Role of Earth Observation in Crop Risk Assessment

A Perspective on drought hazard assessment using EO inputs, risk management strategies and crop insurance

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Indo US workshop on
Small Satellite and Sensor Technology
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March 31, 2014

Risk Associated with Agricultural Production System

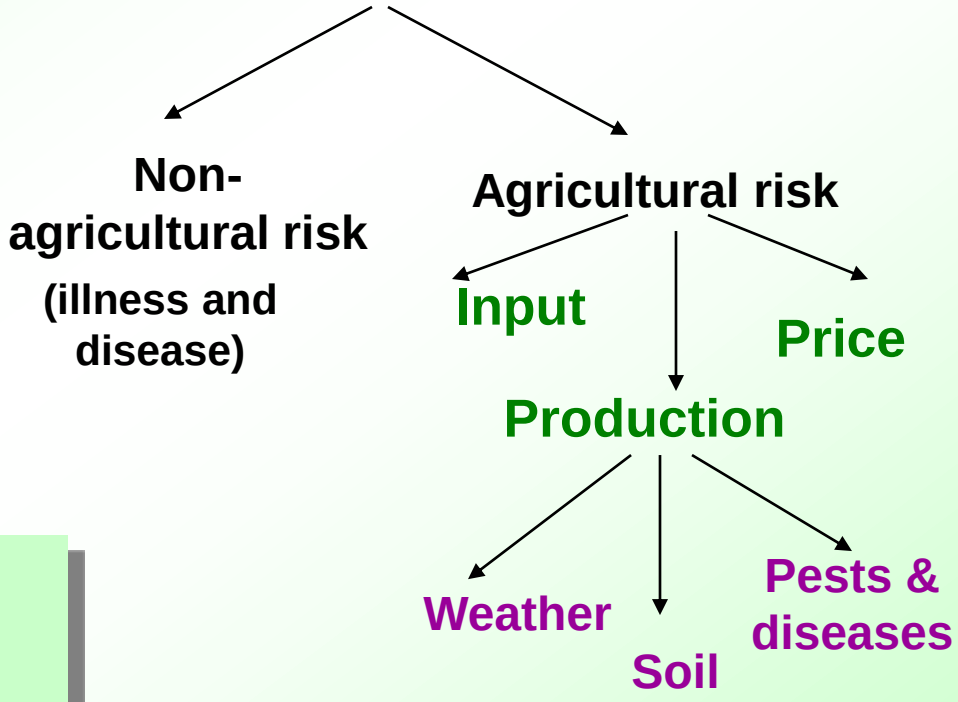
Climatic risks: **drought, flooding, hard rains, hail, frost, snow, hard freeze, or wind, Climate Change**

Environmental risks: **damage to land from soil erosion and to flora and fauna and from pest and disease attacks**

Social and economic risks:
Social problems, family Illness, infrastructure failure

Political risks: **Community resettlement (for example, dam resettlement schemes), conflict/war; and political redistribution of land.**

Farm household risk



Risk Associated in Rainfed Production System

Rainfed areas – characterized by:

***Loss sustained by individual farmers due to*:**

- **loss of yield, harder credit terms for next season, price inflation, loss of livestock**
- **affects credit repayment**
- **lack of credit disrupts next season's agricultural cycle**

Financial institutions :

- **face risk of catastrophic defaults**
- **inability to lend in that area in the following season - affects credit off-take**

Micro-credit contributes greater share of investment in agriculture, especially by small and marginal farmers..

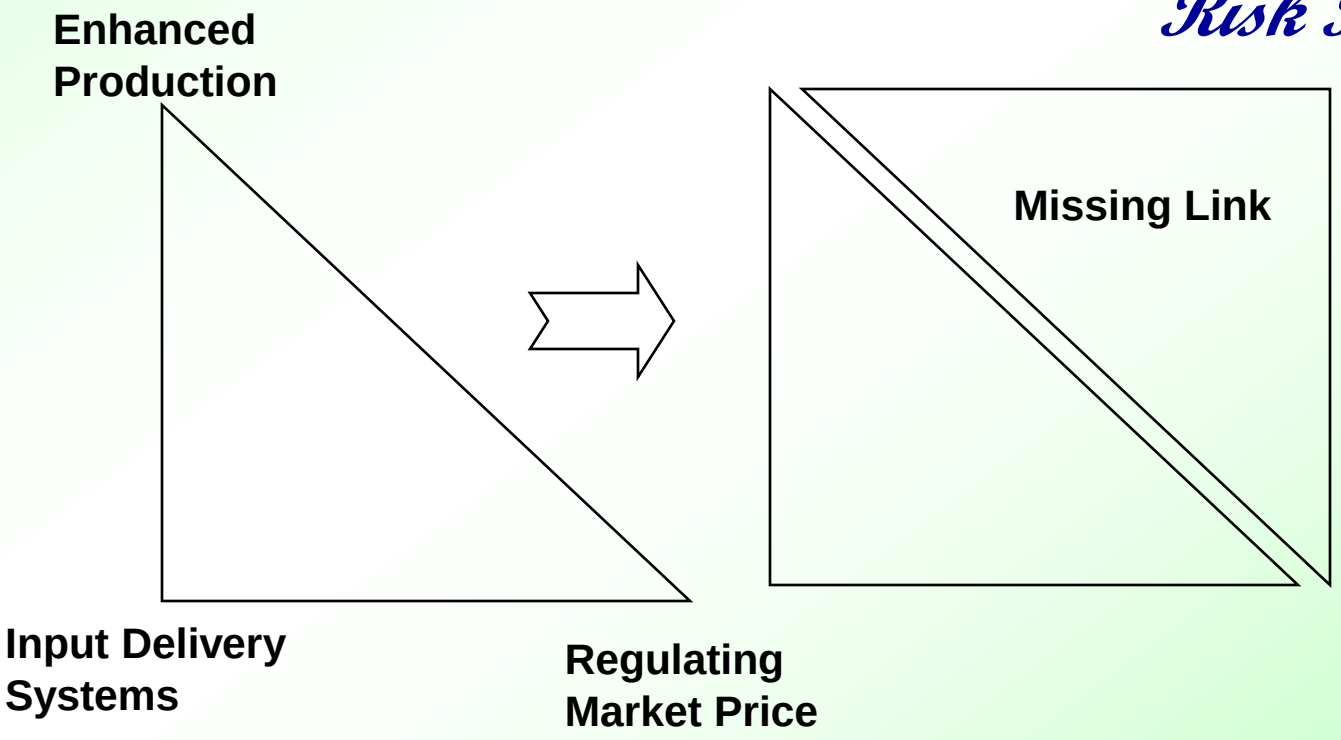
Missing Link..

Safety Nets, Drought-prone Area Programme, Employment Assurance …

Hazard	⟷	Vulnerability
Natural event		Social factors

Hazard + Vulnerability = Risk

Risk Reduction



Risk Reduction: Approaches

Information gathering:
- Collecting and using information available
- Early warning

Avoiding risks:
- Adopting a precautionary stance
- Less risky technologies

Diversification:
- Diversifying production systems.
- Acting with flexibility to adjust to changed circumstances

Sharing of risk:
- Insurance
- Risk pooling in formal or informal arrangements
- Contract marketing and futures trading mechanisms

Risk Management Strategy

Relief & Rehabilitation
- Ad hoc, Reactive Approach
- Calamity Relief Fund
- Emergency Management

Mitigation
- End to end strategy (complete matrix of intervention)
- Community based Hazard proofing

Risk Financing
- Agricultural insurance – subsidy based
- Risk management – Business Model

Drought Vulnerability

- Large Tract of Arid & Semi-arid land
- Increased frequency & severity of drought in recent years
- Severe impact on Food & Agriculture Sector
- Marginalise the poor farming community

- Rainfall Variation accounts for
  - ➢Agriculture yield - 70%
  - ➢Cotton - 90%
  - ➢Groundnut - 47%
  - ➢Barley & Jowar - 45%
- Proportion of yield losses
  - ➢Drought/low rainfall - 70%
  - ➢Flood/excess rainfall - 20%
  - ➢Others - 10%

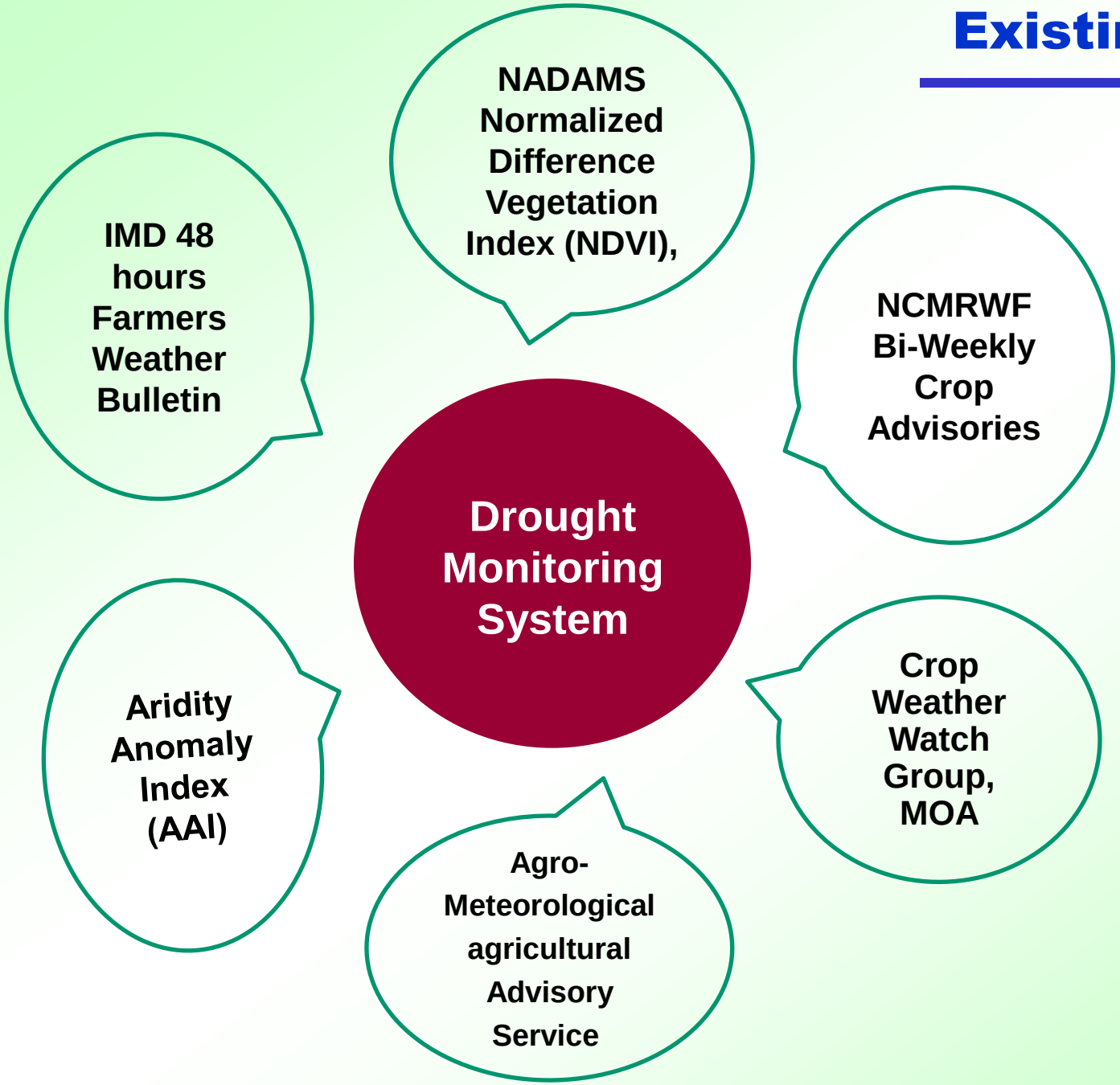
Rainfall Risk

- **Onset of monsoon date variable**: Median - June 1, Mean - May 30, Standard deviation - 9 days
- **Variation of monthly rainfall**: South excluding west coast cv - 60 to 100% during July and August
- **Breaks during the monsoon :** 1888 to 2007 > 60 breaks in July & August

Need to understand scientific basis of genesis & dynamics of drought

Build wherewithal for early warning, monitoring & managing drought

Existing System



Drought Risk and Agriculture in Karnataka

- Karnataka, the number of small and marginal land holdings increasing - resulting the highly vulnerable to drought
- Land holdings of 1.45 and 0.48 hectares for small and marginal farmers
- Karnataka over the past 43 years (1960 - 61 to 2002 - 03) - had a rainfall deficit an average of 1 out of every 4.3 years. Rainfall deficits occurred in 12 out of the 43 years during Kharif season (the main cropping season, June to October), and in 21 out of the 43 years during Rabi season.
- Even during the good rainfall years, at least 25 percent of the taluks [district subdivisions] in the state are affected by uneven distribution of rainfall.
- Crop yields are affected not only by cumulative seasonal rainfall but also by the duration and timing of the rain and duration.

Drought Risk Assessment: A Case Study

Study area:

- **Gulbarga District**

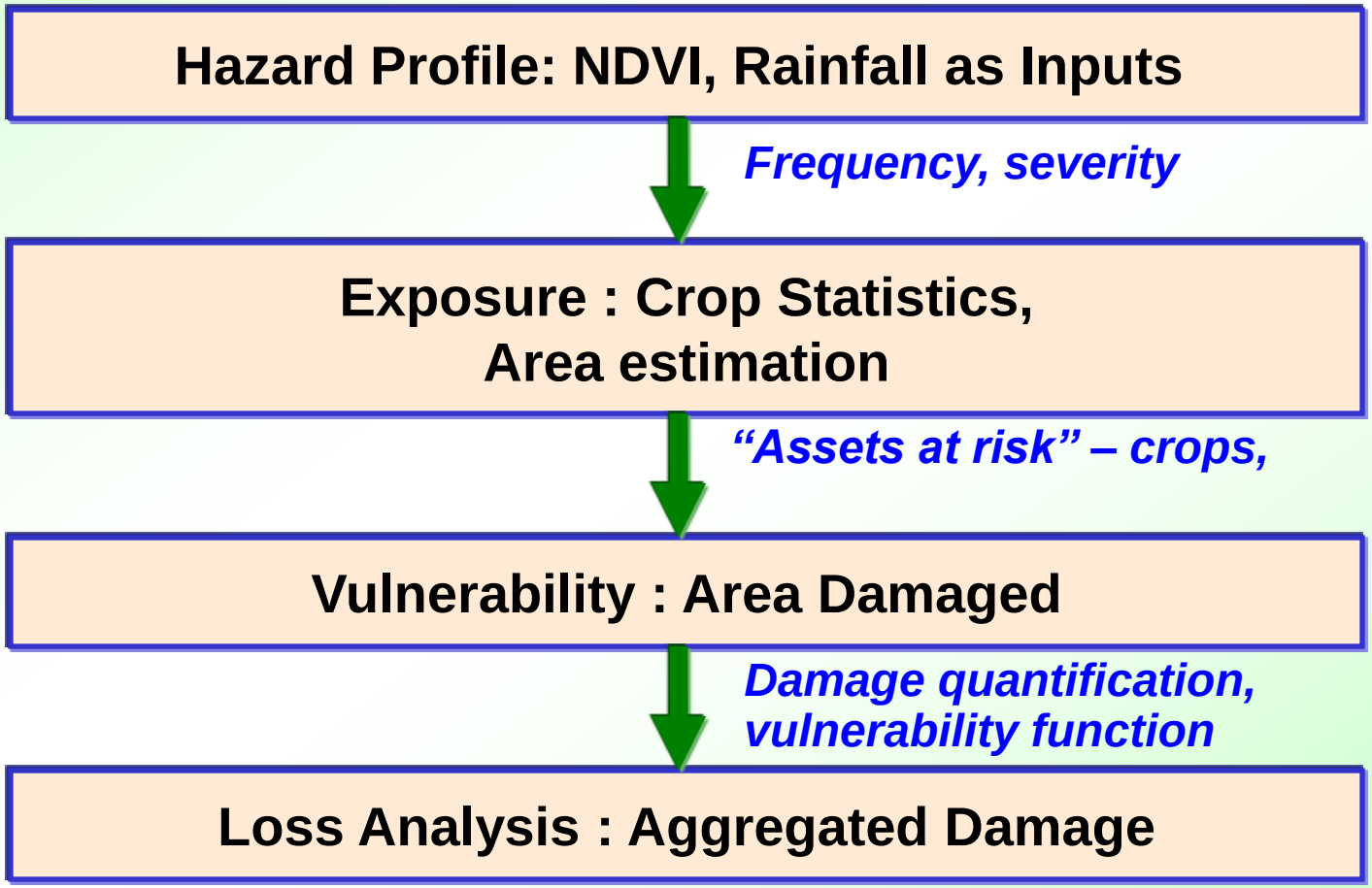
Data collected:

- **38 year rainfall data (~ 1970-2007)**
- **Crop area and yield data of Gulbarga district from 1997-98 to 2006-07**
- **Satellite data (IRS AWiFS, 56 m resolution) for the month of October and December in both the year of 2006 and 2007.**
- **Coarse level NDVI data (MODIS 250 m resolution) to assess district vegetation status (200-07)**

(Bandyopadhyay and Arunachalam)

Area-based Risk Model

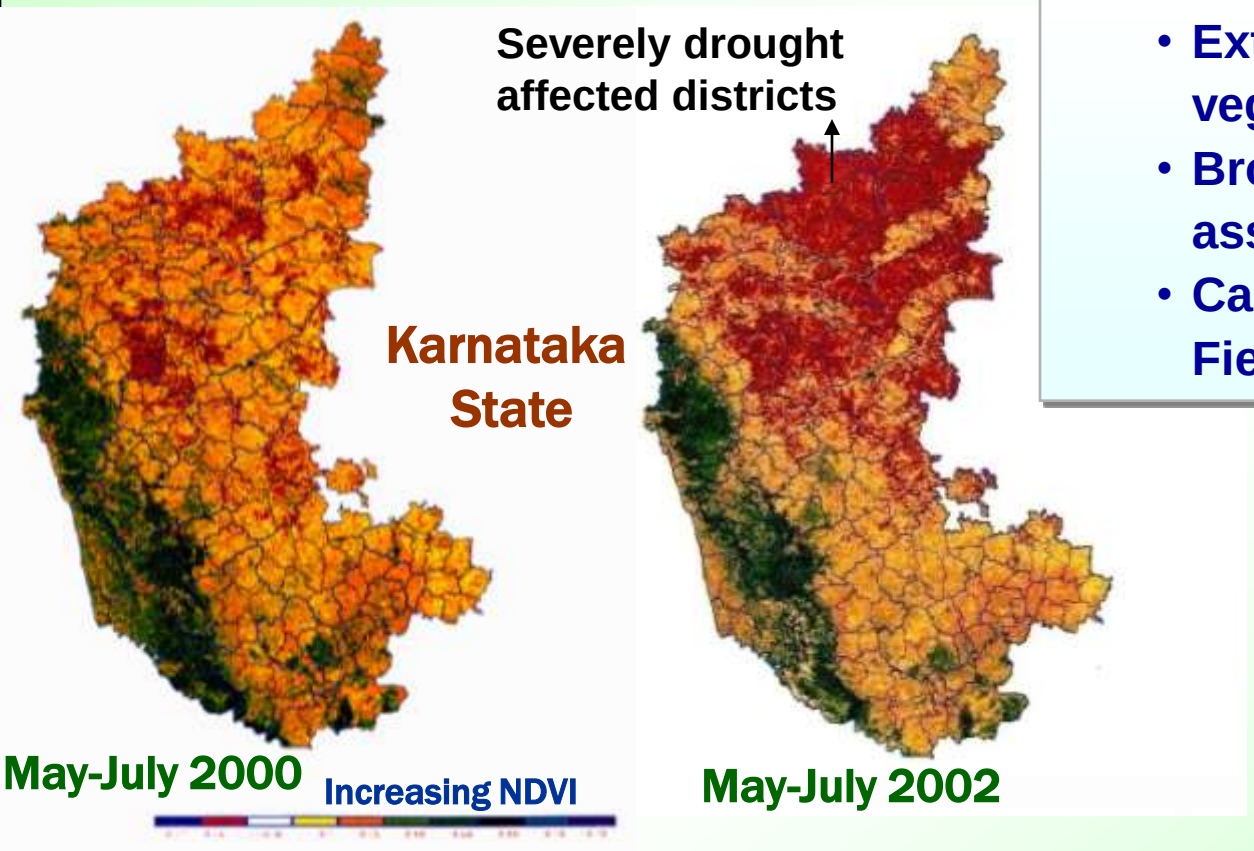
Probabilistic loss estimates –
stochastic events from historical data



Loss calculation (in Rs.) each asset class at each location, aggregation)

Hazard Profile

NADMS Results
State based Systems
(IRS WiFS based) – Districts of Karnataka State

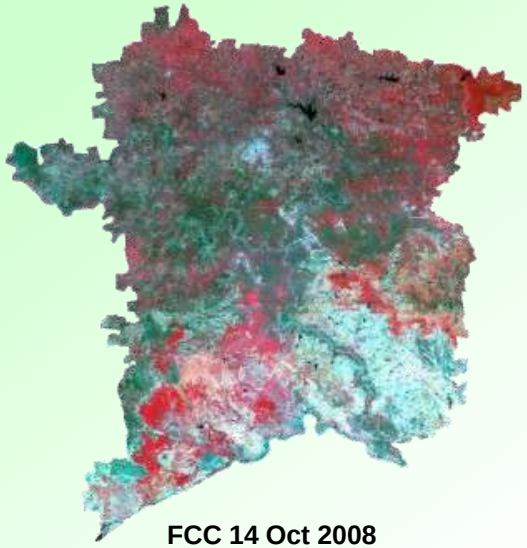


HAZARD LEVELS

- **Extent of severity based on vegetation status**
- **Broad level qualitative assessment**
- **Captures Instantaneous Field Conditions**

Source: Decision Support Centre (DSC), NRSA, 2002

AGRICULTURE RISK MAPPING FOR GULBARGA DISTRICT, KARNATAKA



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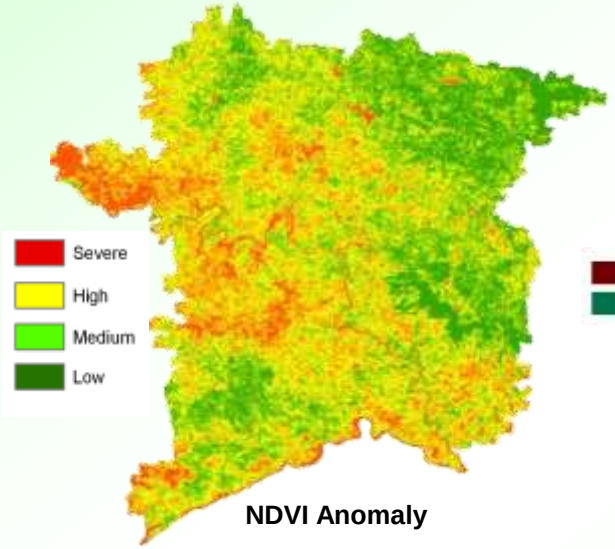
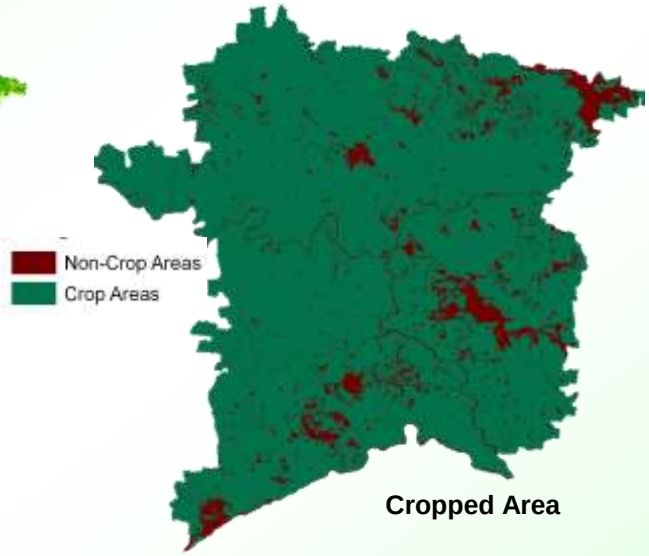
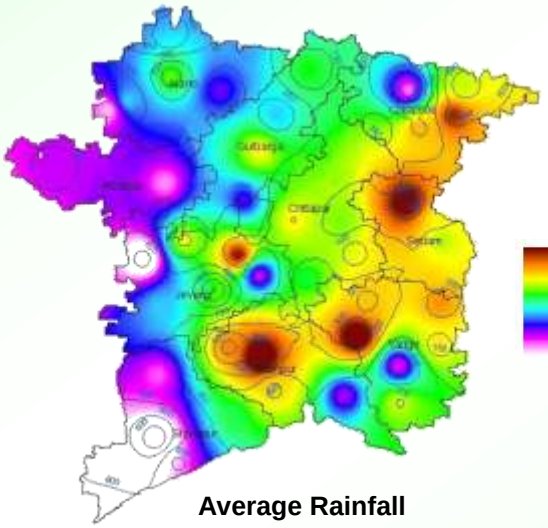


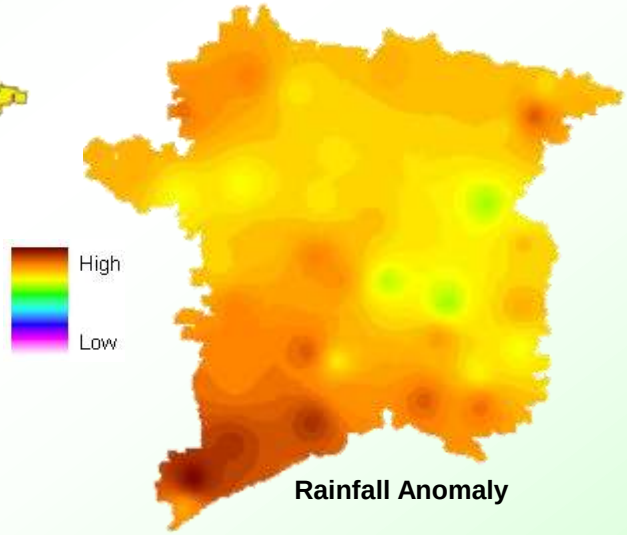
NDVI Anomaly



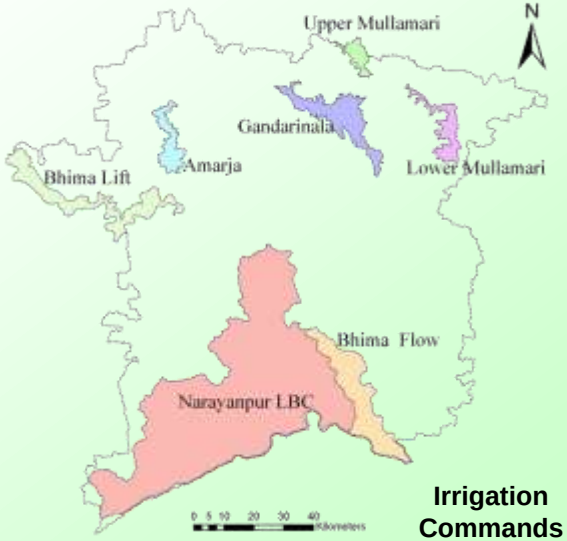
Cropped Area



Average Rainfall

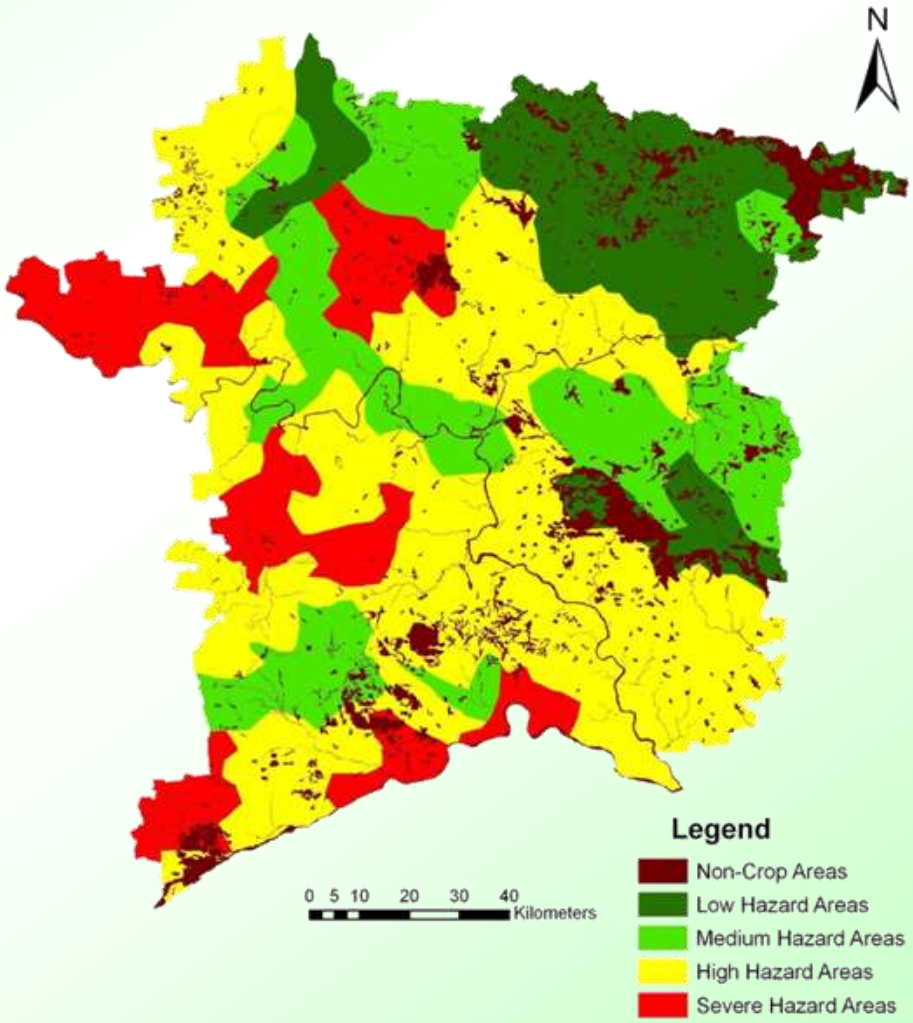


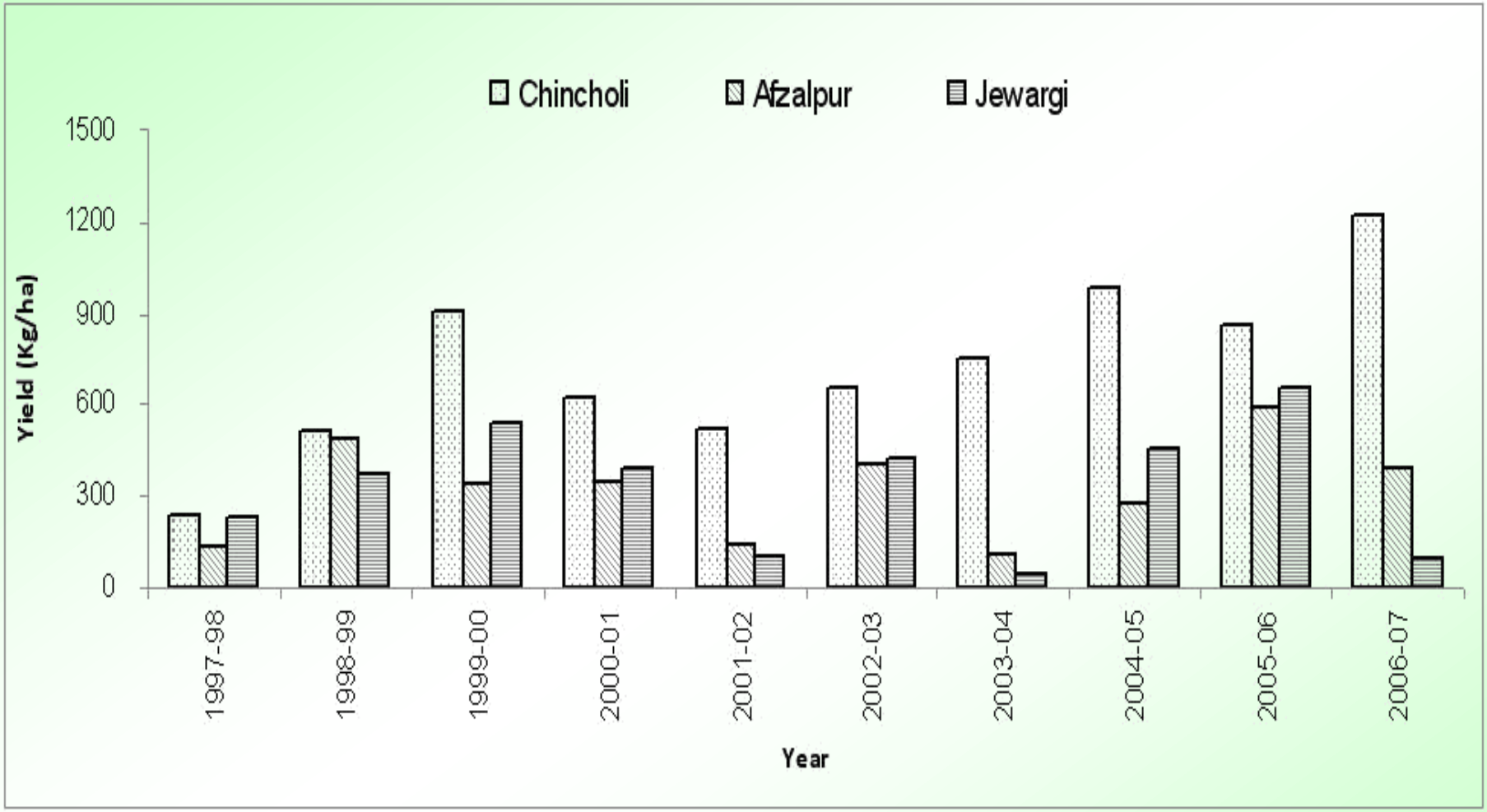
Rainfall Anomaly



Irrigation Commands

Agriculture Drought Hazard Map





Source of data : Dept of Economics and Stat., Karnataka

Tur (*Cajanus cajan*) crop yield variation in the blocks during 1997-98 to 2006-07

Loss Analysis - Gulburga

Crops	Area sown (Ha)	AREA AFFECTED (ha)	% Affected	Loss of Production (t)	Loss (Rs) CC terms (Crore)	Loss (Rs) of MSP terms (Crore)
Jowar	7753	1467	19	1392.183	0.55	0.67
Maize	3134	355	11	1104.05	0.46	0.53
Bajra	60837	7492	12	4794.88	-	2.32
Tur (Arhar)	309520	33364	11	15351.56	20.50	22.80
Blackgram	38007	13475	35	335.5	-	0.45
Greengram	95494	36454	38	6926.26	-	9.21
Groundnut	19251	2194	11	1959.242	2.74	3.00
Sesame	13239	10582	80	4126.98	-	5.98
Sunflower	97519	31363	32	12858.83	15.00	16.07
Soyabean	2823	704	25	549.824	0.50	0.60
Cotton	26456	941	4	244.66	0.30	0.43

Source of data : Dept of Agriculture, 2003

Loss in CC terms = Loss of production in tonnes (t) x [CC per ha / Yield in tonnes (t) per ha]

Loss in terms of MSP = Loss of production in tonnes (t) x MSP per tonnes.

Crop Insurance

Financial Institutions (WB, ADB, ICCI..) – based on corporate risk management

- **Weather based (rainfall & temperature)**
- **Area-based Index insurance: Make payments proportional to decline of area-yield below a certain trigger at the country or district level**

Requirements

- **Efficient crop insurance solutions based on - area, yield, rainfall, other weather perils, etc.**
- **Establishment of a transparent index - highly correlated to the expected crop yield and based on reliable long-term data.**
- **Crop Index Insurance Products - absence of adverse selection, moral hazard or asymmetric information**
  - **low risk premiums,**
  - **provide for easy insurance product delivery**
  - **do not require individual farm monitoring or in-field loss adjustment.**

Need for combining Satellite, Meteorology and Ground based information towards development of comprehensive indices

Methodology Development
- Broad Steps using Diagnostic Parameters

- **Understanding and predicting the impacts of weather variability on the crop**
  - **Finding spatial scale of weather-crop relationships**
  - **Variability Analysis for yield, rainfall, Temp. and relationships**

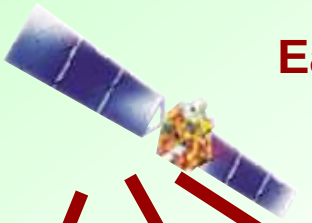
- **Satellite based indices for crop status monitoring – preferably in large scale**
  - **Normalised Difference Vegetation Index (NDVI); Normalised Difference Water Index (NDWI); Temperature Condition Vegetation Index (TCVI); Shortwave Slope Angle index(SASI); Microwave based products development (Soil Moisture Based Products)**

- **Development of crop yield variability (Yvar) model which is the function of rainfall, EO based index, Temp, management practices (M) etc, at the working spatial scale**
  - **Y(var) = f (R, VI,Temp, M……)**

- **Damage assessment through yield loss and area under crop**

- **Insurance product development**

'The Last Mile'



Earth Observations

Inputs to

Inputs to

Direct Outreach: yet to be established

ISRO ***IMD*** ***MOA***
Bhuvan ***Agro Met*** ***MNCFC***
SIS-DP ***Advisory*** ……
….. …..

Policy, Planning

Monitoring, Evaluation

'Last Mile' - Critical Support for Livelihoods

Challenges - To be Accomplished

Task: Assessment of crop damage at village level

- Understanding Crop weather interactions
- Small area statistics, area yield approach
- Appropriate integration of drought indices with EO based indices
- Building up heritage EO based indices vis-à-vis historical data to create appropriate vulnerability index, area-yield index, weather index
- Development of early warning system
- Pilot projects in different regions to build in geographical spread to develop methodologies for risk indexing and modeling

Risk assessment however needs to be dealt with the increasing complexity of risk in order to be relevant to risk reduction objectives.

EO Infrastructure: Future Requirements

- **High resolution Visible and SWIR bands data for crop damage assessment at farm level**
- **Microwave data (Passive and Active combined and rescaled) for crop monitoring and yield assessment**
- **High resolution thermal data for estimating stress indices**
- **Combined use of SAR technology, optical satellite data and sophisticated agro-meteorological plant growth models will provide further improvements.**
- **Frequent revisit capability by developing satellite constellations**
- **Distributed ground based measurements Networks (AWS, Soil Moisture, Soil Temperature….)**

Capacity building; Data availability at affordable cost

Acknowledgements:

Mr. A. Arunachalam, EOS, ISRO HQ
Director, EOS, ISRO HQ
Karnataka State Remote Sensing Centre
DES, Karnataka,
KSNDMC, Karnataka

Thanks