **0.56880** |
| 1993 | 11 | **0.63263** |
| 1994 | 11 | **0.61285** |
| 1995 | 11 | **0.57227** |
| 1996 | 11 | **0.61285** |
| 1997 | 11 | **0.65264** |
| 1998 | 11 | **0.62048** |
| 1999 | 11 | **0.57344** |
| 2000 | 11 | **0.65488** |
| 2001 | 11 | **0.66732** |
| 2002 | 11 | **0.66432** |
| 2003 | 11 | **0.63675** |
| 2004 | 11 | **0.60268** |
| 2005 | 11 | **0.61571** |
| 2006 | 11 | **0.58709** |
| 2007 | 11 | **0.66871** |
| 2008 | 11 | **0.59735** |
| 2009 | 11 | **0.61873** |
| 2010 | 11 | **0.47789** |
| 2011 | 11 | **0.64161** |
| **Promedio** | | 0.61285 |
| **Desvío Estándar** | | 0.04103 |

Tabla A3.9. Index value in Cluster 2 of Police Section 3 of Artigas Department in the 31 years of sample data.

**November Exit Index (EI)**

The Exit Index for November is a value of the Index such that if the observed index falls below it, the full Police Section Sum Insured allocated to November is paid out. In order to calculate it, the parameter "Salida (d.e.)", called $k_{EI}$, should be set out. This parameter indicates the number of standard deviations below the Trigger in which the Exit is set: $EI_m = TI_m - k_{EI}\sigma_m$ (see Sections 3.4 and 4.2 of this Annex). Considering data under analysis in the example so far, and by setting $k_{EI} = 1$, the Exit Indexes using both methods for calculating the Trigger (historical and Normal) are:

$$EI^{Método=Normal}_{Artigas;SP3;Nov} = TI^{Método=Normal}_{Artigas;SP3;Nov} - 1 \times \sigma_{Artigas;SP3;Nov} = 0.56904 - 1 \times 0.04103 = 0.52801$$

$$EI^{Método=Hist.}_{Artigas;SP3;Nov} = TI^{Método=Hist.}_{Artigas;SP3;Nov} - 1 \times \sigma_{Artigas;SP3;Nov} = 0.57489 - 1 \times 0.04103 = 0.53386$$

**Trigger Index and Exit Index for all the months in cover period**

In Table A3.10 is shown the values of Triggers and Exits for each one of the months in the cover period, and by using both methods for Trigger calculation (historical and Normal). Note that the values in November are the calculated previously.

| Mét. Normal | Sep | Oct | Nov | Dic | Ene | Feb | Mar |
|---|---|---|---|---|---|---|---|
| Trigger: | 0.52434 | 0.57041 | 0.56904 | 0.50831 | 0.44412 | 0.49795 | 0.5381 |
| Exit: | 0.48284 | 0.53183 | 0.52801 | 0.44530 | 0.34281 | 0.41946 | 0.4651 |

| Mét. Histórico | Sep | Oct | Nov | Dic | Ene | Feb | Mar |
|---|---|---|---|---|---|---|---|
| Trigger: | 0.51597 | 0.57928 | 0.57489 | 0.50600 | 0.45711 | 0.51256 | 0.5843 |
| Exit: | 0.47448 | 0.54070 | 0.53386 | 0.44299 | 0.35581 | 0.43407 | 0.5114 |

**Table A3.10.** *Trigger Index* and *Exit Index* in cover period. Police Section No. 3 (calculated from Cluster N°2) in Artigas Department, using both methods, namely: Normal and Historical.

### 5.3. Total Sum Insured calculation and allocation along the months in covered period

In this example it will be used a coverage of the 50% of a Livestock Unit nutritional requirements (2kg of ration) and 210 days in the cover period (7 months). And therefore the sum insured is US$ 81.375 per breeding cow (see Table A3.3, in Section 3.8 of this annex). Assuming a homogenous nutritional requirement, one seventh of the sum insured is allocated to each month.

In Artigas, according to affidavit of 2011, there were 266,666 breeding cows in Artigas in the pixels under pasture, and consequently the Department Total Sum Insured (DTSI) is US$ 21,699,946 (266,666 LU times US$ 81.375), whose monthly allocation is shown in Table A3.11.

| | Sep | Oct | Nov | Dec | Jan | Feb | Mar | |
|---|---|---|---|---|---|---|---|---|
| % Coverage | 50% | 50% | 50% | 50% | 50% | 50% | 50% | DTSI (US$) |
| Sum Insured | 3,099,992 | 3,099,992 | 3,099,992 | 3,099,992 | 3,099,992 | 3,099,992 | 3,099,992 | 21,699,946 |
| % DTSI | 14.3% | 14.3% | 14.3% | 14.3% | 14.3% | 14.3% | 14.3% | 100.0% |

Table A3.11. Artigas Department Total Sum Insured and allocation to each month in the cover period.

Notice that the allocation of one seventh to each month is based on the assumption equally nutritional requirements in the whole cover period; however this could change and the percentage allocated to each month could be modified easily in the rating tool.

In Police Section 3 of Artigas, according to affidavit 2011, there were 12,183 breeding cows, which results in a Police Section Total Sum Insured (PSTSI) of US$ 991,392, and, under the assumption of homogeneous nutritional requirement, one seventh of this amount or US$ 141,627 would be allocated to each month.

Following the product design, if the observed index falls below the September Exit Trigger, US$ 141,627 would be paid out, if the observed index falls below the October Exit Trigger, US$ 141,627 would be paid out, and so on.

### 5.4. Payout Rule

The payout of the insurance is triggered in a Police Section in any month of the cover period if the Index is less than the Trigger Index for that month. If the Index is as well less than the Exit Index, the whole Police Section Sum Insured of that month should be paid out. If the Index is between the Trigger and Exit, there is a proportional payout. In order to avoid minimal payouts, a Police Section qualifying franchise (non deductible) is set out in the contract (see Section 3.4 of this Annex).

Figure A3.8 illustrates the payout rule for November as percentage of the Police Section Annual Total Sum Insured, according to the *Trigger* and *Exit* that have been calculated in Section 5.2 of this Annex and the monthly allocation of the Total Sum insured in Section 5.3 of this Annex. In order to perform the calculation, a Normal distribution has been used ("Método = Normal"), the Trigger was calculated using a frequency (month by month) of 1 in 7 years, the Exit has been set out one standard deviation below the Trigger ($k_{EI} = 1$) and the qualifying franchise has been set out in 2% of the Police Section Annual Total Sum Insured.

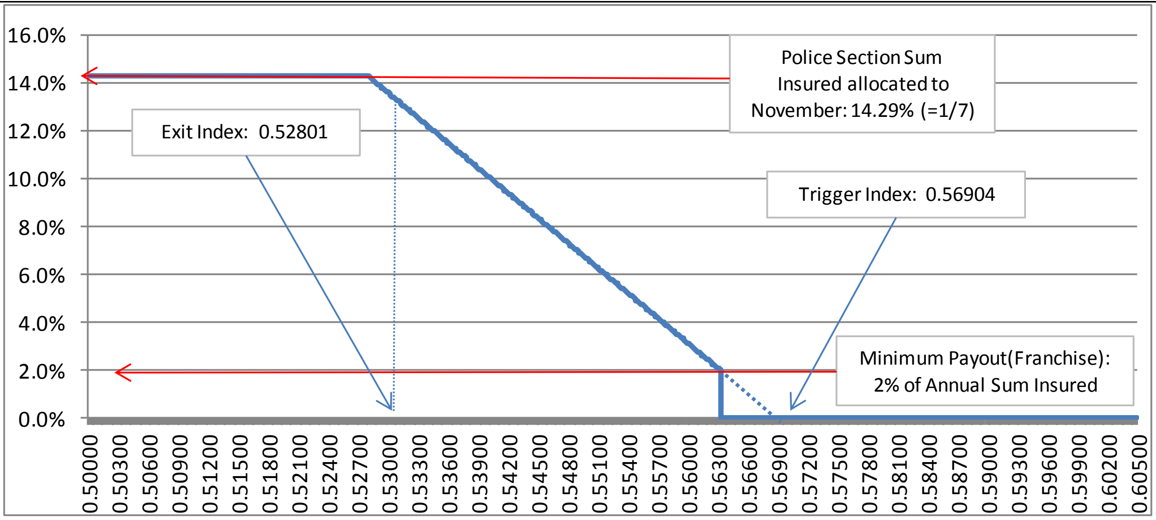



Figure A3.8. Payout rule for November, expressed as percentage of the Annual Total Sum Insured. Cluster 2, Police Section 3, Artigas. Parameters: Return Period = 7 years. Método = Normal. Franq. x SP x mes = 2%. Salida (d.e.) = 1 (see Section 4.2 of this Annex)

Figure A2.9 illustrates the payout rule in November, but expressed in U.S. dollars, using the same parameters as in Figure A3.8.

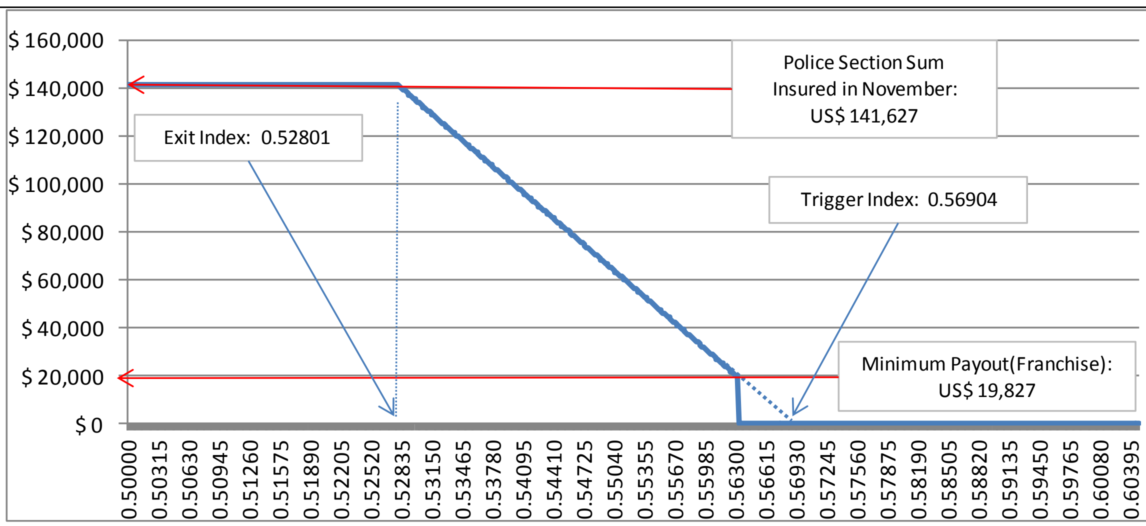



Figure A3.9. Payout rule in November, expressed in US$. Cluster 2, Police Section 3, Artigas. Parameters: Return Period = 7 years. Método = Normal. Franq. x SP x mes = 2%. Salida (d.e.) = 1 (see Section 4.2 of this Annex)

### 5.5. Historical payouts and Burn Analysis

According to the parameters set out so far, the payouts that would have been made in the 30 years of the database, if the insurance would have been operating, were calculated.

For instance, in November 1992, in Cluster SP3_2 of Artigas the Index value was 0.56680 (see Table A3.9 in Section 5.2 of this Annex). The Trigger and Exit for November are 0.56904 and 0.52801, respectively (see Section 5.2 of this Annex and Figures A3.8 and A3.9), and consequently a loss would have been incurred in November 1992. The amount of the loss would have been (see Section 3.4 of this Annex):

$$Loss_{Nov-1992} = \frac{0.56904 - 0.56880}{0.56904 - 0.52801} \times \$141{,}627 = \$828$$

However, the Police Section qualifying franchise was set at 2% of the Annual Total Sum Insured or US$ 19,827 (see Figure A3.9). Therefore, no payment at all would have been made (See Section 3.4 of this Annex).

In November 1989, Index value in Cluster SP3_2 of Artigas was 0.54295 (see Table A3.9 in Section 5.2 of this Annex). The loss incurred would have been:

$$Payout_{Nov-1989} = \frac{0.56904 - 0.54295}{0.56904 - 0.52801} \times \$141{,}627 = \$90{,}064$$

This amount is higher than the Franchise, and consequently would have been actually paid out in full (see Section 3.4 of this Annex).

Table A3.12 illustrates historical payouts that would have been made in Police Section 3, Artigas, as percentage of Annual Total Sum Insured and in U.S. dollars.

By performing a similar procedure for each one of the month in the cover period, the theoretical historical payouts, as percentage of the Police Section Annual Total Sum Insured, have been calculated (see Table A3.13). The Police Section Risk Premium rate is estimated by averaging the values in last column of Table A3.13, and amounts 8.72% in Police Section 3, Artigas.

| Year | Payout (% PSTSI) | Payout |
|---|---|---|
| 1981 | 0.0% | 0 |
| 1982 | 0.0% | 0 |
| 1983 | 0.0% | 0 |
| 1984 | 0.0% | 0 |
| 1985 | 0.0% | 0 |
| 1986 | 0.0% | 0 |
| 1987 | 0.0% | 0 |
| 1988 | 0.0% | 0 |
| 1989 | 9.1% | 90,064 |
| 1990 | 0.0% | 0 |
| 1991 | 0.0% | 0 |
| 1992 | 0.0% | 0 |
| 1993 | 0.0% | 0 |
| 1994 | 0.0% | 0 |
| 1995 | 0.0% | 0 |
| 1996 | 0.0% | 0 |
| 1997 | 0.0% | 0 |
| 1998 | 0.0% | 0 |
| 1999 | 0.0% | 0 |
| 2000 | 0.0% | 0 |
| 2001 | 0.0% | 0 |
| 2002 | 0.0% | 0 |
| 2003 | 0.0% | 0 |
| 2004 | 0.0% | 0 |
| 2005 | 0.0% | 0 |
| 2006 | 0.0% | 0 |
| 2007 | 0.0% | 0 |
| 2008 | 0.0% | 0 |
| 2009 | 0.0% | 0 |
| 2010 | 14.3% | 141,627 |
| 2011 | 0.0% | 0 |

Table A3.12. Historical Payouts in November for Police Section 3, Artigas (percentage of Police Section Annual Total Sum Insured and US dollars)

| year \ month | Jan | Feb | Mar | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|
| 1981 | | | | 0.0% | 4.4% | 0.0% | 0.0% |
| 1982 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1983 | 0.0% | 0.0% | 0.0% | 14.3% | 0.0% | 0.0% | 0.0% |
| 1984 | 0.0% | 0.0% | 0.0% | 8.1% | 0.0% | 0.0% | 0.0% |
| 1985 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 3.2% |
| 1986 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1987 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1988 | 0.0% | 0.0% | 0.0% | 5.2% | 0.0% | 0.0% | 0.0% |
| 1989 | 5.2% | 14.3% | 14.3% | 0.0% | 14.3% | 9.1% | 0.0% |
| 1990 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1991 | 0.0% | 0.0% | 0.0% | 0.0% | 11.5% | 0.0% | 0.0% |
| 1992 | 0.0% | 0.0% | 0.0% | 14.3% | 0.0% | 0.0% | 0.0% |
| 1993 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1994 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1995 | 14.3% | 0.0% | 0.0% | 12.5% | 0.0% | 0.0% | 0.0% |
| 1996 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1997 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1998 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1999 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 8.2% |
| 2000 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2001 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2002 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2003 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2004 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2005 | 0.0% | 2.7% | 11.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2006 | 0.0% | 14.3% | 14.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2007 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2008 | 0.0% | 12.6% | 7.3% | 0.0% | 0.0% | 0.0% | 7.4% |
| 2009 | 10.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2010 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 14.3% | 14.3% |
| 2011 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

| Policy Year | Payout |
|---|---|
| 81-82 | 4.4% |
| 82-83 | 0.0% |
| 83-84 | 14.3% |
| 84-85 | 8.1% |
| 85-86 | 3.2% |
| 86-87 | 0.0% |
| 87-88 | 0.0% |
| 88-89 | 39.0% |
| 89-90 | 23.4% |
| 90-91 | 0.0% |
| 91-92 | 11.5% |
| 92-93 | 14.3% |
| 93-94 | 0.0% |
| 94-95 | 14.3% |
| 95-96 | 12.5% |
| 96-97 | 0.0% |
| 97-98 | 0.0% |
| 98-99 | 0.0% |
| 99-00 | 8.2% |
| 00-01 | 0.0% |
| 01-02 | 0.0% |
| 02-03 | 0.0% |
| 03-04 | 0.0% |
| 04-05 | 13.9% |
| 05-06 | 28.6% |
| 06-07 | 0.0% |
| 07-08 | 19.9% |
| 08-09 | 17.5% |
| 09-10 | 0.0% |
| 10-11 | 28.6% |
| Tasa Pura | 8.72% |

Tabla A3.13. Historical Payouts per month in cover period (percentage of Police Section Annual Total Sum Insured). Police Section 3, Artigas.

### 5.6. Results summary

In Table A3.14 are shown the Sum Insured and Risk Premium (Average Loss) for each one of the Police Sections in Artigas, which have been obtained by performing the same procedure as in previous section. The departmental loss cost in any year is the weighted average (by sum insured) of the Police Sections loss costs, provided this average is higher than the departmental franchise. The Risk Premium Rate for the whole Department amounts 8.51%, which have been obtained as the average departmental loss cost in the 30 year of sample. Notice that this could be not the same as a weighted average (by sum insured) of the Police Sections' Risk Premiums, because of applying of the Departmental Franchise: the weighted average of Police Section loss cost in any year could be less than the Departmental Franchise, and no payout would have been made in that year, which finally would result in a lower total average loss cost.

In Table A3.15 are shown the global results for all Departments in Uruguay, which have been obtained by repeating the methodology applied in Artigas, and considering a Global Franchise of 0.86% of the Total Sum Insured, or US$ 2.7 million. The Global Risk Premium Rate for the whole Uruguay is 7.57%, which has been calculated as the average loss cost of 30 year sample data. Similarly as in the per department case, this global risk premium could be different to the weighted average (by sum insured) of the departmental risk premium because of applying the global franchise.

| Police Section | Main Cluster | Breeding cows | Sum Insured (US$) | Risk Premium |
|---|---|---|---|---|
| 3 | SP3_2 | 12,183 | 991,392 | **8.72%** |
| 4 | SP4_2 | 24,636 | 2,004,755 | **8.57%** |
| 5 | SP5_1 | 38,465 | 3,130,089 | **8.12%** |
| 6 | SP6_1 | 19,707 | 1,603,657 | **8.71%** |
| 7 | SP7_2 | 4,849 | 394,587 | **7.91%** |
| 8 | SP8_1 | 43,436 | 3,534,605 | **9.12%** |
| 9 | SP9_1 | 40,676 | 3,310,010 | **8.80%** |
| 10 | SP10_1 | 33,156 | 2,698,070 | **7.97%** |
| 11 | SP11_1 | 32,197 | 2,620,031 | **8.09%** |
| 12 | SP12_1 | 17,361 | 1,412,751 | **8.73%** |
| | | 266,666 | 21,699,946 | **8.51%** |

Table A3.14. Summary of Results for Artigas using the following parameters:
- Return Period = 7 years.
- Salida (d.e.) = 1.
- Police Section Franchise = 2%.
- Departmental Franchise = 2%
- Método = Normal.

| Parámetros del Modelo | | | |
|---|---|---|---|
| Recurrencia: | 7 | Franq. x SP x mes: | 2.00% |
| Método: | Normal | Franq. x Dpto: | 2.00% |
| Disparador (d.e.) | -1.068 | Franq. País: | 0.86% |
| Salida (d.e.) | 1.000 | Rec. Seg.: | 15% |
| Per. Cobertura: | CicloCrec. | Recurrencia PML: | 100 |

| Departamento | Vacas de Cría | Suma Asegurada (US$) | Franquicia (no Deducible) | Prima Pura | |
|---|---|---|---|---|---|
| | | | | % | $ |
| Artigas | 266,666 | $ 21,699,946 | $ 433,999 | 8.51% | $ 1,845,892 |
| Canelones | 80,910 | $ 6,584,051 | $ 131,681 | 6.36% | $ 418,577 |
| Cerro Largo | 340,069 | $ 27,673,115 | $ 553,462 | 7.69% | $ 2,127,525 |
| Colonia | 90,002 | $ 7,323,913 | $ 146,478 | 6.90% | $ 505,581 |
| Durazno | 267,095 | $ 21,734,856 | $ 434,697 | 7.58% | $ 1,646,605 |
| Flores | 119,970 | $ 9,762,559 | $ 195,251 | 7.54% | $ 736,520 |
| Florida | 286,450 | $ 23,309,869 | $ 466,197 | 7.08% | $ 1,651,168 |
| Lavalleja | 248,028 | $ 20,183,279 | $ 403,666 | 6.80% | $ 1,372,602 |
| Maldonado | 104,088 | $ 8,470,161 | $ 169,403 | 7.14% | $ 604,821 |
| Paysandú | 265,954 | $ 21,642,007 | $ 432,840 | 7.65% | $ 1,656,096 |
| Río Negro | 126,326 | $ 10,279,778 | $ 205,596 | 7.76% | $ 797,573 |
| Rivera | 245,064 | $ 19,942,083 | $ 398,842 | 8.26% | $ 1,647,285 |
| Rocha | 270,835 | $ 22,039,198 | $ 440,784 | 6.93% | $ 1,528,315 |
| Salto | 316,916 | $ 25,789,040 | $ 515,781 | 7.96% | $ 2,052,313 |
| San Jose | 124,822 | $ 10,157,390 | $ 203,148 | 7.39% | $ 750,855 |
| Soriano | 98,166 | $ 7,988,258 | $ 159,765 | 7.84% | $ 626,301 |
| Tacuarembo | 364,594 | $ 29,668,837 | $ 593,377 | 8.18% | $ 2,427,968 |
| Treinta y Tres | 252,134 | $ 20,517,404 | $ 410,348 | 7.35% | $ 1,508,427 |
| **TOTAL** | **3,868,089** | **$ 314,765,742** | **$ 2,700,000** | **7.57%** | **$ 23,813,877** |

**Table A3.15. Summary of Global Results for Uruguay.**

# Annex 4. Institutional Framework and Options for NDVI Insurance in Uruguay

### *Introduction*

This Annex presents four main institutional and operational framework options for the NDVI Pasture Index Insurance Program in Uruguay for the Government of Uruguay (GoU) and other interested parties to consider namely:

1. Micro-level Voluntary individual scheme
2. Micro-level Voluntary individual scheme, but with government premium subsidy support
3. Macro-level scheme with government as the Insured.
4. Meso-level (bank assurance product)

### *International Experience with Pasture NDVI Programs: Institutional Framework and Government Support*

To date there are four commercial livestock NDVI schemes operating in the World, all of which have been implemented in the past ten years. Three of these programs operate as voluntary micro-level individual farmer schemes in Spain, USA and Canada and one scheme in Mexico is a macro-level program purchased by the Federal and State governments' on behalf of the small-scale livestock sector. Salient features of these four schemes are summarised in Table A4.1. below along with an indication of the type of government support. It is noted that on the three voluntary individual livestock producer NDVI programs, (i) that premium rates are high for catastrophe NDVI-pasture cover and (ii) government provides very high levels of premium subsidy support usually above two thirds of the costs of premiums.

**Table A4.1. Key Features of Government Support to Commercial NDVI pasture Insurance programs**

| *Country* | *Type of scheme* | *Premium subsidies* | *Source of NDVI & Resolution* | *Government support to reinsurance* | *Insured Area (ha) 2009* |
|---|---|---|---|---|---|
| USA | Individual (voluntary) | YES | USG-EROS (8 km 2) | YES (RMA-Federal Govt.) | 7.2 mio acres |
| Canada | Individual (voluntary) | YES | NOAA-AVHRR (1.1 km 2) | YES | |
| Spain | Individual (voluntary) | YES | MODIS (250 x 250 metres) | YES Consorcio de Compensacion de Seguros (CCS) | 7% of livestock insured |
| Mexico | Government for small livestock producers | Government buys cover (100% subsidized) | NOAA-AVHRR (1.1 km 2) | YES. Agroasemex | 60 million Ha in 20 states |

### *Scale of the Livestock (Cattle) Sector in Uruguay and the costs of major droughts*

The key objective of the Uruguay Livestock pasture-NDVI insurance scheme is to protect the beef cattle industry against catastrophic droughts which result in a major reduction in natural and planted pasture and grazing for the cattle and to ensure that the livestock producers receive timely insurance payments as the drought develops in order for them to purchase necessary fodder and supplementary feeds for their livestock during the period of the drought. The indicative values set out in this report suggest that the costs of supplementary feeds may be in the order of about US$ 315 million to meet nutritional requirements of the 3.87 million registered breeding cows in Uruguay for seven months in an extreme drought situation.

### *Options for Government of Uruguay support to Livestock NDVI Program*

The advantages and disadvantages of each option are listed below.

#### *Option 1. Micro-Level Voluntary Insurance Program and no government support*

Under this option, the government through OPYPA-MGAP would assist the livestock sector and insurance companies in the design stage of the product only. After this the insurance companies would be free to market the livestock NDVI-pasture drought policy as an individual framer policy to any livestock producers they wished to do so on a purely voluntary basis. Government would not, however, provide any form of financial assistance, either in the form of premium subsidies and or assistance with reinsurance financing.

The Uruguayan insurance companies could either (i) act singly, marketing their own livestock NDVI policies and placing their own reinsurance requirements with international reinsurers and with each company making arrangements with a third party remote sensing specialist to provide them with real-time NDVI reporting during the insurance cover period and on which basis insurance payouts would be made or (ii) to form a Uruguayan Livestock NDVI coinsurance pool. In this latter instance the rationale of forming a coinsurance pool would centre on the reduced costs (a) of marketing and sales, (b) contracting of a remote sensing specialist and (c) of purchasing a single pooled reinsurance program. (See Figure A4.1).

It is however, highly unlikely that the Uruguayan Insurance Companies would agree to a purely voluntary scheme for the following reasons which they have identified in the conduct of this Feasibility Study:

- Given the fact that the NDVI product is being designed using satellite imagery with a spatial resolution of 5 km x 5 Km (2,500 Ha) and to then indemnify pasture losses at a Police Section level or several tens of thousands of hectares, it is not best suited to being marketed as an individual livestock producer pasture-drought cover because it will not be able to distinguish pasture-grazing losses at the individual farmer and field level. Rather it is intended to cover catastrophe regional (e.g. at Seccion Policial and Provincial level) drought impacts on pasture production and grazing quality.

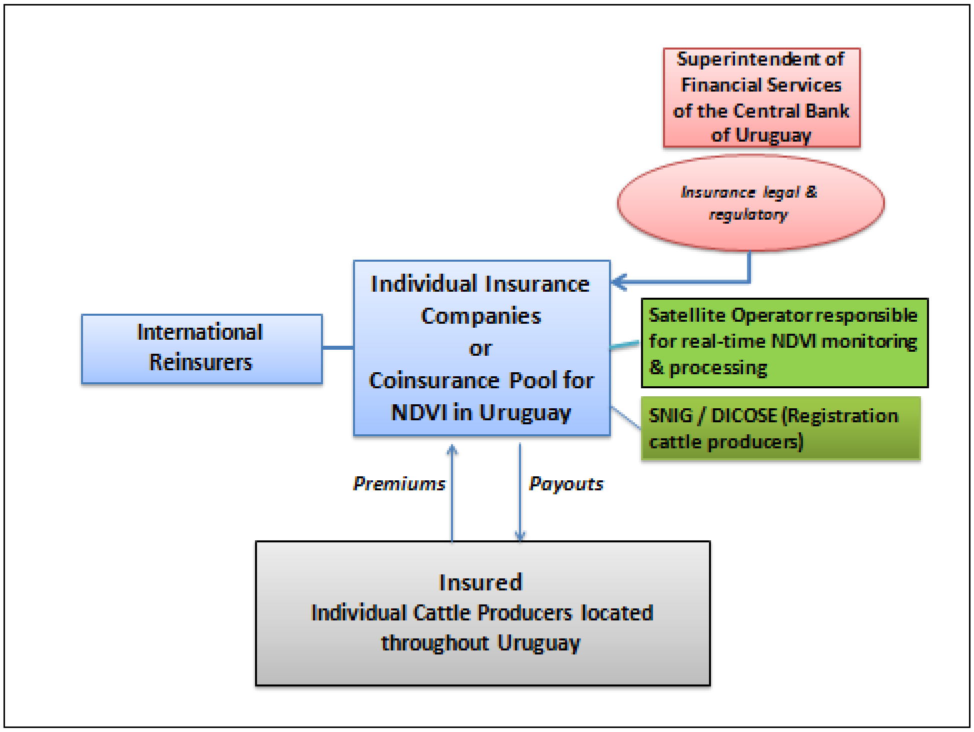
- To distinguish pasture-grazing losses at the individual farmer and field level it would be necessary to perform previous inspections to see what is on the ground (i.e.: resources and animal load) and to follow up the cattle and pasture management implemented by the Insured. Owing to the low insured value per insured cow and per hectare potentially involved in this coverage, the transaction cost of performing such activities is very high.

- The high design and start-up costs of such a program mean the companies are unlikely to be willing to cover these costs under a purely voluntary program where they have no a priori knowledge of the likely demand for this new product.

- The insurers believe that without government premium subsidy support, the demand for this NDVI cover will be very low by livestock producers.

- Given the catastrophe nature of drought in pasture, insurers are reluctant to support such an initiative without complementary technical and financial assistance from the public sector.

**Figure A4.1. Option 1 Organizational Arrangements for a Voluntary Livestock NDVI-Pasture Scheme**

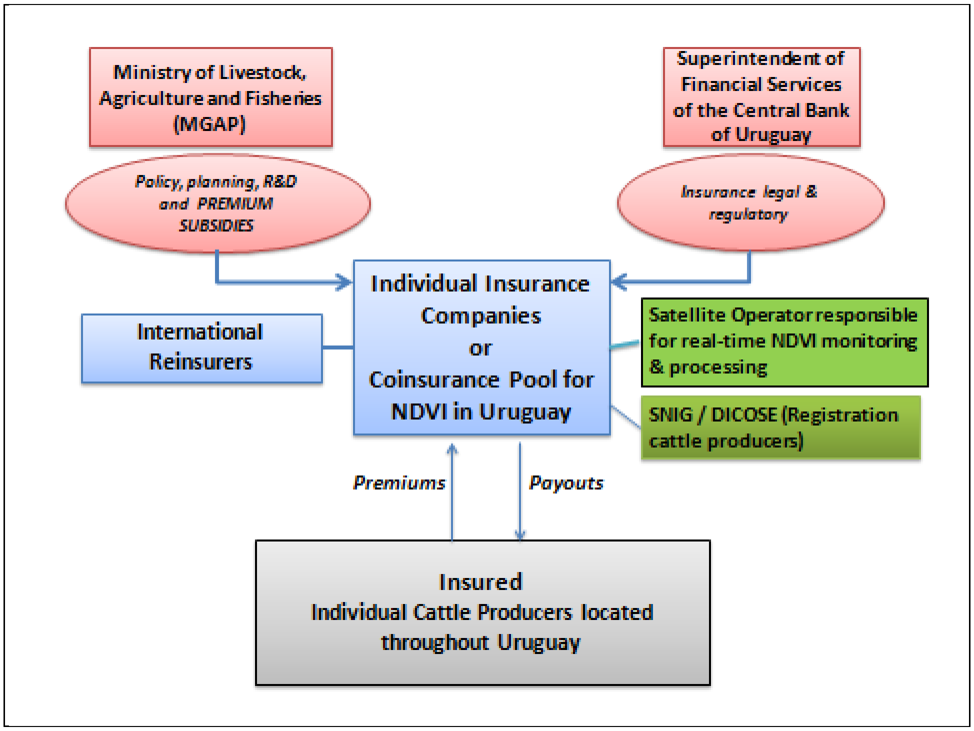



***Option 2. Micro-Level Voluntary Insurance Program and Government Premium Subsidy support***

Under this scenario, it is assumed that the NDVI scheme would continue to be a voluntary individual farmer (micro-level) insurance scheme underwritten either by insurance companies separately, or as an industry coinsurance pool. The only difference would be in this case that government through MGAP would actively support the NDVI scheme in the form of ***Premium Subsidies*** (See Figure A4.2).

The main advantage of premium subsidies is that these should enable the insurer (or pool of insurers) to market the product more readily to Uruguayan livestock producers and to achieve a higher level of uptake and penetration than under the voluntary non-subsidized Option 1. This model is in place in Canada, USA and Spain. In the three countries, even with the existence of premium subsidies the penetration of NDVI is very low.

**Figure A4.2. Option 2 Organizational Arrangements for a Voluntary Livestock NDVI-Pasture Scheme with Government Premium Subsidy support**




***Option 3. Macro-Level National Livestock NDVI-pasture Drought Insurance Program purchased by Government on behalf of the Cattle Industry***

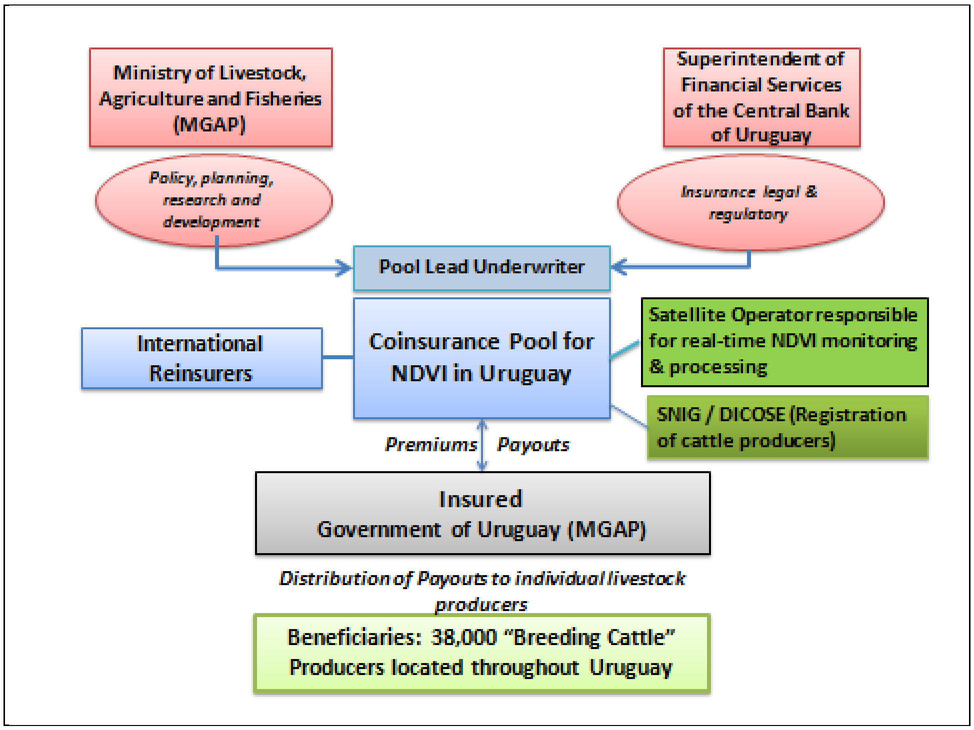
This macro-level option is the recommended model for the Uruguay pasture insurance program and is similar to the Mexican NDVI pasture program. Under this Option, Government of Uruguay (GoU) or its appointed representative (e.g. MGAP) would purchase an annual NDVI pasture policy on behalf of the cattle sector in Uruguay: GoU would be the Insured and would be responsible for paying the premium for this policy. In this case it is assumed that on account of the massive scale of the program which aims to cover about 38,000 beef cattle producers and 3.87 million head of breeding cows with Total Sum Insured estimated at about US$ 315  that the Insurance companies would elect to form a coinsurance pool.

Under the procedures set out in Chapters 5 and 6 of this report, the Insurers would use the SNIG-DICOSE national livestock register to list each and every livestock producer ("the final recipients") in the insured Police Sections in each of the 18 Departments[50] of Uruguay including details of their individual livestock holding (numbers of insured breeding cows) and sum insured. In the event of NDVI drought (or other natural peril) losses being triggered in any Police Section during a particular month(s) of the cover period, the indemnity due would be calculated for each livestock producer in the affected Police Section according to their sum insured and the Pool Insurers would either 1) settle the payouts either as lump sum to the Insured (government or its

[50] Montevideo Department is not included in the coverage.

representative e.g. MGAP) to then distribute to the affected farmers, or 2) if agreed with Government, the Pool would settle losses directly to the registered cattle producers. In Uruguay the recommended payout option is 1) and MGAP would be actively involved in distributing NDVI compensation payouts in kind (animal feed rations) (Figure A4.3.)

**Figure A4.3. Option 3 Organizational Arrangements for a Macro-level National Livestock NDVI-Pasture Scheme**




The major advantages of the macro-level option 3 include:

- All beef cattle producers would automatically be included (protected) under this national NDVI-pasture-drought insurance program.
- This ex-ante livestock drought insurance program, would reduce the pressure on the government budget in times of catastrophe drought and could replace the ad hoc disaster compensation payouts government has to make to farmers in affected regions in times of drought and other natural disasters.
- The insurance scheme would operate at the Police Section level and compensate catastrophe droughts and other natural events. In this case where the product is designed as a macro-level product the 5 km x 5 km resolution of the satellite imagery would not pose a problem.
- The program would be attractive to the insurance companies and international reinsurers because there would be a critical mass and significant premium volume to justify investment in staffing, operating systems and procedures to implement this macro-level scheme.

*Option 4. Meso-level NDVI Insurance Product for Regional Financial Institutions or for Livestock Producer Associations*

The NDVI product could also be designed to protect the financial interests of regional banks lending to livestock (cattle) producers in Uruguay. In the event of catastrophe droughts which result in major reduction in pasture and grazing and forced sales of cattle and financial losses to large numbers of individual producers in specific regions, this may lead to inability to repay the loans to the banks and widespread default. The NDVI-pasture index can readily be adapted to protect the financial interests of a bank lending to livestock producers (see Figure A4.4).

This option is, however, unlikely to be of major interest to the insurance companies in Uruguay unless it is again supported by government in the form of premium subsidies.

**Figure A4.4. Option 4 Organizational Arrangements for a Meso-level Livestock NDVI-Pasture Scheme for Banks or other Financial Institutions**