Vulnerabilities to climate change in the agriculture sector

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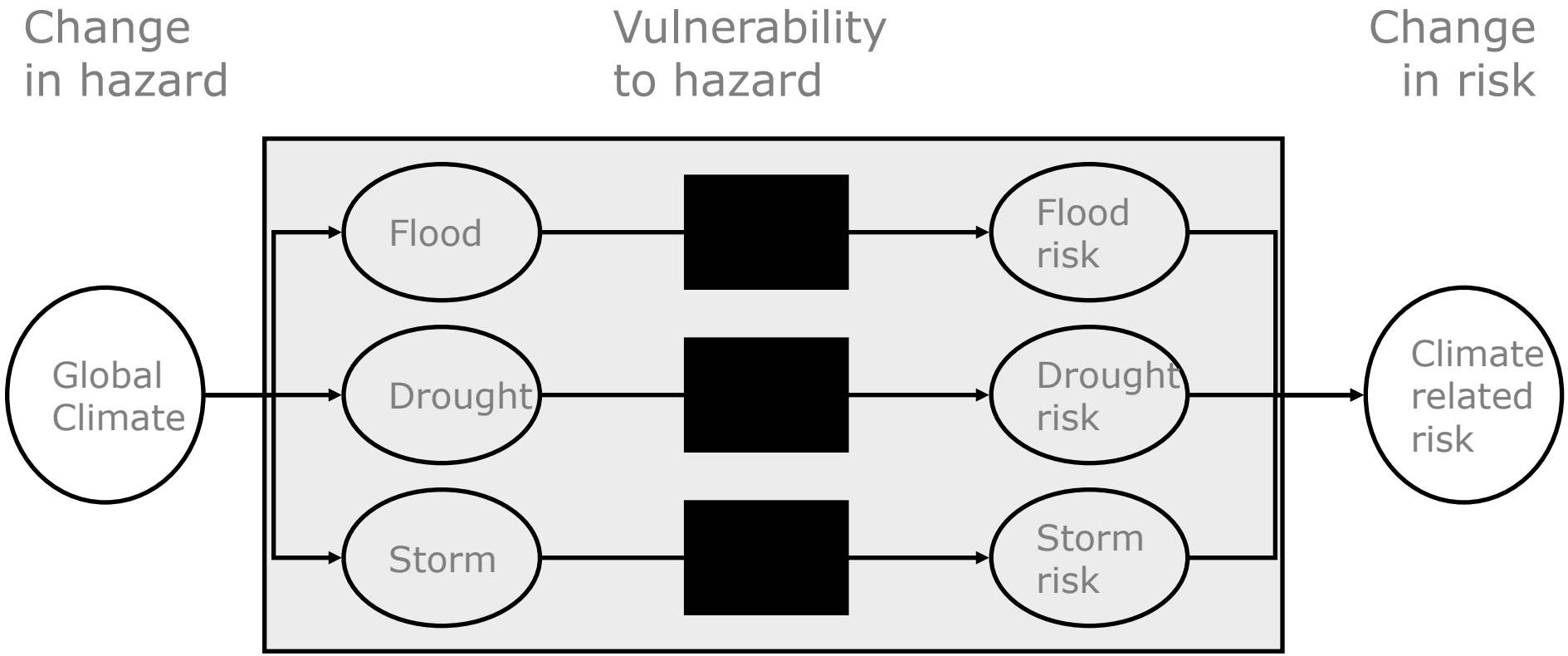
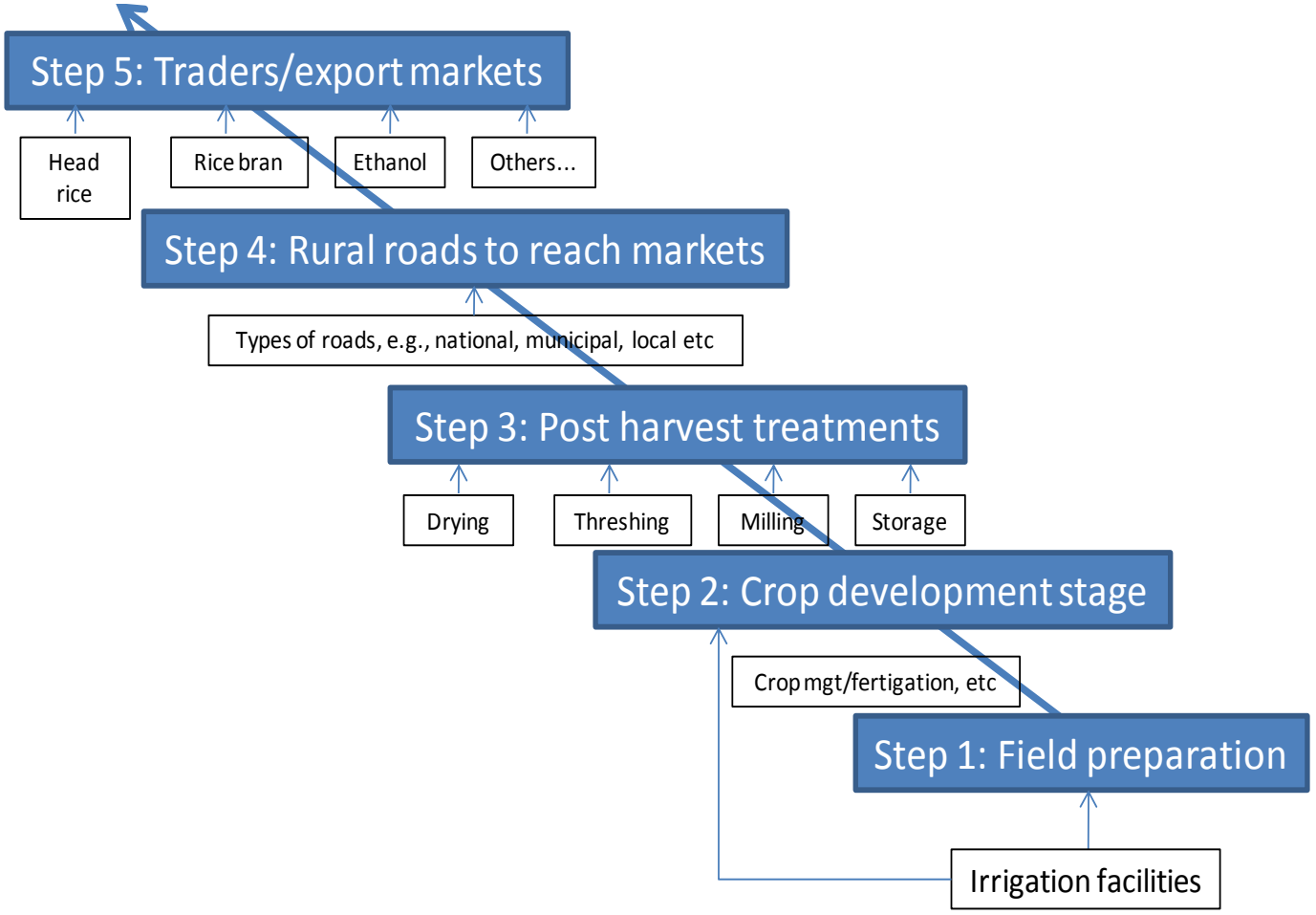
What does "Vulnerability to Climate Change" mean?



ADAPTATION KNOWLEDGE PLATFORM

Elements of Agriculture Sector Value Chain



Source: RMSI, 2008

Understanding the problem

Trends

Hotter, drier summers

Milder, wetter winters

Greater proportion of rain in heavy downpours

Sea level rise

Events

Heat waves

Droughts

Floods

Fewer cold snaps

Storms

Impacts

Damage to physical assets

Loss of access to agri. facilities

Effects on biological/ industrial processes

Changing commodity prices/ availability

Damage to critical infrastructure

Changing lifestyles and consumer tastes

Uncomfortable indoor environment

Consequences

Loss of business continuity

Changing raw material, repair, maintenance, insurance costs

Increased/ decreased productivity

Changing markets

Effect on reputation

Health/ comfort implications for employees

Understanding Climate Vulnerabilities for Agriculture

- **Vulnerability**
  - **Heuristic approach**
    - **Climate indices**
    - **Critical threshold**
    - **Risk indices**
  - **A process based deterministic approach**
    - **A case study from India**
- **From impacts to future risk**
  - **Probabilistic approach – reference case study from Philippines**
    - **Vulnerability to risk (loss) quantification**
- **Key messages**
  - **Recommendations**

Heuristically developed metrics using stakeholder consultations

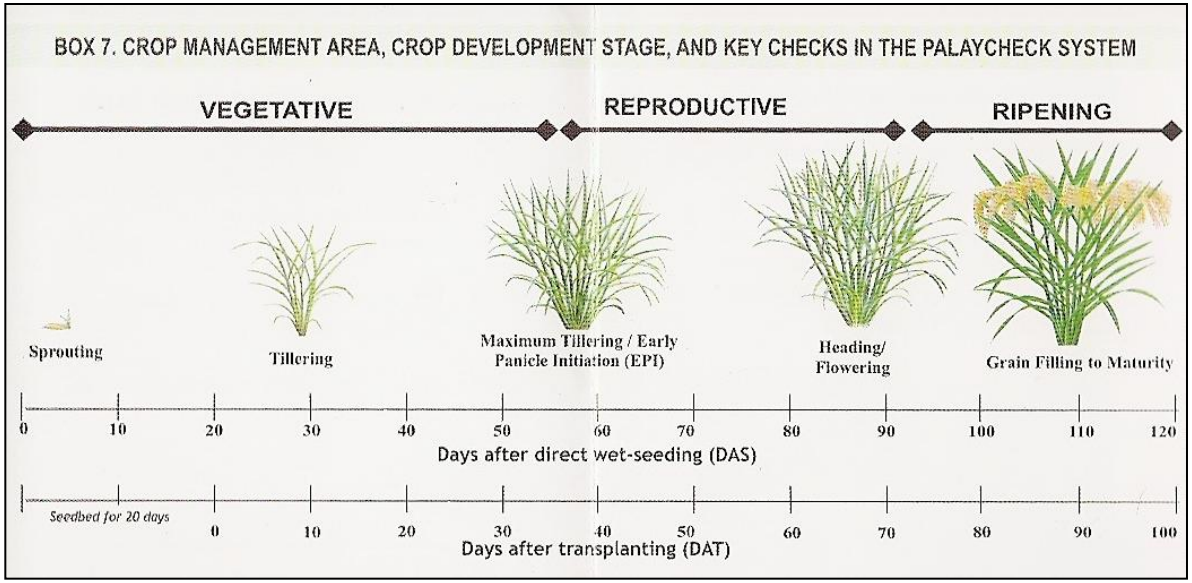
Categories	Vulnerability Criteria	Indices
Biophysical Indicators	Exposure	Climate
		Soil
		Crop calender
		Water storage
		Biomass/Production
Socio-Economic Data	Sensititivity	Crop insurance programs
		Trade flow
		% Agriculture sector in subsistence (e.g. heath, education)
		% Agriculture sector in poverty and inequality, (e.g. wages)
Agricultural System Characteristics	Adaptive Capacity	Technological change
		% Arable land currently in use
		% Rainfed crops/Irrigated crops
Climate Mitigation Programs	Risk Reduction	Kyoto commitment capacity
		Carbon sequestration potential; CDM projects in place, planned

Source: Cynthia Rosenzweig, et al

Design climate indices for rainfed rice

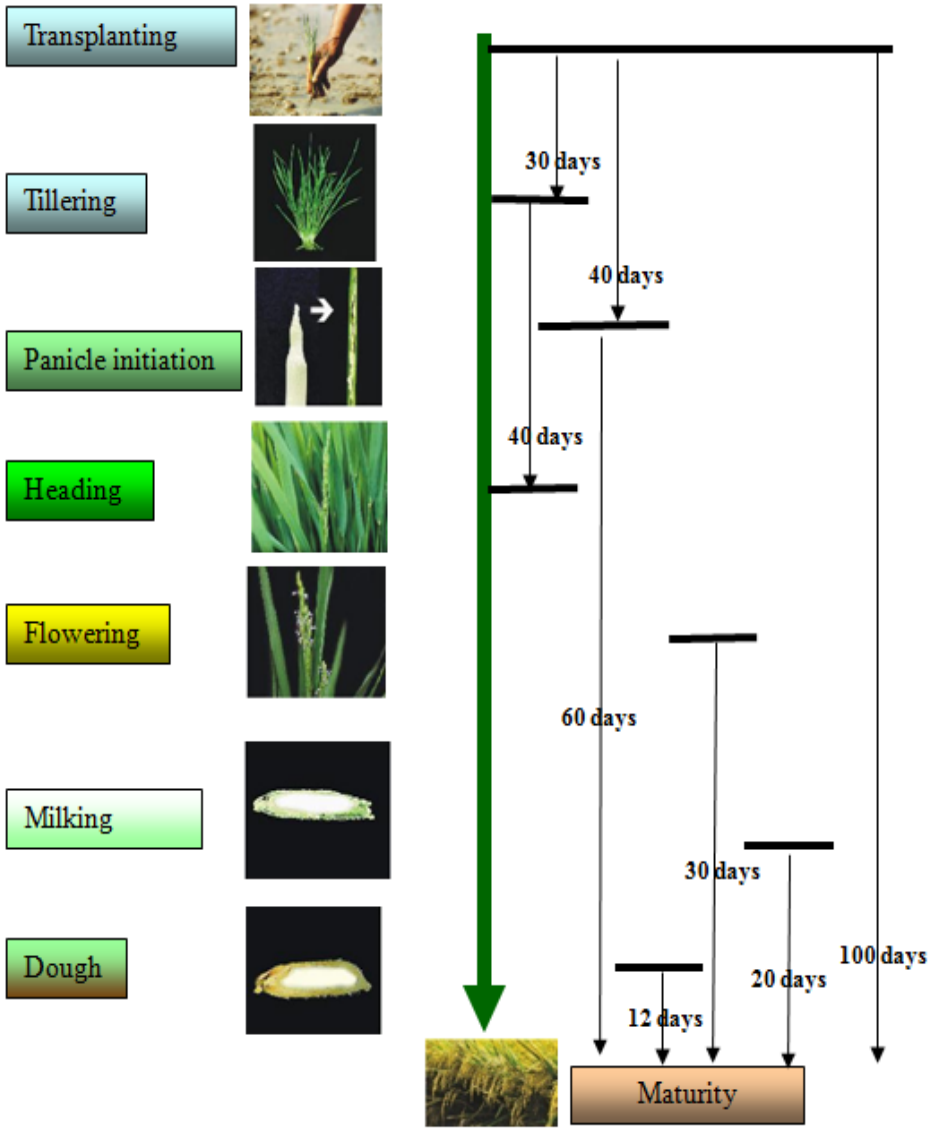
Climate indices related to farming practice and crop phenology:

- Assume planting when rainfall exceeds a certain threshold
- Calculate rainfall and temperature characteristics for the 3 different crop growth stages (vegetative, reproductive, ripening)
- Calculate the net water to the soil at different crop stages



Source: PhilRice, 2007

Critical threshold and Risk indices



Source: http://www.knowledgebank.irri.org/growthStages/

Drought matrix table (Source: DA, GoP)

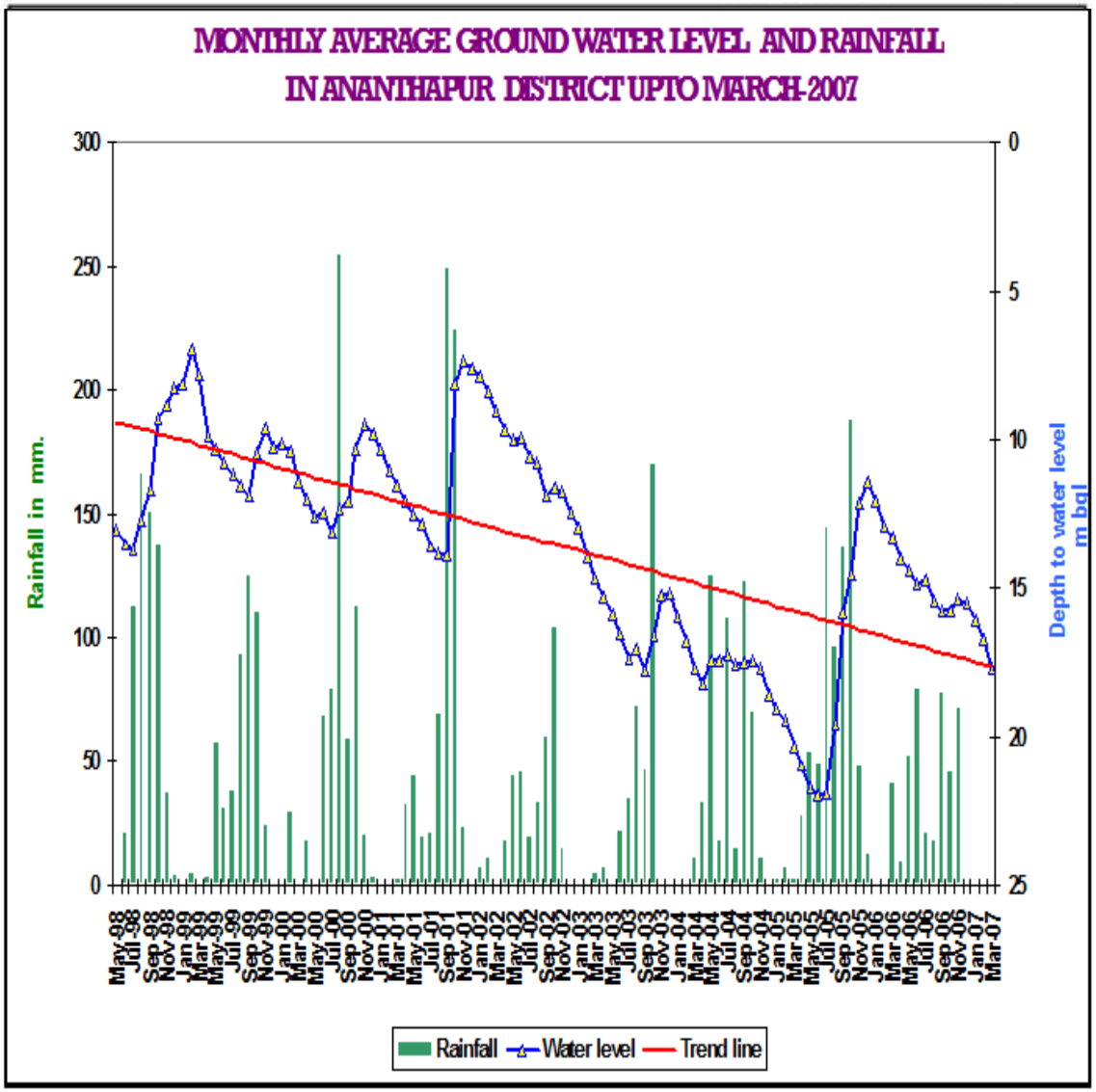
No.	Period of stress	% yield loss
1	Transplanting to maximum tillering (early vegetative stage)	40 – 50
2	Transplanting to panicle initiation (early vegetative to reproductive stage)	60 – 75
3	Transplanting to heading (early vegetative to reproductive stage)	65 – 70
4	Max. tillering to heading (max. vegetative to reproductive stage)	45 – 50
5	Panicle initiation to maturity (reproductive to maturity stage)	60 – 100
6	Booting to maturity (reproductive to maturity stage)	60 – 100
7	Flowering to maturity (reproductive to maturity stage)	60 – 100
8	Milking to maturity (late reproductive to maturity stage)	45 – 60
9	Soft/hard dough to maturity (maturity stage)	10 or less
10	Transplanting to maturity (min. tillering to maturity stage)	95 – 100

Limitation: DA table does not highlight the effect of multiple incidences of water stress and consequent losses in rice yields

Case Study: Drought Prone Andhra Pradesh in India

Background:

- 5th largest state in terms of both geography and population
- State falls under arid part of Indian peninsula
- Drought is a recurring threat
- Surface water are limited
- Groundwater extraction is high
- Water availability is binding constraints on farming systems



Source: World Bank, 2009

Objective and Approach

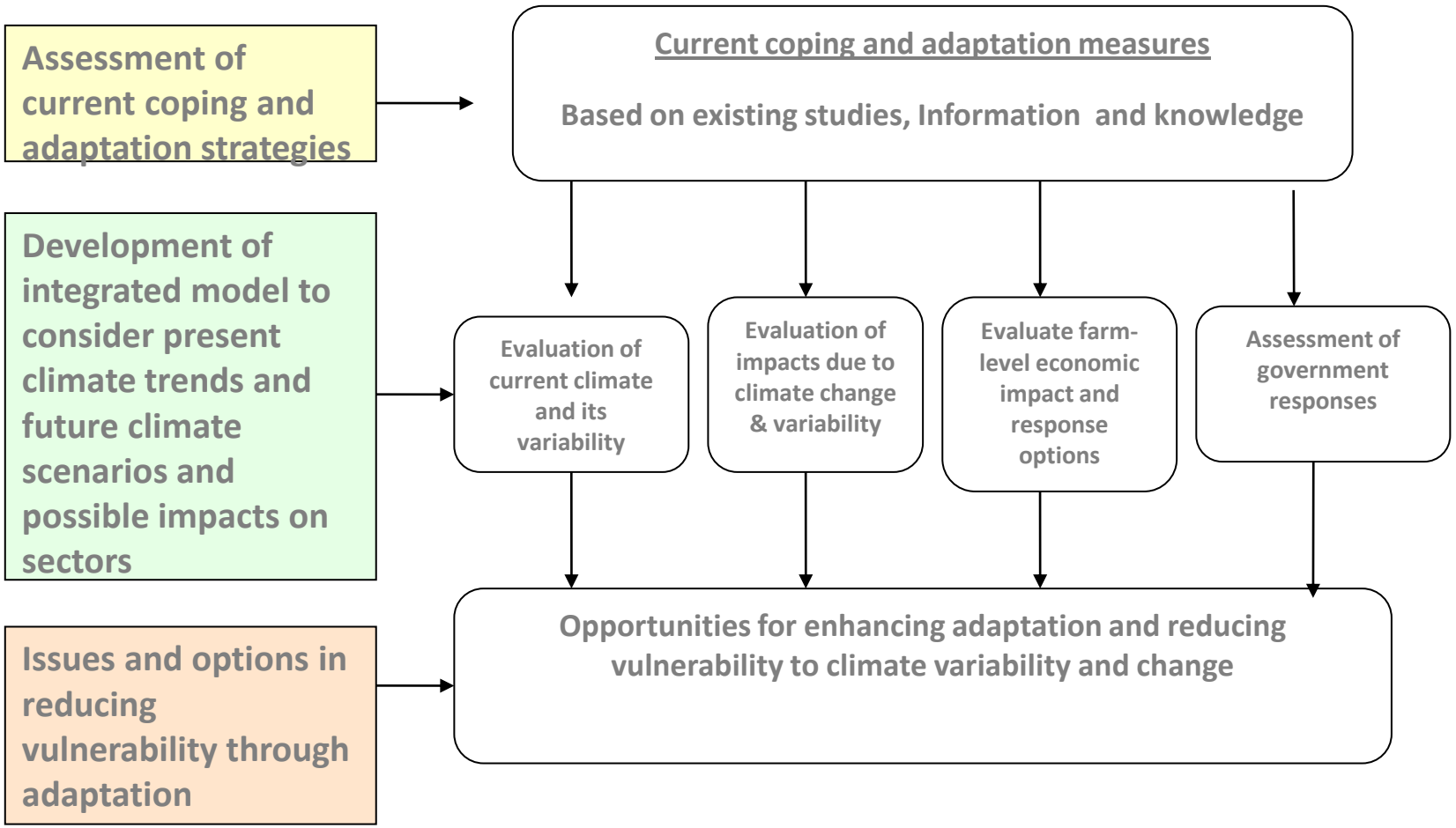
Objective:

Mainstream climate risk management into development policy through a bottom up approach

Approach:

- To generate information and understand current coping and CRM strategies in response to droughts
- To understand government responses and their effectiveness
- To develop and demonstrate the climate modelling framework for future risks
- To use this knowledge to assist adaptation plan that can help improve adaptive capacity

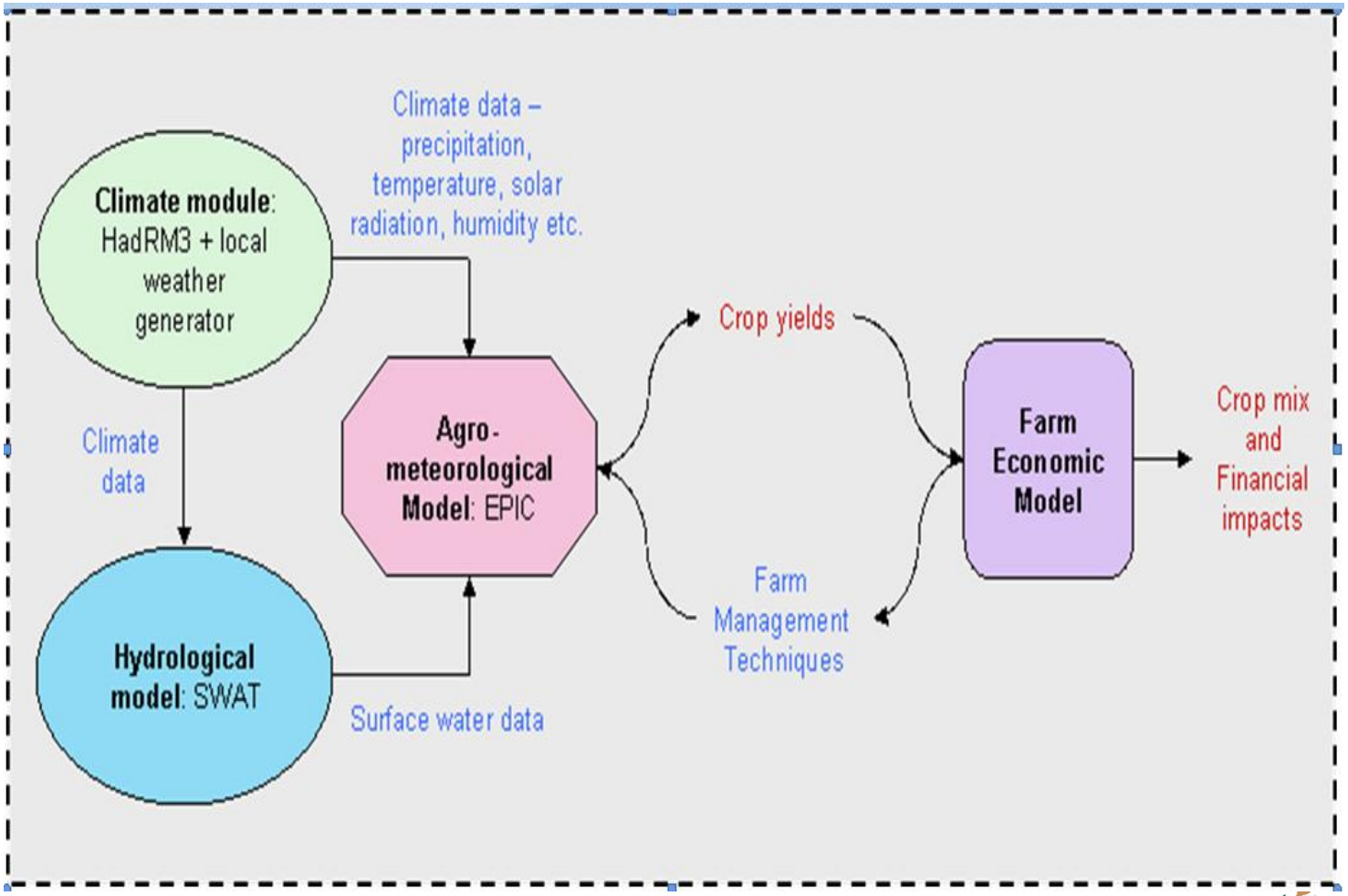
Study Framework



Source: World Bank, 2009

Process: Methodology for Climate Impact Analysis

- Learning from the past and Present
- Looking to the future



Source: World Bank, 2009

Anatomy of the Sample Villages

Income

- Average monthly income ranges from Rs 2686 to 1731

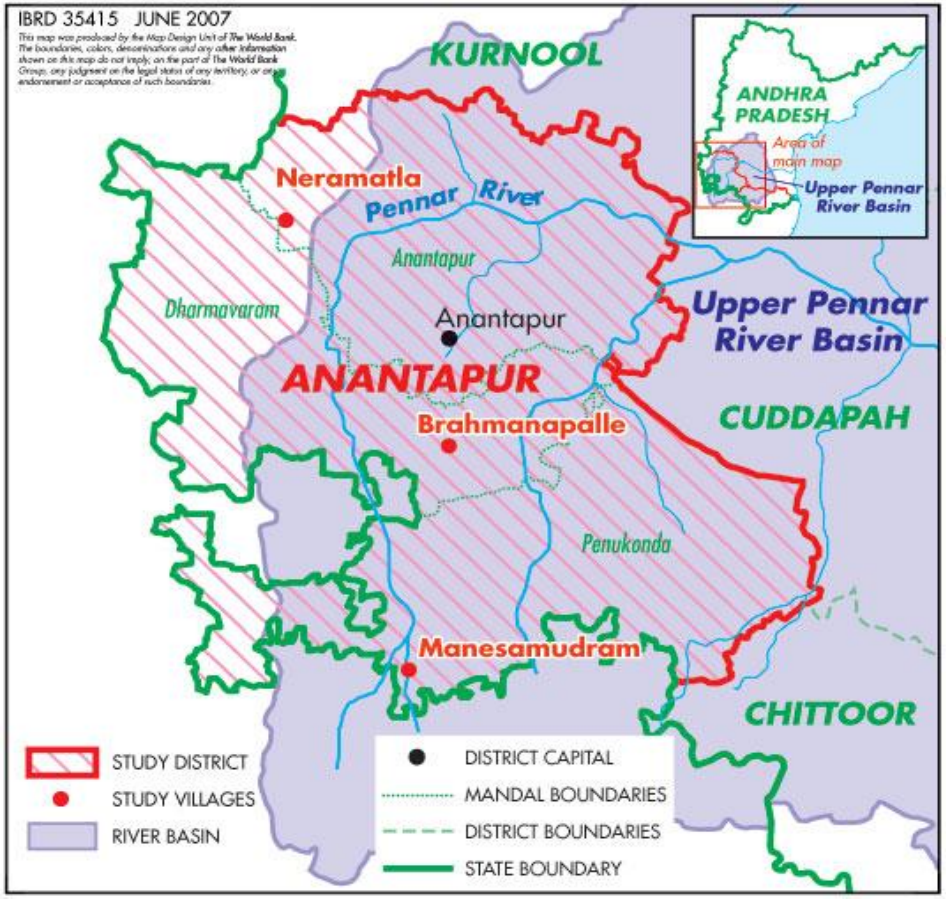
Definition of household:

- Large: >= 5 Ha of land size
- Medium: >= 3.5 Ha of land
- Marginal <=2 Ha of land
- Landless

High Dependence on agriculture:

- Large and medium obtain 86% of income from farming
- Small and landless farmers has almost no asset – forced into wage employment

Study Villages in Ananthpur district



Source: World Bank, 2009

Socioeconomic Profile of Study Villages

Table: Socioeconomic Profile of Sampled Households by Landholding Size

Landholding size (% of total households)	Ownership of utility assets (%)	Ownership of productive assets (%)	Mean normal monthly income (Rs)	Years of schooling	Access to health facility (%)
Large (14%)	48	59	4,550	10	23
Medium (48%)	33	22	2,428	10	27
Marginal (8%)	24	7	1,479	9	19
Landless (30%)	16	0	1,092	7	10

Table: Average Share of Sources of Income in Total Income in Sampled Households

	Agricultural income			Nonagricultural income				
	Cultiv.	Agric. labor	Total	Nonagric. labor	Petty business	Dairy	Remits.	Total
Large	82	4	86	12	1	1	1	14[a]
Medium	63	24	87	10	1	1	1	13
Marginal	39	34	73	18	5	1	3	27
Landless	0	74	74	20	4	0	2	26

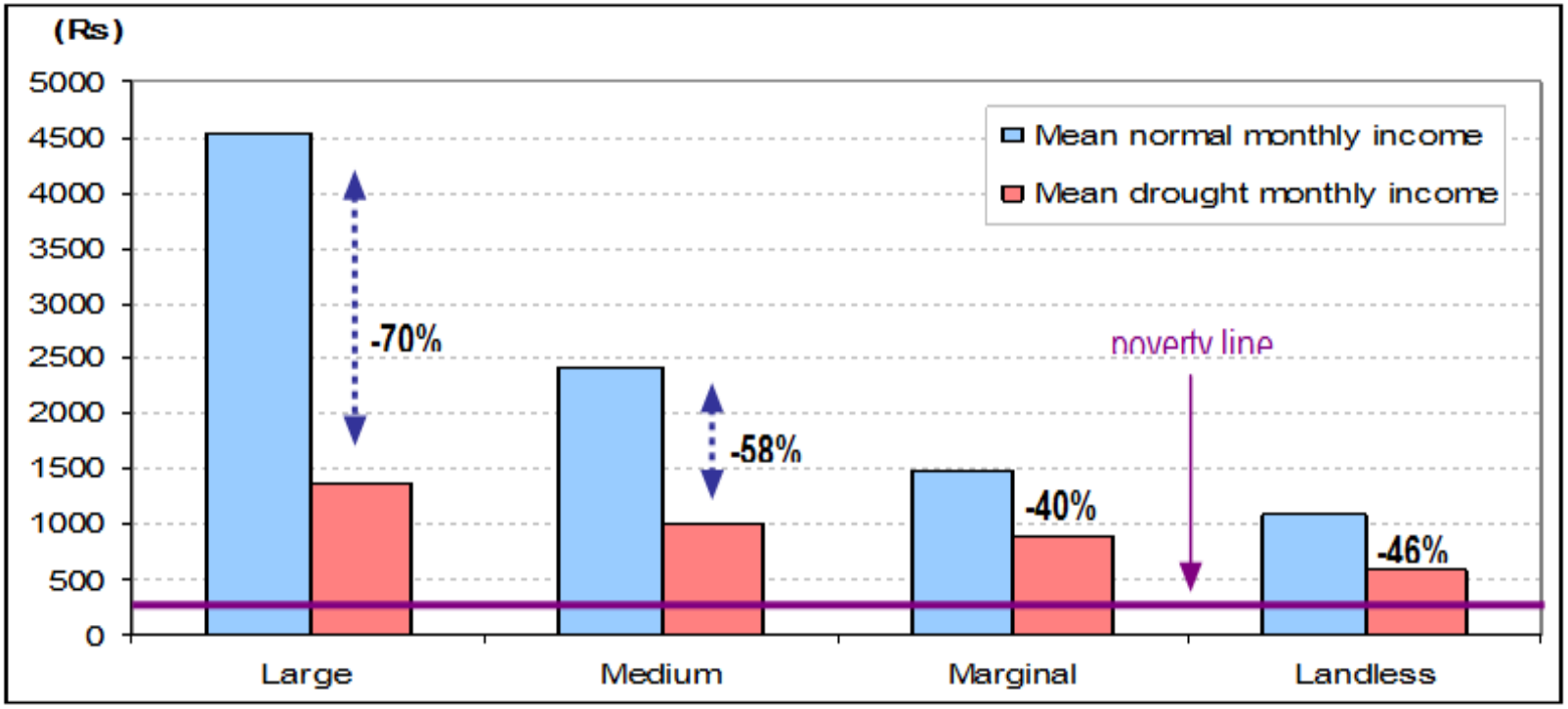
a. Discrepancy in total is due to rounding off of percentages.

Source: World Bank calculations based on TERI survey data.

Source: World Bank, 2009

Impact of Drought on Households: Current Coping Options

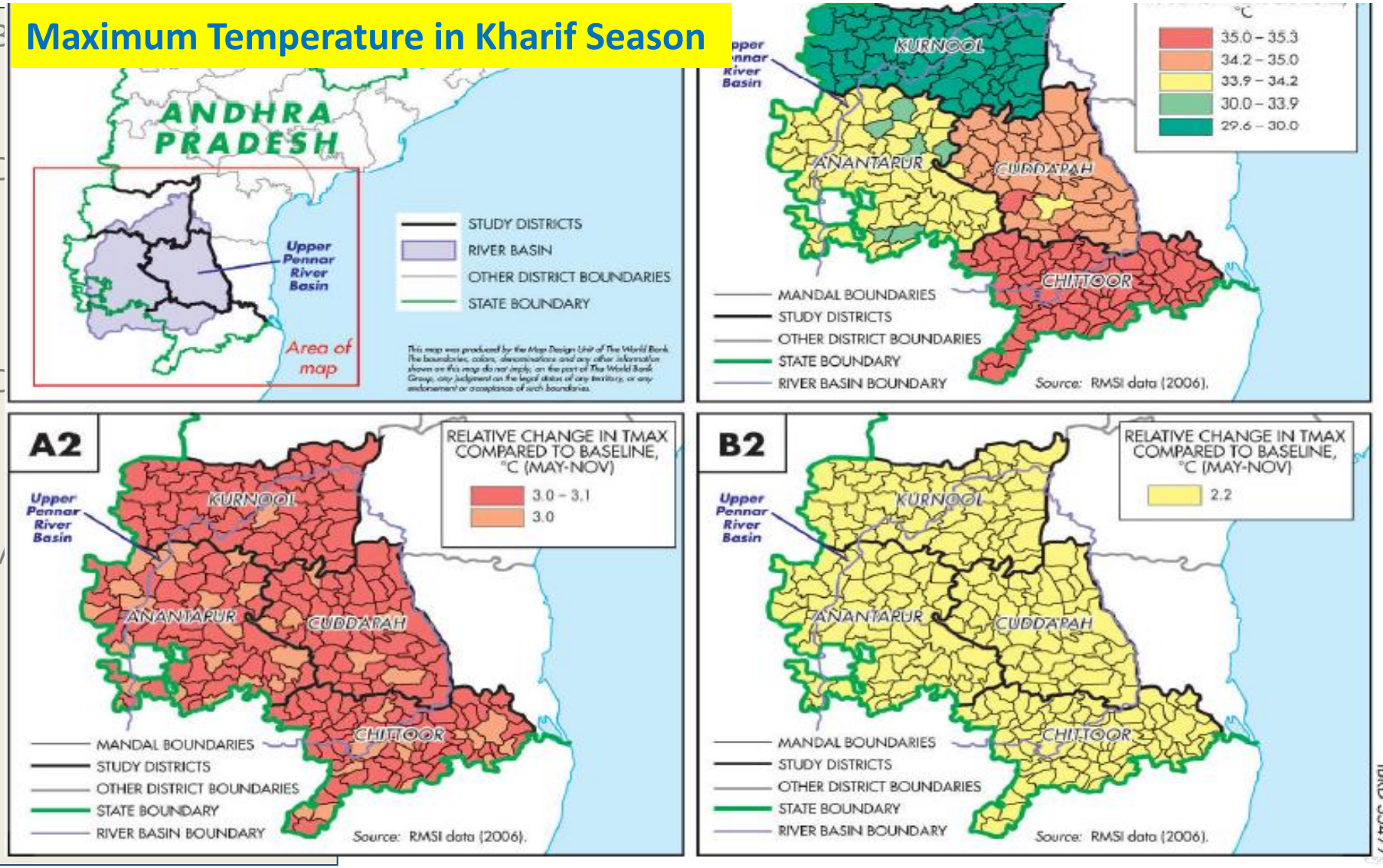
Figure: Impact of Drought on Income



Source: World Bank, 2009; Drought year 2002-03 and Normal year 2003-04

Future Prospects under Climate Change

Maximum Temperature in Kharif Season



Source: World Bank, 2009

Crop Response to Climate Change

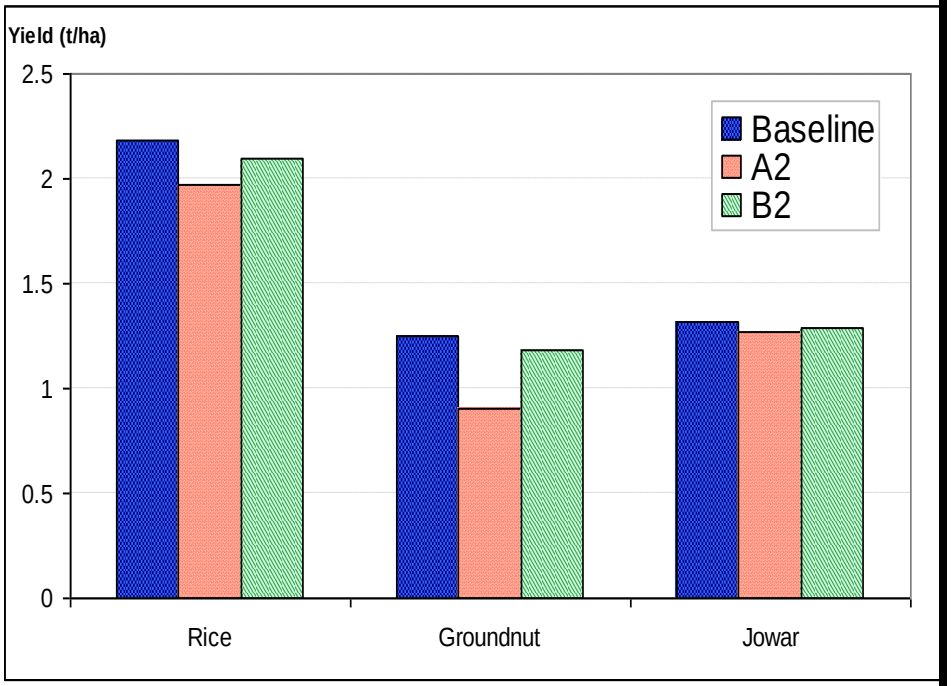
Focus:

- Three major crops – 70% of total outputs
- Jowar and Groundnut are dryland crops whereas rice is a subsistence crop

Results:

- Changes in the level and distribution of rainfall
- Groundnut yields fall in A2 by 28% and in B2 by 6%
- Jowar exhibits resilience - 4% decline in A2 and 2% in B2
- Rice yield declines by 10% and 4% in A2 and B2

Yields of Rice, Groundnut and Jowar under Climate Change Scenarios



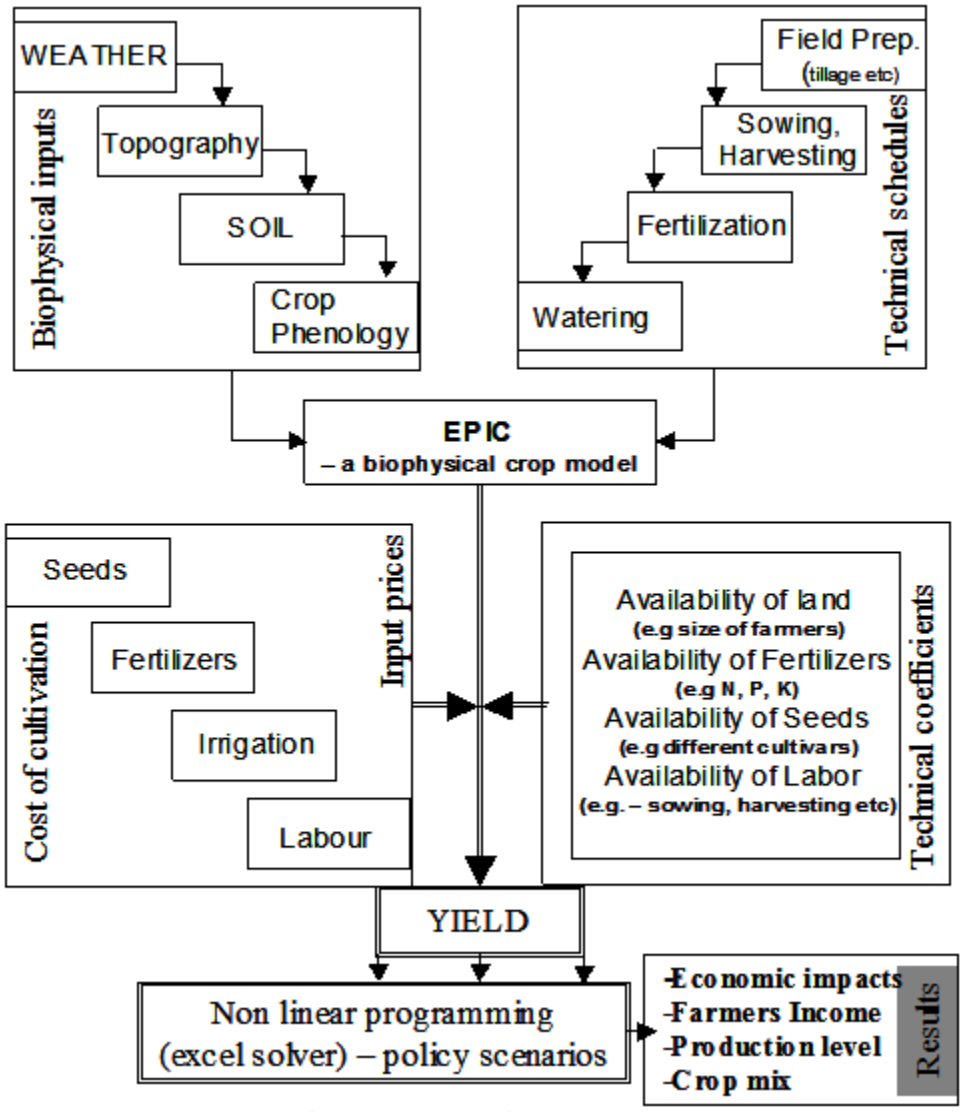
Evaluation of Farm Economic Impact Options

Will Crop Response to Climate Change influence

- Farm incomes?
- Crop Choices? and
- Farm management regimes?

To answer these questions the economic model compares and estimates

- The baseline, A2, B2
- Cropping mix options based on farm size, returns, with climatic events and water avail.
- Prices used (as in 2007)



Source: RMSI, 2008

Economic Assessment: Baseline Comparisons

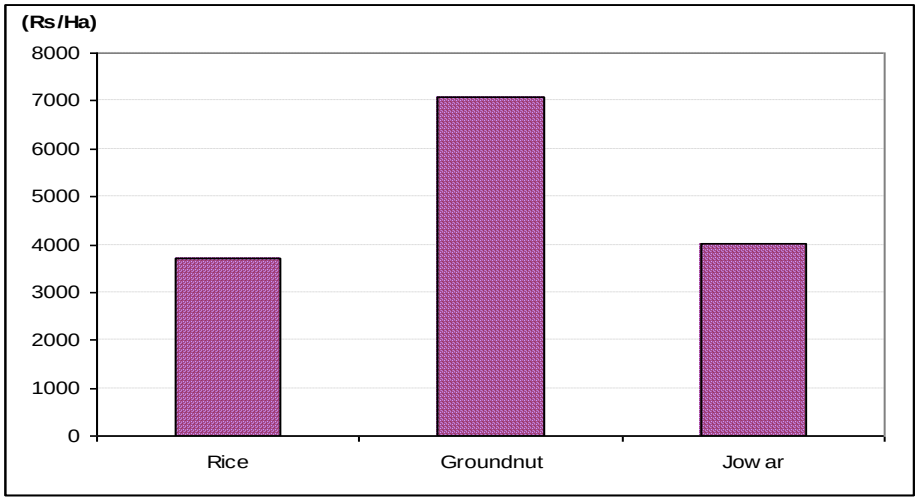
Per Ha Baseline Comparisons

- Groundnut dominates on average profitability followed by jowar and rice crop
- Profits from each crop reflect a) the yield; b) the price of the crop and) the production costs

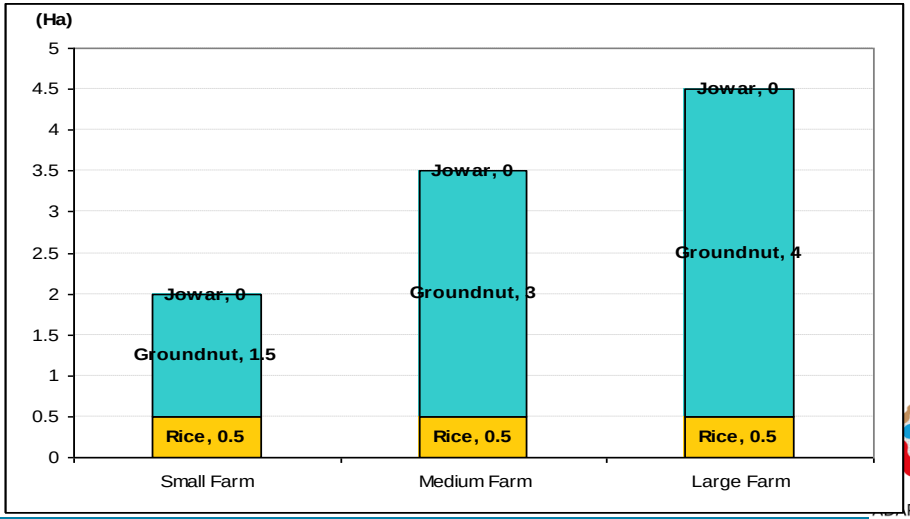
Area in Baseline Predicts

- Cropping mix options based on farm size, returns, MSP, with climatic events and water avail.
- Prices used (as in 2007)

Per Hectare Average Profits in Baseline Scenario



Area Allocation in Baseline Scenario, Ananthpur



Source: World Bank, 2009

Projected Impacts of Climate Change Scenarios

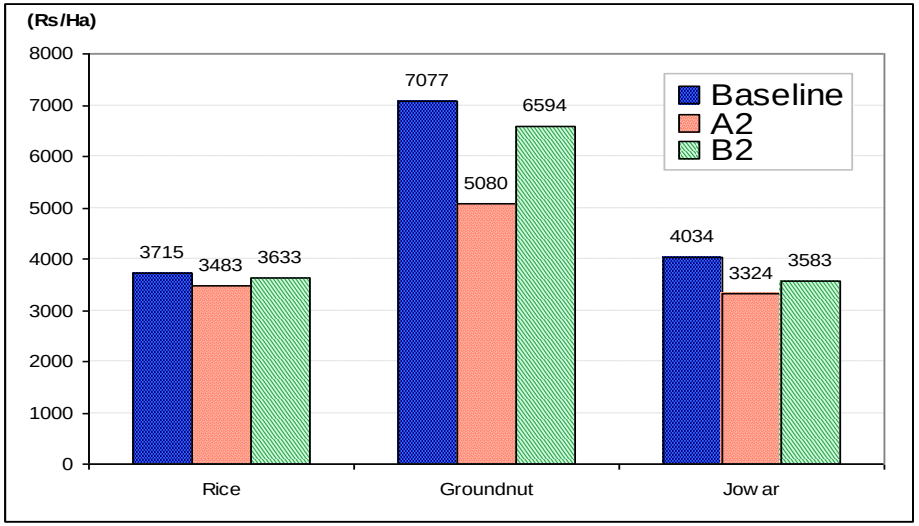
Per Hectare Profits

- With all else equals under climate change scenarios : groundnut remains the most profitable crop
- Therefore, there is no change in planting mix between the three crops

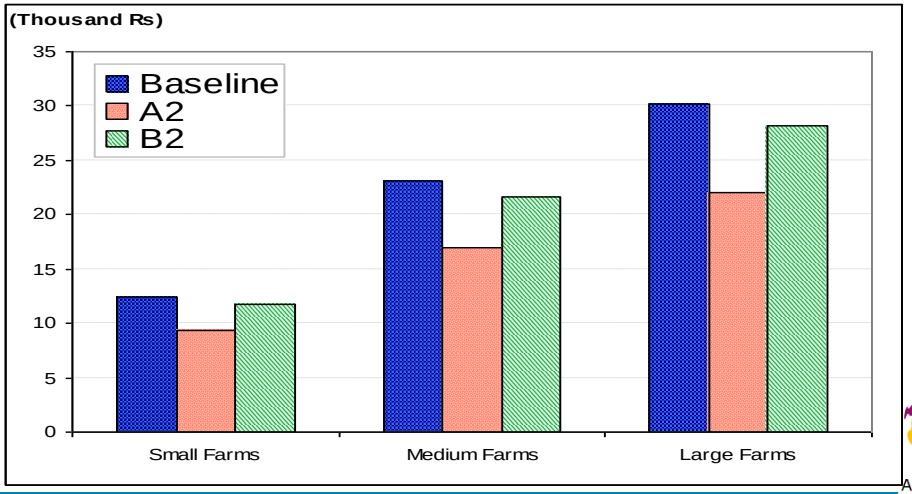
Total Profits

- With declining average yield – overall profitability declines
- Greatest reduction in A2 ~ 20%; B2 ~ 5%
- With returns falling down - income of small farmers are not enough to sustain

Per Hectare Average Profits in CC Scenario



Total Profits in CC Scenario, Ananthpur

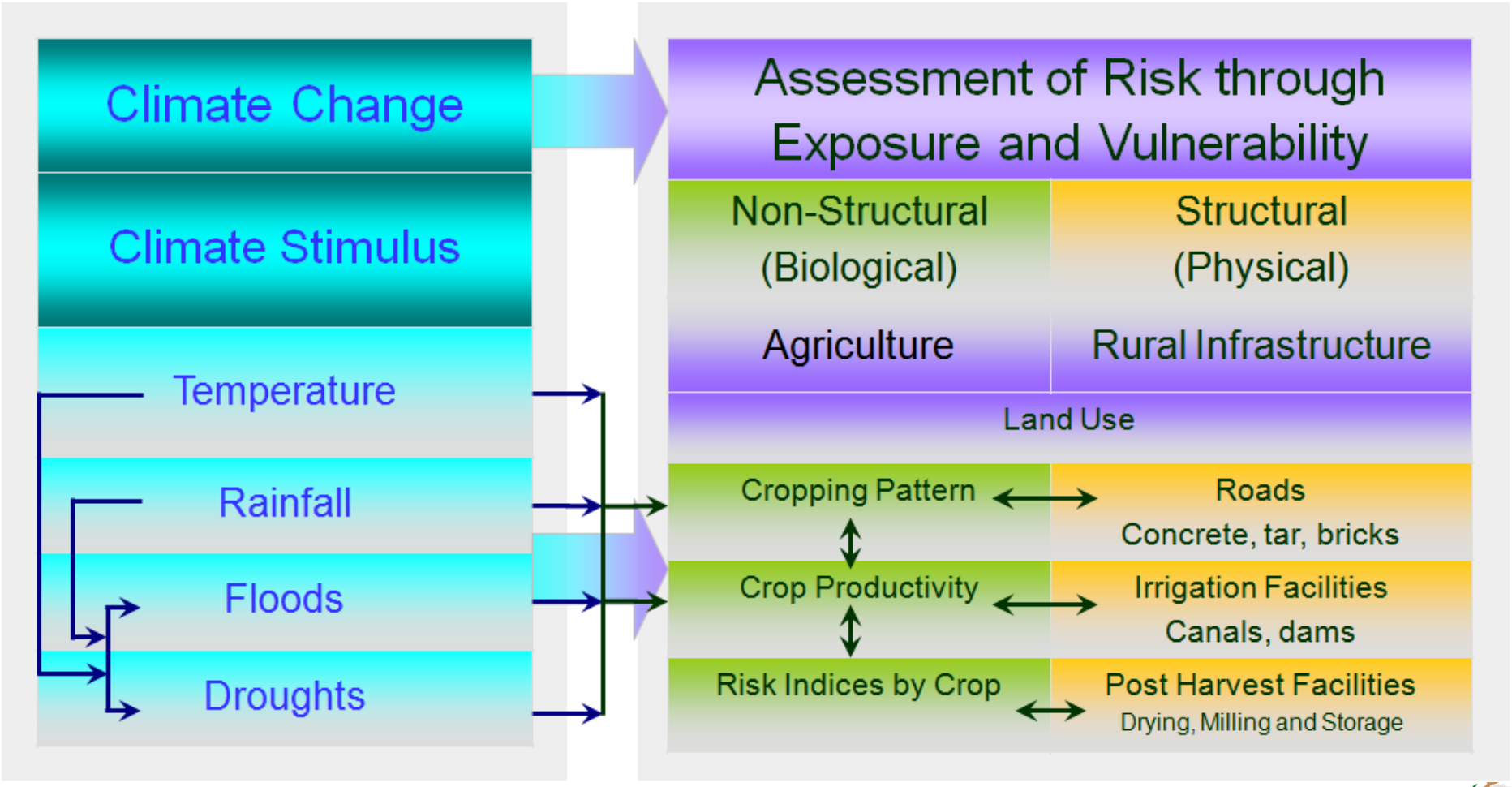


Source: World Bank, 2009

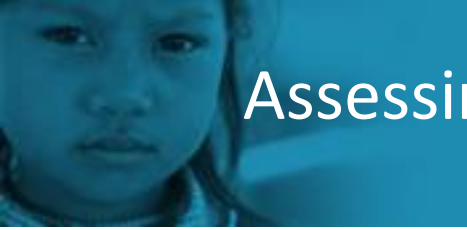
Pulling Together the Pieces: Policy Implications

- **Innovation and Reforms in Agriculture**
  - Water conversation and management
  - Agriculture diversification
  - Smart subsidies and incentives
- **Information on Vulnerabilities and Risks to Build Adaptive Capacity and Resilience**
  - Tools are needed to identify area facing increased risks to build synergies with existing program and communities
  - Diagnostic tools are needed to assess economic life of long-terms infrastructure investments against climate risks
- **Financial and Economic Instruments**
  - Debt Relief to Facilitate Income Diversification
  - Weather Indexed Insurance: Challenge and Opportunity (An illustration)
- **Institutional Needs and Priorities**
  - Vertical and horizontal integration

Influence of CC on Agriculture Vulnerabilities



Source: RMSI, 2009



Assessing Impacts to the Rural Infrastructure Sector

- Climate Change Analysis
  - Historical analysis and changes
  - Future climate change and scenarios
  - Downscaling of climate data
- Risk Assessment
  - Development of probablistic risk model
  - Impacts of Climate Change on hydro-meteo risks and expected economic losses
  - Agriculture and rural infrastructure such as agri. production chain
- Address Adaptation issues such as
  - Status of todays rural infrastructure inventory
  - Evaluation of rural infrastructure in a longer term planning context
- Deliver a climate-resilient approach through
  - Ex: climate and drought/flood risk model

Disaggregating Risk

Economic Losses in Rural Areas due to Extreme Hydro-Meteorological Events

Simulate Hydro-meteorological Phenomena	Estimate Return Period and Extent of Events	Estimate Vulnerability of Rural and Agricultural Assets	Map Exposure of Agricultural Assets Categories	Compute Damages to Agricultural Assets
Stochastic Module	Hazard Module	Vulnerability Module	Exposure Module	Loss Module
Historical Observations of Floods, Streamflow, Precipitation, and Temperature.		Historical Losses, Crop Models, Field Experiments, Cropping Systems, Water Use, Engineering Data etc.	GIS data on cropping patterns, (non-) irrigated areas, land use, infrastructure etc.	Probabilistic Estimates of Potential Economic Losses

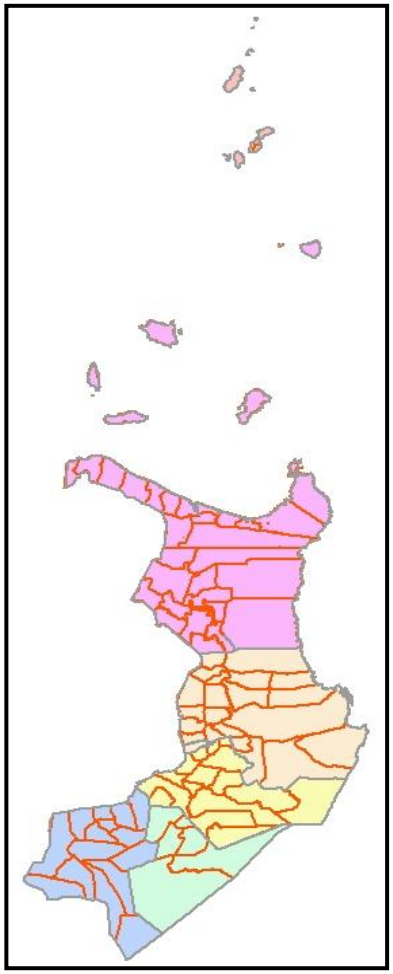
Source: RMSI, 2009

Resolution

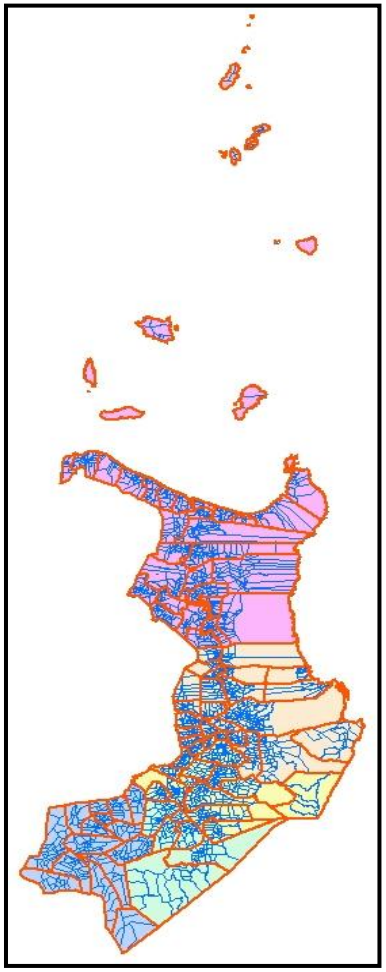
Philippines Provinces

- Batanes
- Cagayan
- Isabela Del Norte
- Isabela Del Sur
- Nueva Vizcaya
- Quirino

Philippines Provinces - 6
Area – 22269.5 sq. km.



Philippines Municipalities
Number of Municipalities - 93



Philippines Barangys
Number of Barangys - 2329

Source: RMSI, 2009

Risk Quantifier and Exposure

Drought - Event definition

- Probabilistic approach
  - Location, size, and rate

Exposure definition

- Location and value
  - Crop acreage and yield
  - Roads, irrigation and buildings replacement cost

Vulnerability

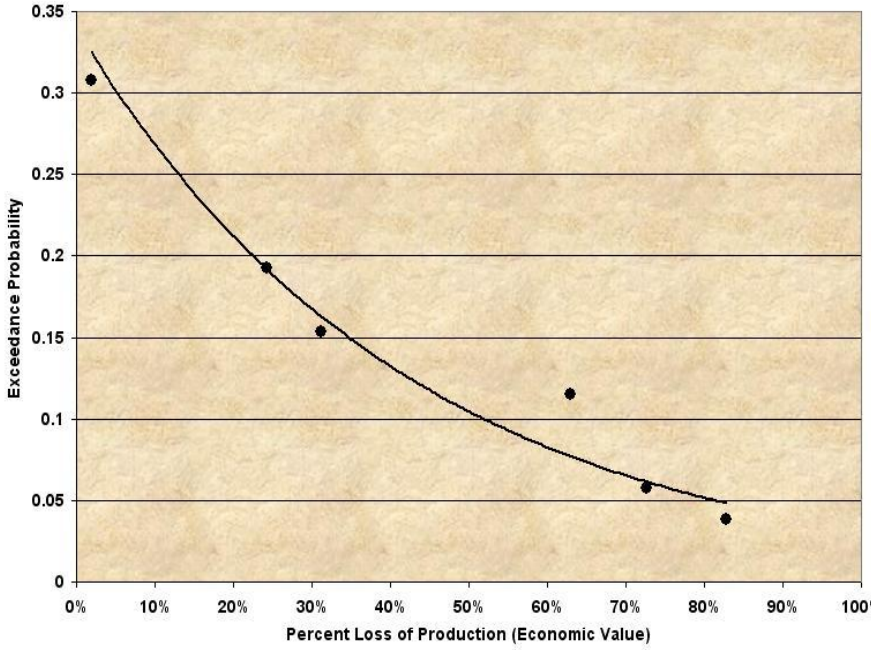
- Crop acreage and yield reduction
- Roads, irrigation canals and buildings repair cost (MDR)

Loss

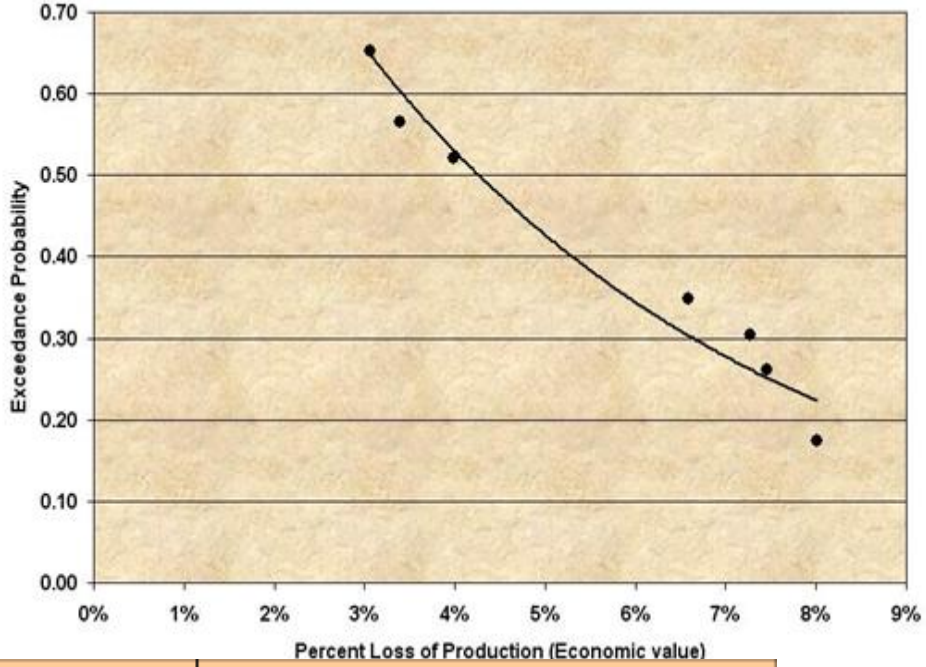
- Monetary quantification

Loss exceedance curves

Rain-fed crop wet season - Cagayan



Irrigated crop wet season - Isabella



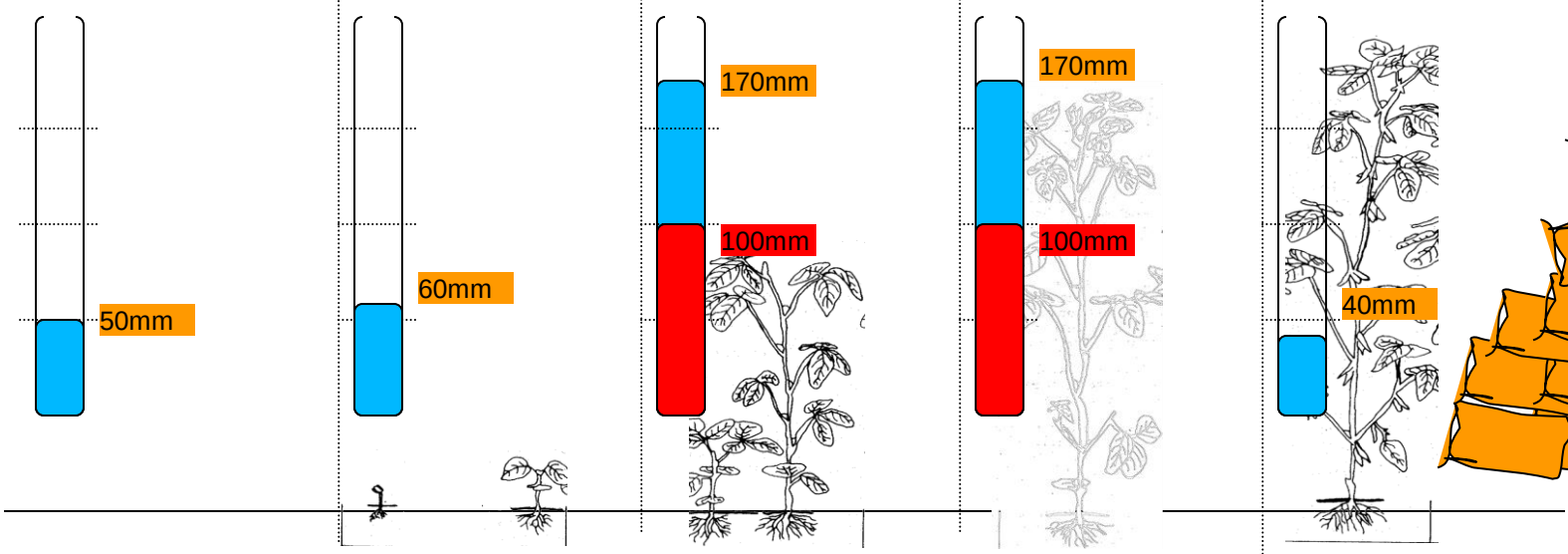
Return Period (Year)	Drought (Rain-fed crops)		Drought (Irrigated crops)	
	Production Loss (MT)	Loss in million pesos	Production Loss (MT)	Loss in million pesos
20	32,110	355	71,563	791
10	20,557	227	56,159	621
5	9,005	100	40.756	451
AAL	**1,903**	**21**	10,152	**112**

Source: RMSI, 2008

Risk Transfer Mechanism: Weather Insurance

Example: Deviation in rainfall and impact on yield

Stages	Presowing	Seedling	Vegetative	Reproductive	Maturity
Time	11-24Jun	25Jun-15Jul	16Jul-26Aug	27Aug-7Oct	8Oct-11Nov
	2 wks	3 wks	6 wks	6 wks	5.5 wks
Water requirement	40-50mm	50-60mm	150-170mm	160-170mm	40mm



Loss in yield

Output

(Source: ICICI Lombard)

Key Recommendations

- Phenophase-based vulnerability assessment
  - Existing damage matrices need to be upgraded to phenophase (crop stage) based matrices
- Modeling framework/tools can be utilized and ported to other areas with following modifications
  - Data base
  - Model base
  - Knowledge base
- Examine effectiveness of wide range of policy interventions
  - Changes in MSP
  - Resource optimization
  - Weather Index Insurance
- Sufficient data are needed to perform fully deterministic and probabilistic risk analysis for drought, flood and cyclones
  - Such an approach should be followed in any further analysis
  - Stochastic set of events for hydro-meto perils should be generated to create a unbiased picture of the risk

Thank you!!

Email: Satya.Priya@rrcap.unep.org

Working closely with national & regional partners to develop and implement programme of activities

Secretariat

AdaptationKnowledgePlatform

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