

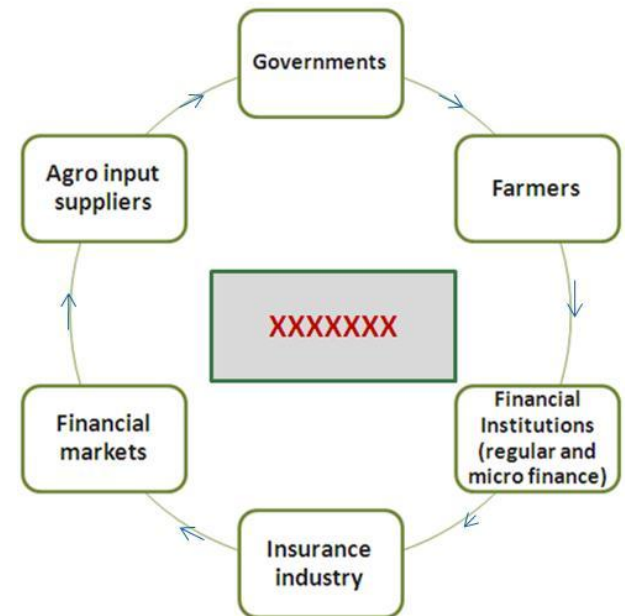
Agricultural Risk Insurance – Can Weather Based Indices Alone Provide the Solution in Developing Countries?

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Background

- Many micro (small-scale farmers, rain fed) parametric weather based agriculture insurance risk initiatives and schemes over the past 30+ years
- Many Issues
 - Identification of **Delivery Channels** for quick claims settlement / payouts
 - High investment costs associated to the development of parametric weather based indices
 - Objective indices not sufficiently correlated with losses (**Large Basis Risk**)
 - Difficulty in scalability (on going participation of the stakeholders) and maintenance
- Much more is needed so fairness to farmers **and** economic feasibility of the insurance programs are improved

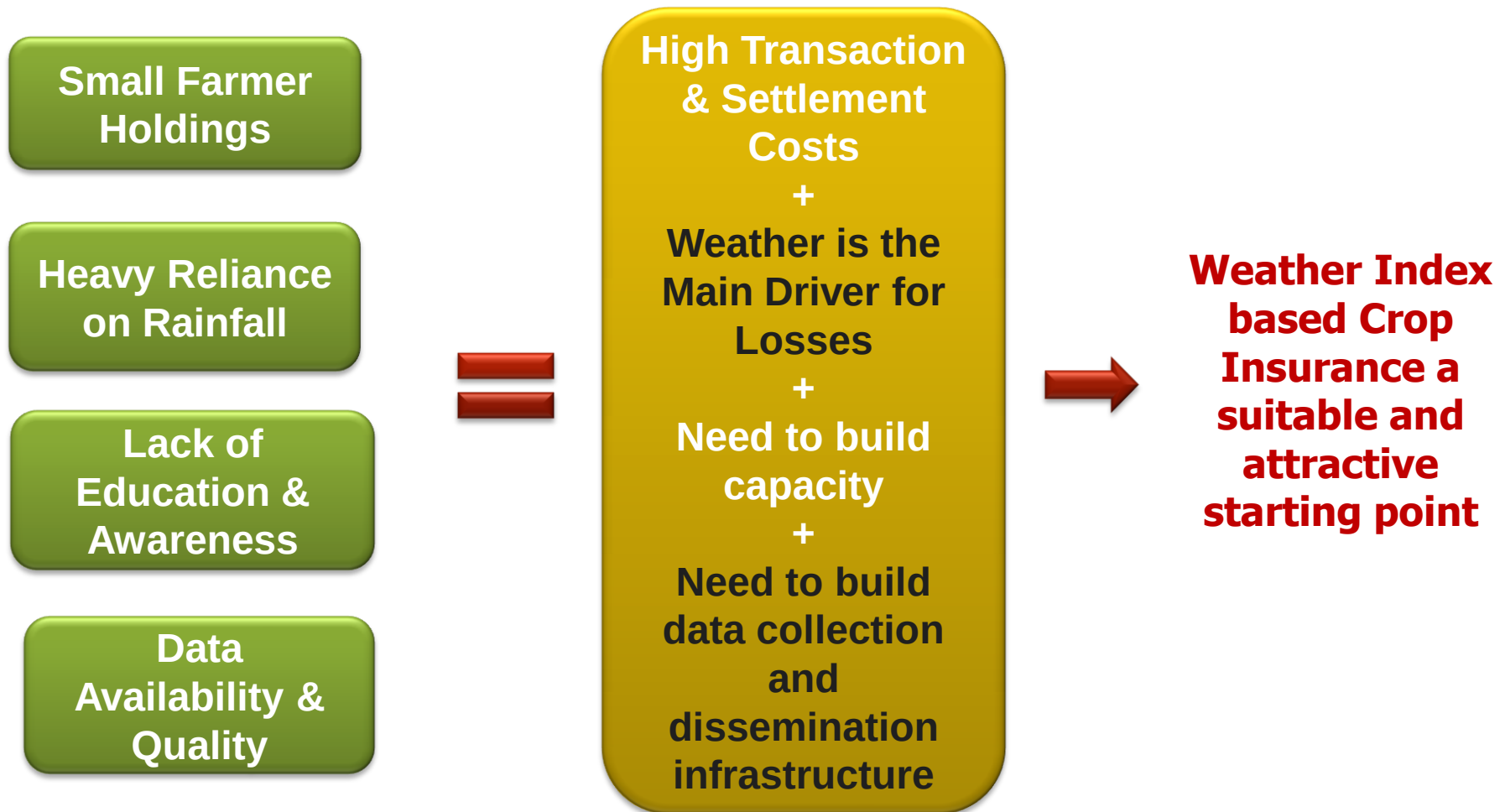


Agricultural Insurance Product Classifications

Sources: Rene Gommès, Iturrioz, 2009

<i>Type of Agricultural</i>	<i>Payouts</i>	<i>Availability</i>
a) Indemnity Based Agricultural Insurance <i>(insurance payouts based on the actual loss at the insured unit level)</i>		
1. Named Peril	Percentage of Damage	Widespread
2. Multiple Peril	Yield Loss	Widespread
b) Index based Agricultural Insurance <i>(insurance payouts based on an index measurement)</i>		
3. Area-Yield Index	Area-yield Loss	USA, India, and Brazil
4. Crop Weather Index Insurance	Weather Index payout scale	India, México, Malawi,
5. NDVI ¹ Index Insurance	NDVI Index payout scale	Mexico, Spain, Canada
6. Livestock Mortality Index Insurance	Livestock mortality index payout scale	Mongolia
7. Forestry Fire Index Insurance	Ignition focus/ burnt area payout scale	Canada, USA
c) Crop Revenue Insurance <i>(insurance payouts based on yield measurement and crop prices)</i>		
6. Crop Revenue Insurance (CRI)	Yield and Price Loss	Limited to USA

Developing Countries – Weather Indices Attractiveness



- Typically Cover **Cost of Production/Inputs** - Developing World
- In USA, Multi-Peril Scheme covers Market Value of Produce – that is production as well as **price risk**

Different Perspectives (1/2)

■ The farmer:

- Recognition of the value proposition (perception of high cost for coverage and ignorance of the true cost of protection); simplicity, practicality
- Insurance is often seen as an “*intangible good that offers stochastic benefits*” (basis risk)
- Can deal with small losses of livelihood. Communities can deal with a catastrophic loss for one of its members **but** not for all members at the same time

■ The insurer / reinsurer:

- Not all risks are insurable. Risks should be simple to understand
- Sustainable production methods and use of best available production techniques
- Spread and diversification of the agricultural risks
- Validation of results against historical data and other relevant experiences
- Pricing is function of the expected losses, cost of business **and** of the **Uncertainty** in the assessment of these losses

$$\text{Premium} = \text{Expected Loss} + \text{Risk Margin} + \text{Administrative Costs}$$

Different Perspectives (2/2)

■ The 'statistical' modeler:

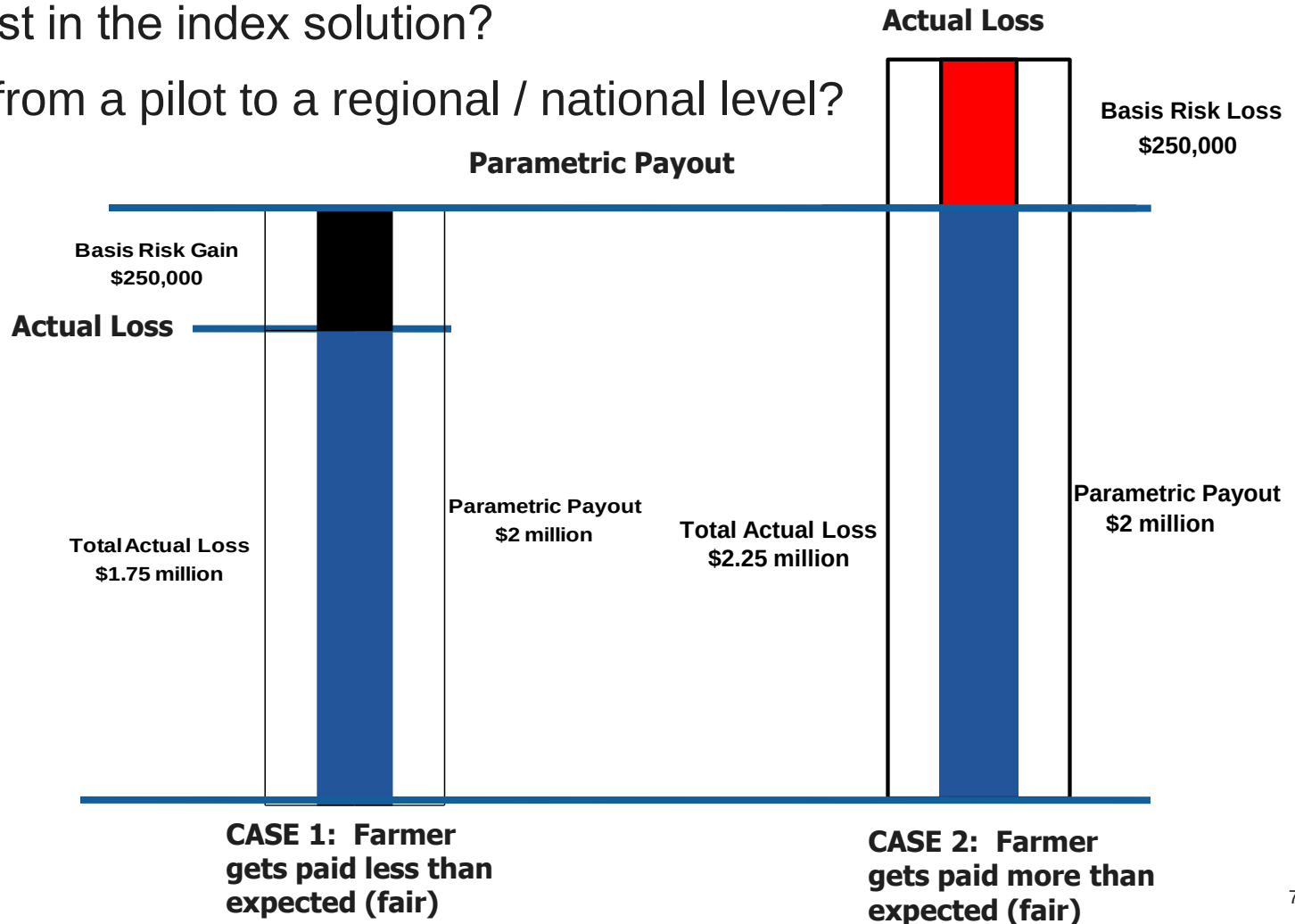
- Weather indices should explain most of the variance in crop yield variations with use of statistical methods (dynamic)
- Basic indices have already been developed (e.g. deficit or excess rainfall, freeze) and more complex ones are more difficult to derive
- Need for a lot of good and reliable data to perform regression analysis between weather indices and crop yield

■ The 'agro climate' modeler:

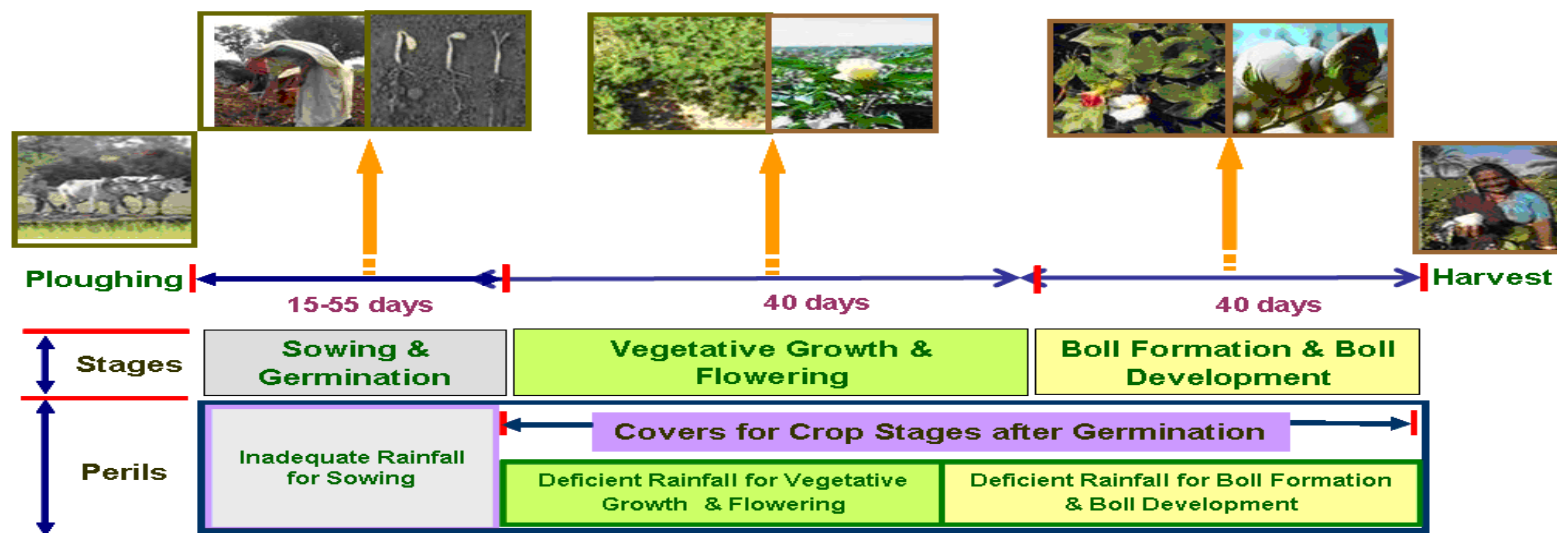
- Experience in crop modeling and crop forecasting can be used in developing indices and overcome some of the shortcomings relying only on historical data
- Lack of weather and crop yield data could be dealt with
- Need insurance oriented calibration methods

Basis Risk – Need to Be Dealt With

- The risk of mismatch between a parametric payout and actual loss incurred in relation to actual loss
- Farmers' trust in the index solution?
- Scaling up from a pilot to a regional / national level?



Example: Weather Based Index Contract Term Sheet



Details of Weather Perils Covered	Phase 1	Phase 2	Phase 3	Phase 4
	15 th June-10 th July	11 th July-31 th July	1 st August-25 th August	26 th August-15 th October
Deficit Rainfall Cover	Covered	Covered	Covered	Covered
Excess Rainfall Cover	Covered	Covered	Covered	Covered
Consecutive Dry Days Cover	1 st July- 31 st August			

Example: Payout Structure of a Simple Weather Index Policy

1. COVER : **DEFICIT RAINFALL**
2. INDEX : **TOTAL RAINFALL DURING A PERIOD/PHASE IN MM**
3. RAINFALL LOWER THAN A **THRESHOLD** RESULTS IN YIELD LOSS
4. PAYOUT STRUCTURE : **NON-LINEAR BUT APPROXIMATED AS MULTI-LINEAR**
5. LOSS CAPPED VIA AN EXIT TRIGGER

Strike - value of the index where payout function (slope) changes.

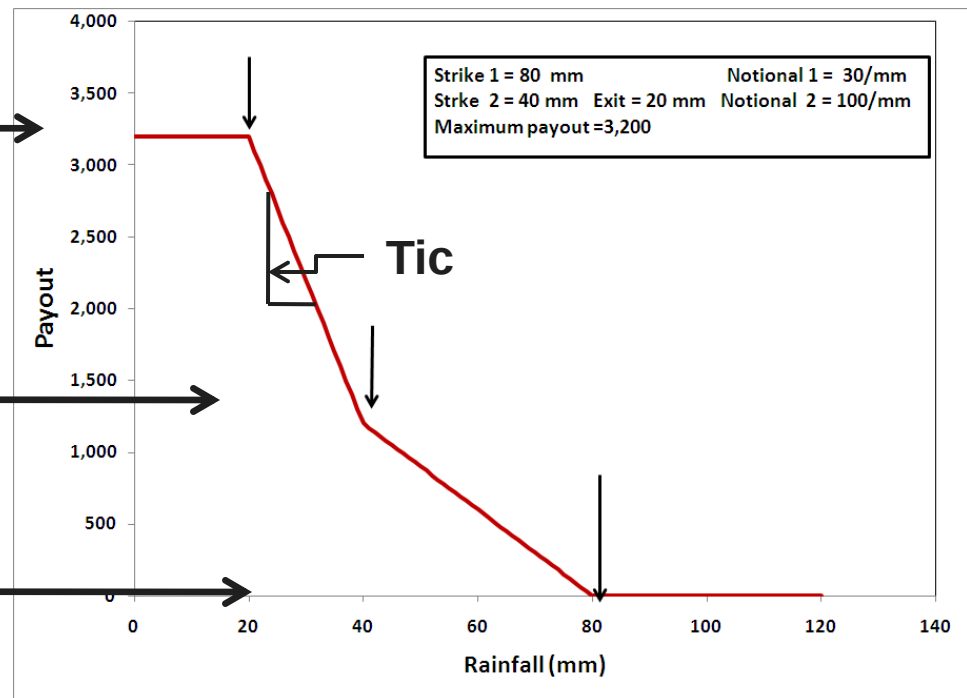
Notional – payment amount per Index unit between two strikes.

Say Index value is 60, which is $(80-60) = 20$ units between strike 1 and 2. The policy will pay 20×30 (Notional 1) = 600

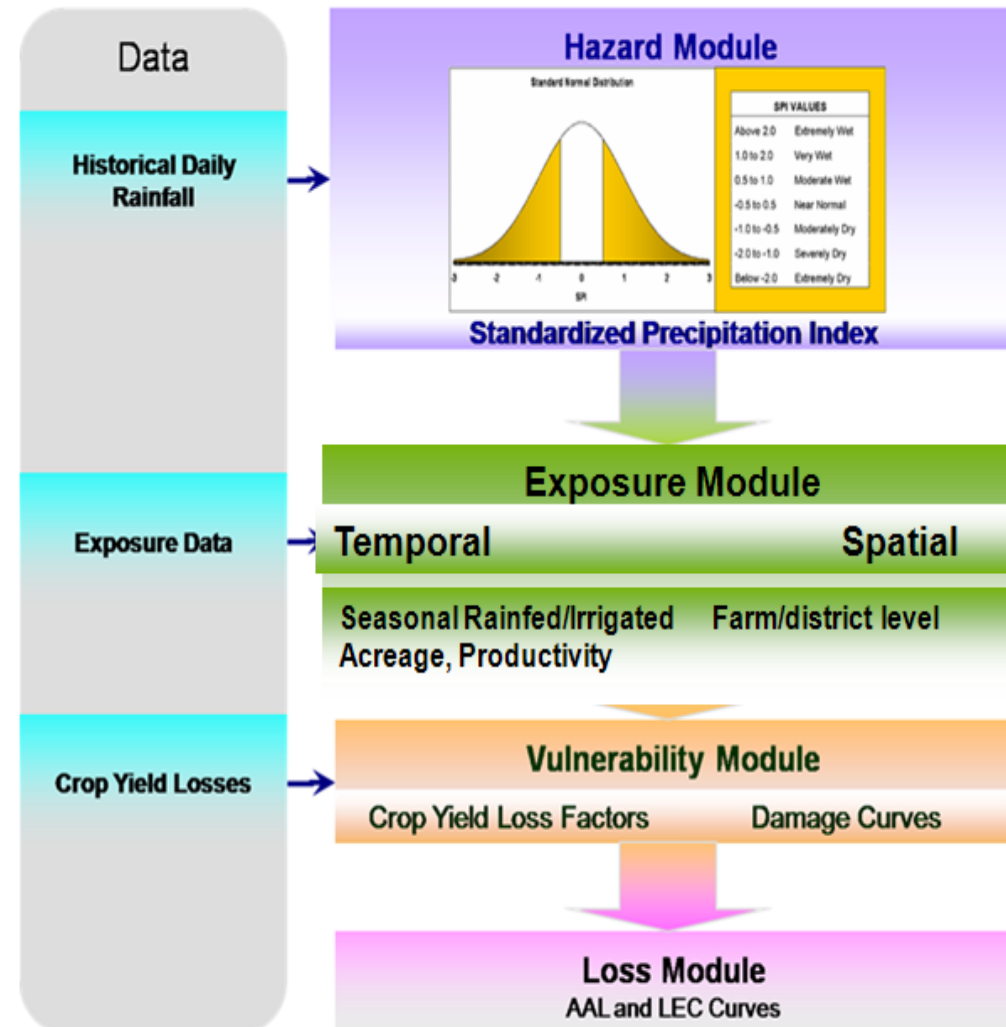
Exit Trigger

Strike2/Trigger2

Strike1/Trigger1



Crop Weather Index Model Using Modular Approach



■ 4 building blocks

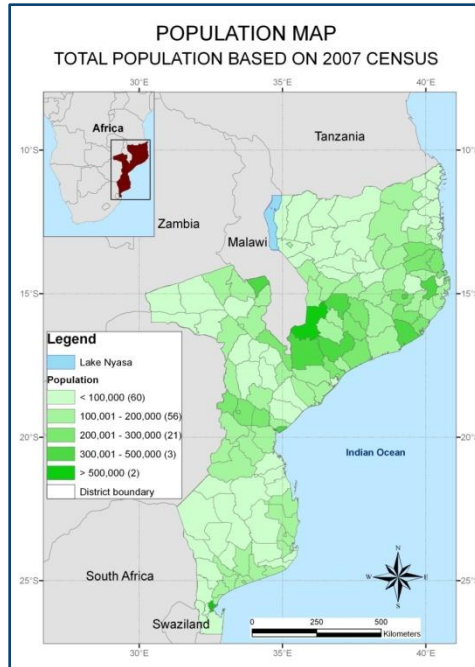
- Hazard module
- Exposure module
- Vulnerability module
- Loss module

■ Steps

1. Historical or simulated weather
2. Develop crop weather index
3. Correlate weather index to crop yield (vulnerability) and financial loss
4. Perform historical/simulation analyses
5. Estimate risk metrics and price risk

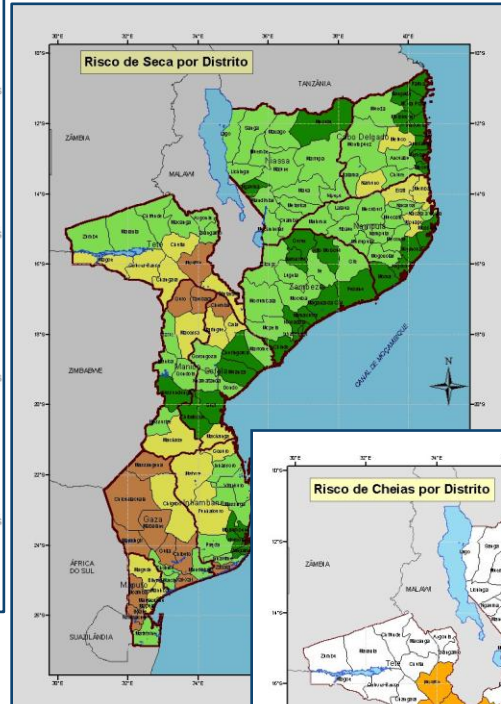
Mozambique Example - Mosaic of Perils

What to Cover and What Perils to Address?

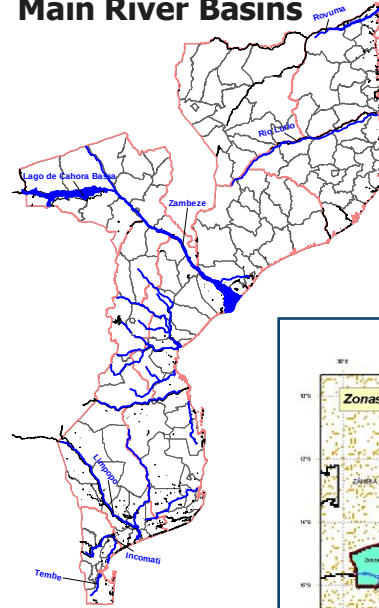


Population: 20.5 million
Area: 800,000 km² (15% > Texas)

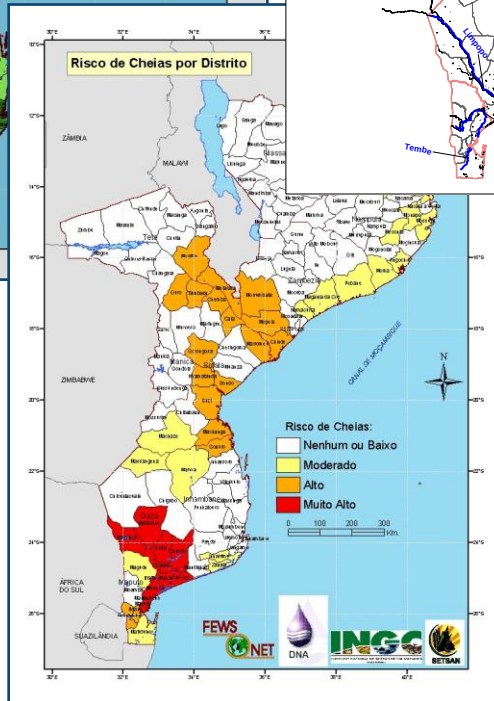
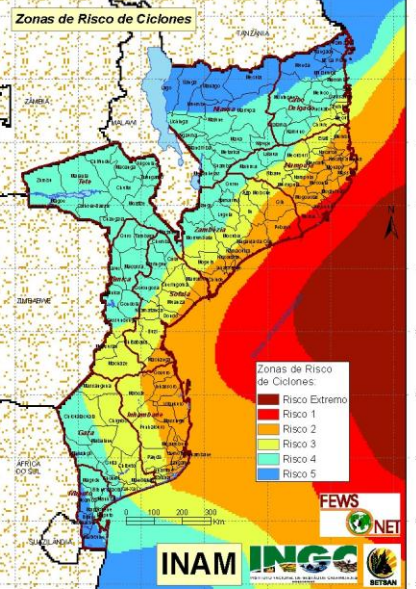
Drought Prone Districts



Main River Basins



Risco de Cheias por Distrito



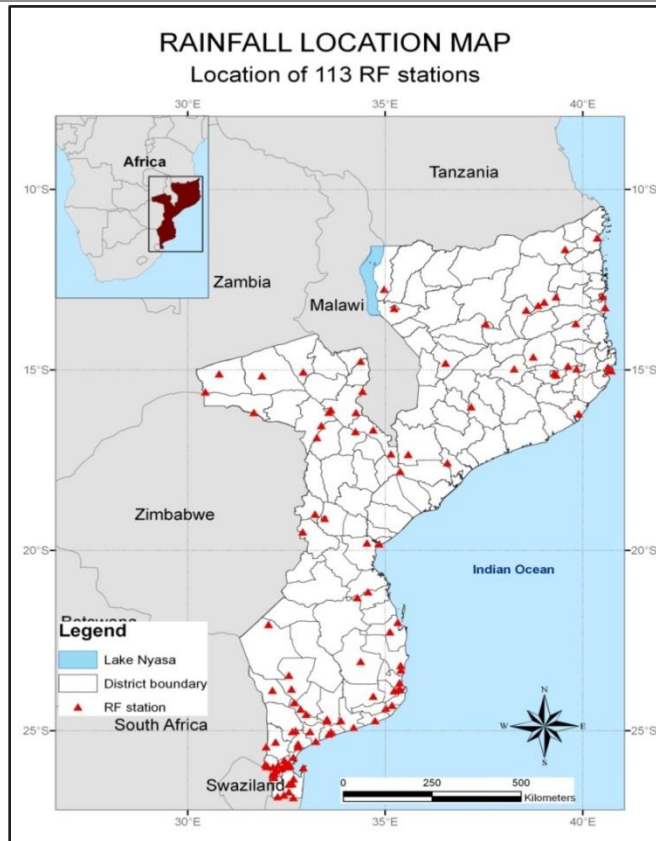
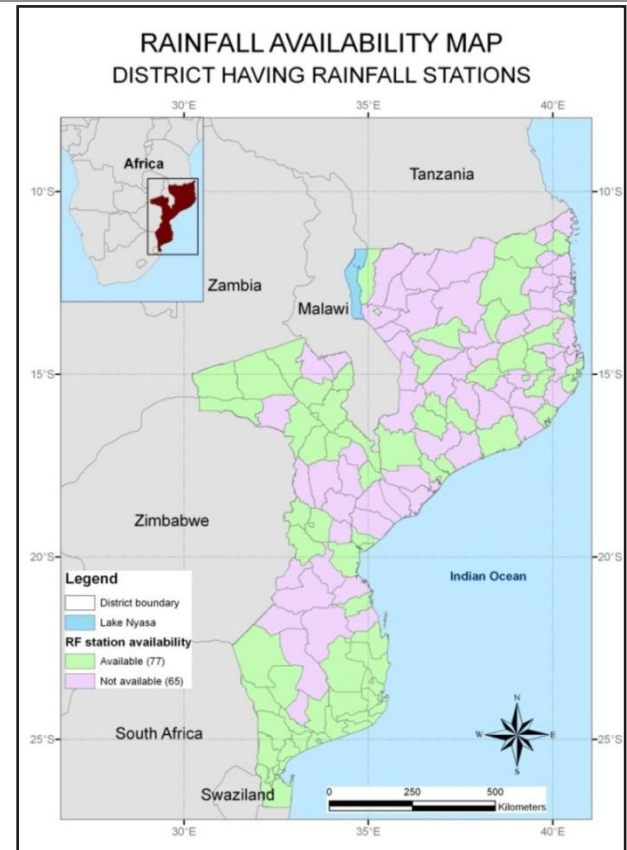
Cyclone Prone Districts

AGRO RISK DRIVERS:

- **Drought**
- **Flood / Excess Rainfall**

Meteorological Data - Meteorological Stations

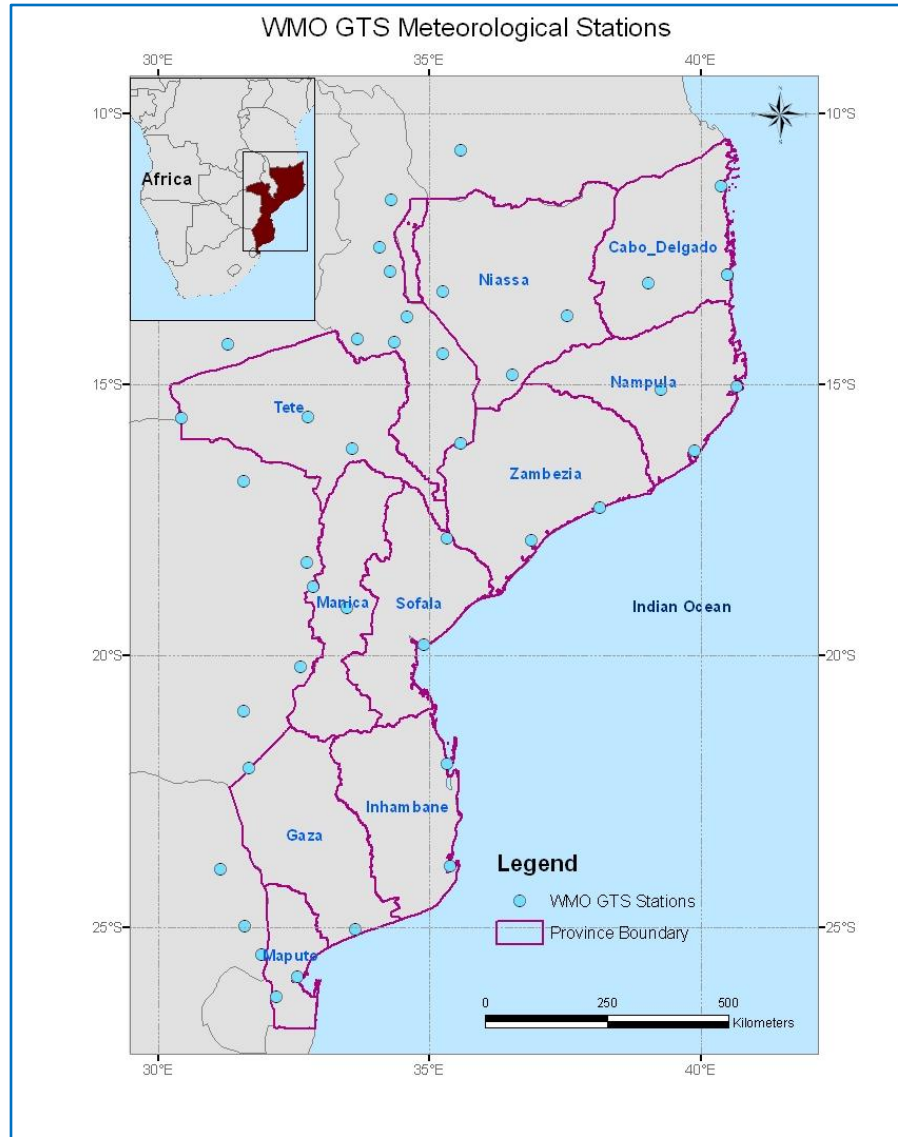
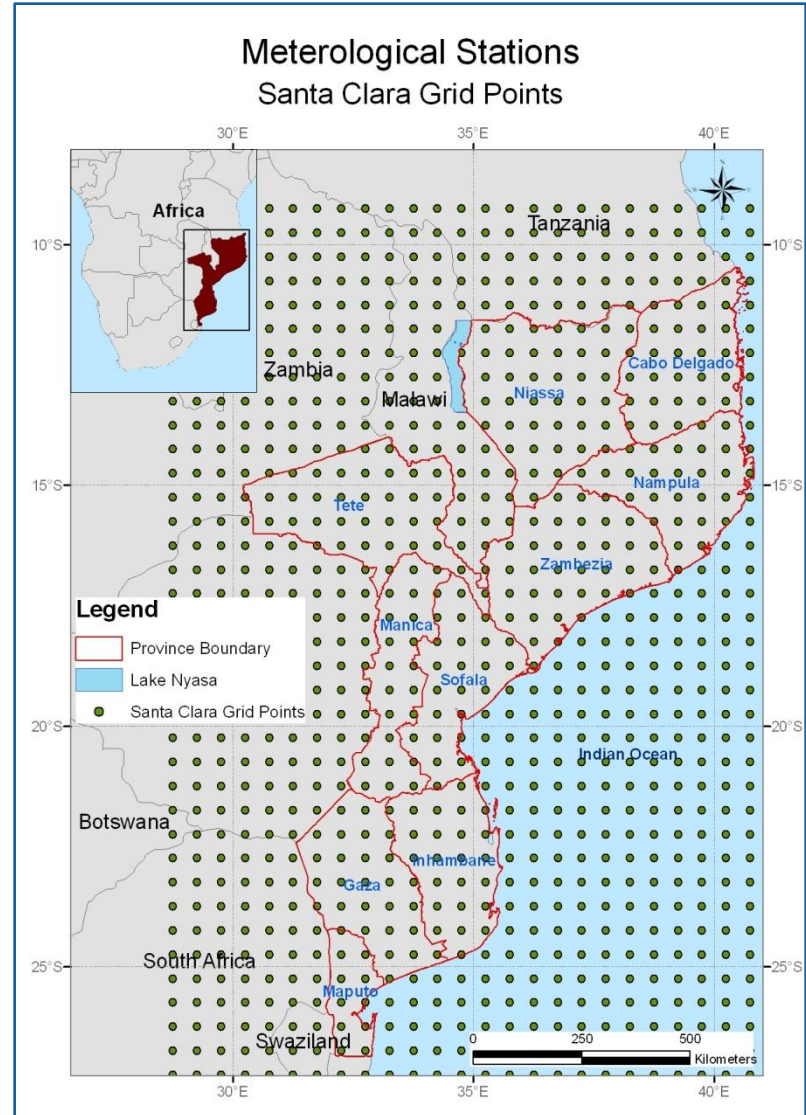
Where are the ground weather data? and ... Crop yield ?



- 113 stations distributed in 69 districts
- Record duration from 10 to 50 years
- **73 districts without stations (Weather stations only cover 1/3 of the territory and have many periods of incomplete data)**

Meteorological Data – Weather Stations and Re-analyzed and Gridded Data – Availability in the future?

Reanalyzed rainfall data



Remote Sensing Rainfall Estimates

How Long are the Time Series?

- Tropical Rainfall Measuring Mission (TRMM)
 - National Oceanic and Atmospheric Administration (NOAA) and the Japanese Aerospace Exploration Agency, since 1998
 - 3 hourly and monthly rainfall at 25 km grid resolution
- Water Requirement Satisfaction Index (WRSI) Precipitation Estimates
 - FEWS NET at the USGS and National Oceanic and Atmospheric Administration (NOAA), since 1995
 - Supported by the University of Santa Barbara (California)
 - Dekadal rainfall at 10 km grid
- Both approaches lead to very similar results
 - WRSI was selected because a processing tool is supported on the internet
- Others

Examples of Weather Indices for Vulnerability Modeling – 1/2

Based only on meteorological parameters

Easy

■ Deficit rainfall, excess rainfall, Temperature deviation, etc.

■ **SPI - Standardized Precipitation Index**

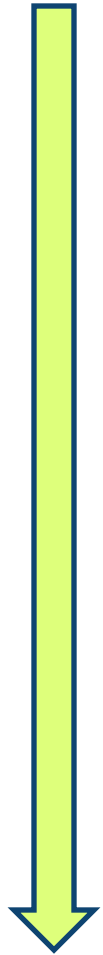
— A measure the temporal & geographical deviation from

- Average rainfall in the region
- Rainfall requirement for the crop considered
- Can be estimated within selected time periods

■ **WRSI – Water Requirement Satisfaction Index**

— Ratio of Actual ET to Potential (optimum) ET

- AET is calculated based on water balance (rainfall and soil moisture) – 10km grid every dekad
- PET is calculated as a function of temperature, humidity and wind speed.- 100km grid every dekad



More complex

Examples of Weather Indices for Vulnerability Modeling – 2/2

Based on meteorological and crop physical parameters (remote sensing)

Open ■ NDVI Normalized Difference Vegetation Index

- 
- $(\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$
 - NIR – Near Infra Red
 - Red large for stressed vegetation – NDVI close to zero
 - Red small for healthy vegetation – NDVI close to one

■ NPP (Net Primary Productivity)

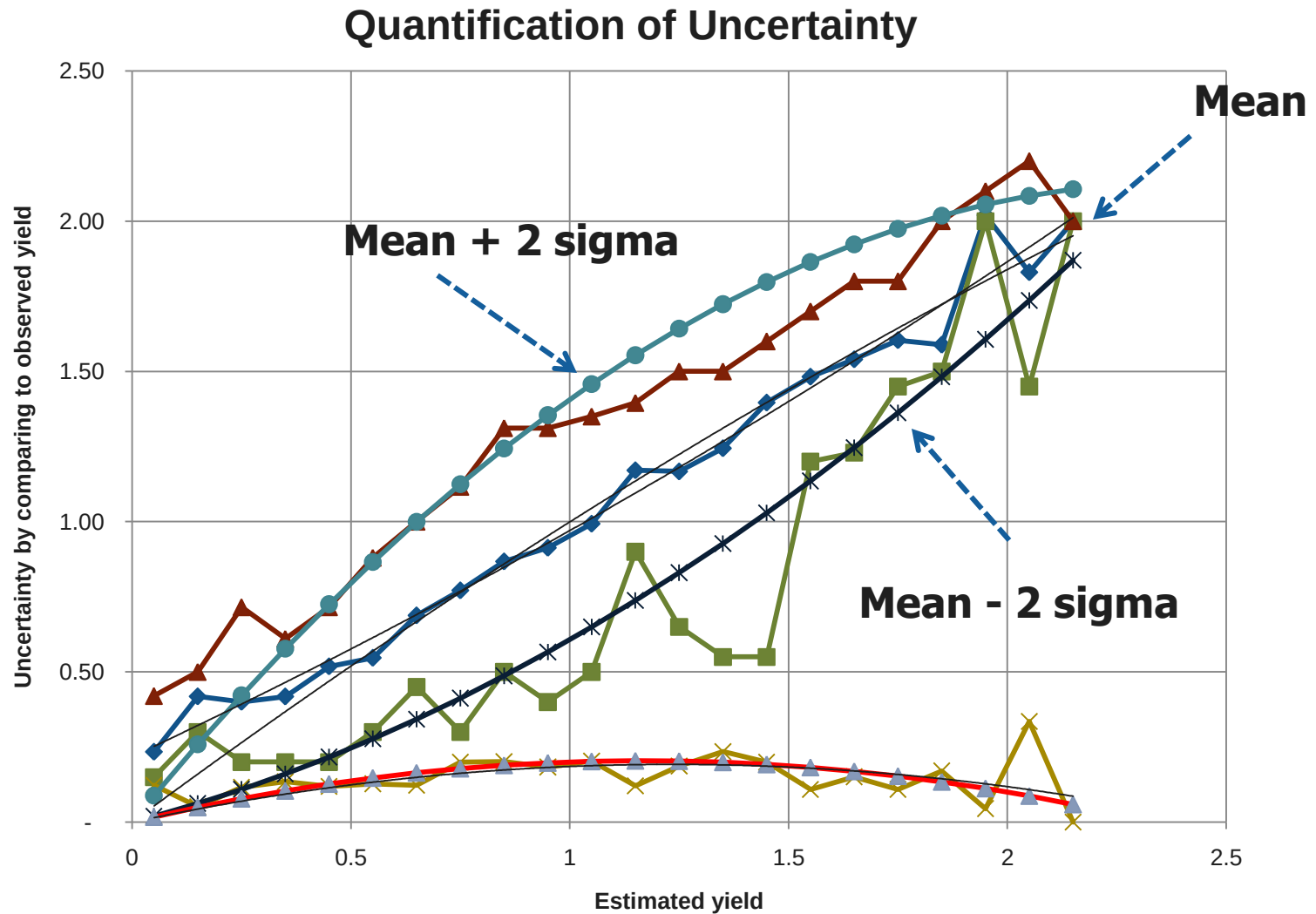
- Crop bio mass integration index (net carbon assimilation of a particular crop)
- Function of NDVI, temperature, radiation, etc

■ EARS

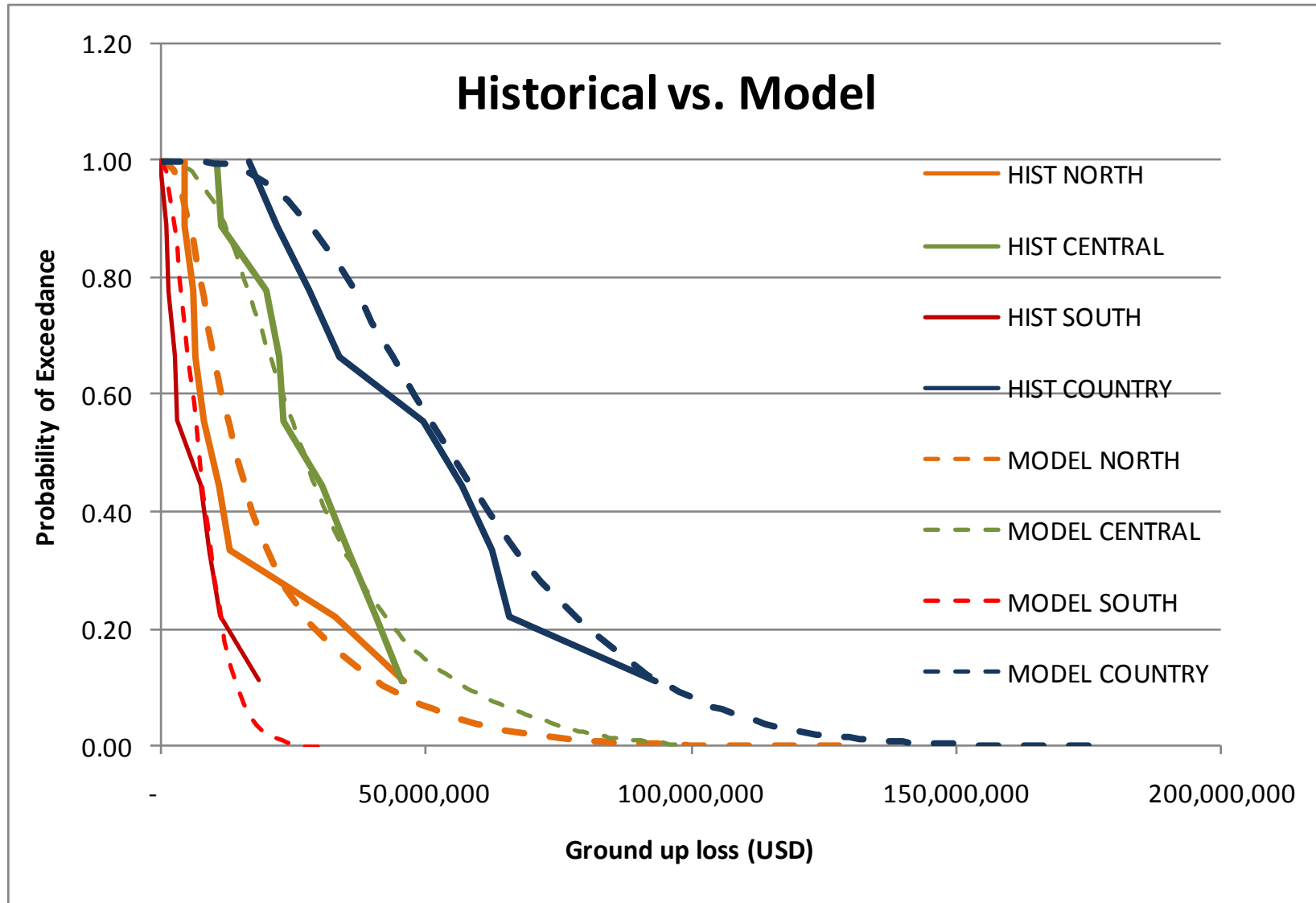
- Ratio of Actual ET to Potential (optimum) ET
 - AET is based on solar energy –
 - PET is a percentage of solar energy (80%)

Proprietary

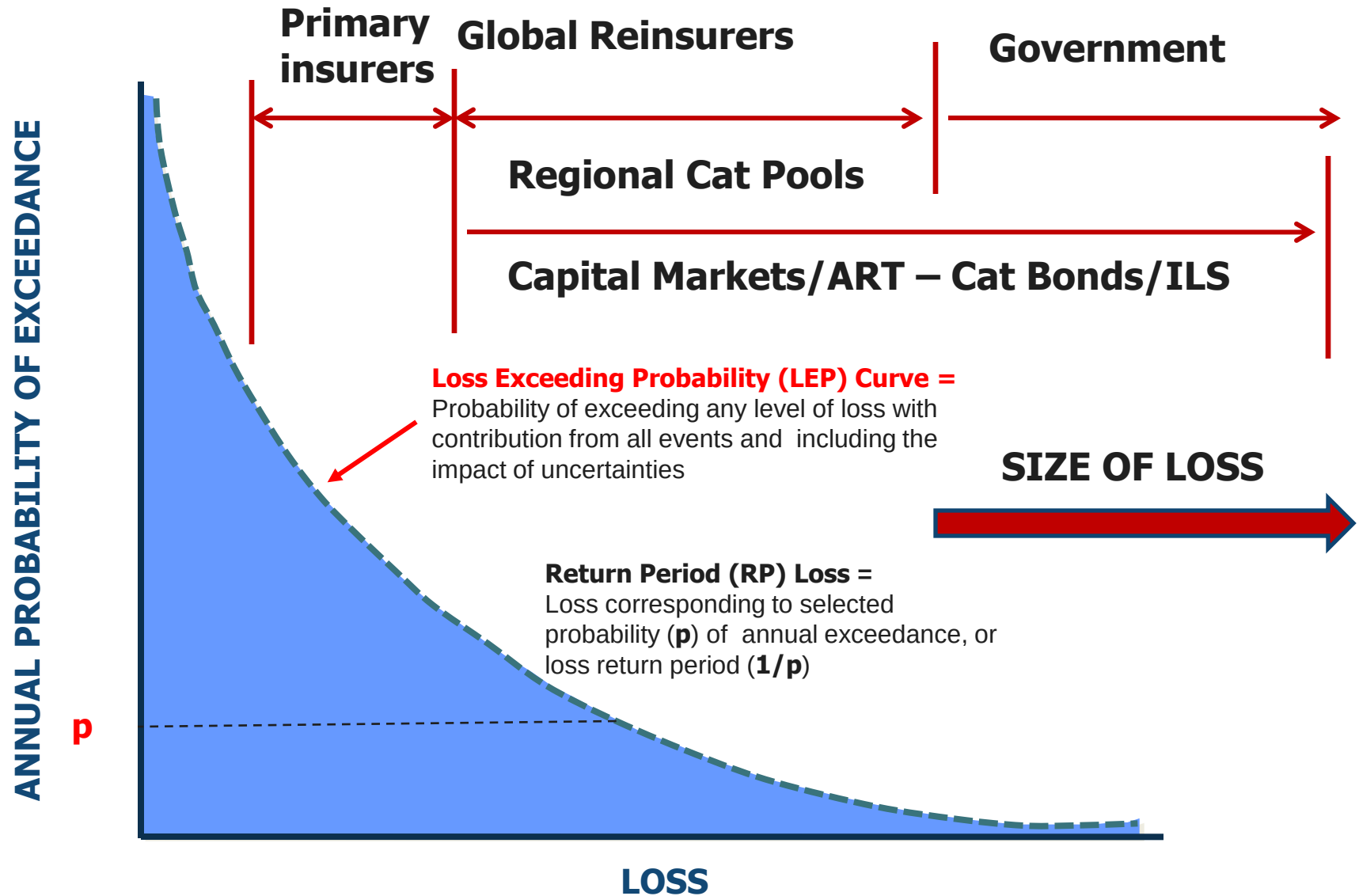
Quantification of Uncertainty



Mozambique Maize Country Level Probability of GU Loss (Loss Curves)



Risk Transfer Layers



Risk Metrics

- Exceedance Probability Curve (LEP) provides information on the losses and their probabilities of being exceeded. It is a fundamental interface between catastrophe models and risk metrics
- Risk metrics derived from the LEP
 - Average Annual Loss (**AAL**) represents the yearly loss averaged over a long period of time
 - Standard Deviation of the annual loss (**STD**)
 - Probable Maximum Loss (**PML**) is the loss associated with an annual likelihood of occurrence (e.g. on-in-100 year)
 - Tail Conditional Expectation (**TCE**)
 - Excess Average Annual Loss (**XSAAL**) for reinsurance programs
- The Key Issues: Uncertainty and Basis Risk

Other Considerations

- Impacts of climate changes (spatial/temporal variability) on weather patterns agro ecosystem productivity
- Use of crop physiology and climate concepts to understand the constraints and errors affecting indices
- Use of state-of-the art techniques (satellite imagery / remote sensing / numerical crop forecasting modeling / integrated approaches) to improve design of weather indices and reduce basis risk
 - Calibration with local ground truthing
- Basis Risk:
 - Farmer level (will I get paid if a loss and how much?)
 - Village, district, province, etc.
 - Primary Insurance
 - Reinsurance



Types of Insurance Products

Traditional Indemnity Based Crop Insurance

- Named Peril
- Multi-Peril
- Area Yield Index

Parametric/Index Insurance

- Index
- Imagery (e.g. NDVI)
- Other Indices

Hybrid ?

- Parametric/Index at low resolution
- Indemnity at higher resolution
- Use of new technologies to reduce the costs of claims settlement and administration
- Trade off : reduced bases risk vs. costs

Moving Forward

- Weather index based insurance still in progress (research to applications)
- Currently more suitable for aggregate applications
 - More efforts needed to reduce the basis risk
- Risk quantification for microinsurance is not a “micro modeling” exercise
 - Data issues
 - Combination of traditional approaches and new technologies
 - Investigative and evidence based approaches selection
 - Increased complexity of hybrid solutions for risk pricing and risk management requires most robust modeling approaches.

THANK YOU !