DROUGHT VULNERABILITY, COPING CAPACITY AND RESIDUAL RISK:EVIDENCE FROM BOLANGIR DISTRICT IN ODISHA

Dr Mrutyunjay Swain

Research Officer (Economics)

Agro-Economic Research Centre

Sardar Patel University, Vallabh Vidyanagar, Gujarat, India

Introduction

- **Understanding Drought Vulnerability and Risk**

  The complex process of climate change affects the vulnerable populations, livelihoods and different sectors through a rise in frequency and intensity of CINDs (IPCC, 2007).

  Drought is the most complex and least understood among all CINDs, affecting more people than any other hazards.

- **Drought Planning and Mitigation**

  One of the main aspects of any drought mitigation and planning is the 'vulnerability assessment' (Wilhelmi *et al* 2002). Vulnerability assessment requires the identification of who and what are most vulnerable and why.

Objectives

- **To analyze the observed impacts of the climate change and recurrent droughts in Bolangir district of Orissa.**
- **To assess the nature and determinants of drought risk and vulnerability experienced by selected blocks of drought prone study region.**
- **To critically examine the relative influence of different socioeconomic and biophysical factors to the levels of drought vulnerability in the study region.**
- **To suggest some policy measures to reduce the extent of drought vulnerability and risk in the study region.**

Data and Methodology

Multistage Sampling Method

First stage: Bolangir district was chosen.

Second stage: Three blocks were selected on the basis of degree of drought vulnerability which are Saintala (most vulnerable), Patnagarh (moderately vulnerable) and Titlagarh (least vulnerable).

Third Stage: Three villages, one from each of the selected blocks: Samara of Saintala; Mundomahul of Patnagarh; and Bijepur of Titlagarh

Fourth Stage: Sample households (HHs) were chosen from each of the selected villages through **Stratified Random Sampling Method** covering 12 major livelihood groups : (1) Large Farmer (more than 10 acres), (2) Medium Farmer (5.01-10 acres), (3) Small Farmer (2.51-5 acres), (4) Marginal Farmer (up to 2.5 acres), (5) Agricultural Labourer, (6) Non-agricultural Laborer, (7) Forest Resource Dependent, (8) Rural Artisan, (9) Businessman, (10) Service Holder, (11) Livestock Rearer, and (12) Others including Fishing Community, Stone Merchants, and Tailors.

Data and Methodology…..

Indexing and Vulnerability Profile method

- Method was used to generate aggregate indices like Composite Drought Vulnerability Index (CDVI) and Composite Drought Adaptability Index (CDAI) and Physical Exposure Index (PhyExpo) and Drought Risk Index (DRI) for block-wise and livelihood group wise analysis of drought vulnerability and risk .
- The normalization procedure for adjusting indicator values to take the values between 0 and 1 using formula: $V_{ij} = \{(X_{ij} - \text{Min } X_i)/ (\text{Max } X_i – \text{Min } X_i)\}$,

Where,

V_{ij} = Normalized value of drought vulnerability indicator

X_{ij} = Value 'i' th drought vulnerability indicator in the 'j' th block or livelihood group

Min X_i = Minimum value of the 'i' th drought vulnerability indicator across blocks or livelihood groups

Max X_i = Maximum value of the 'i' th drought vulnerability indicator across blocks or livelihood groups

Data and Methodology…..

Indexing and Vulnerability Profile method…

Component Drought Vulnerability Index (DVI) $= 1/m \left[\sum_{i=1}^{m} K_i V_{ij}\right] \times 100$

Two DVIs for computing CDVI: Bio Physical DVI and Socio-economic DVI

Composite Drought Vulnerability Index (CDVI) $= 1/n \left[\sum_{i=1}^{n} W_i DVI_i\right] \times 100$

K_i is the weight attached to 'i' th normalized drought vulnerability indicator with the value of 'i' varying from 1 to m. 'm' is the number of drought vulnerability indicators considered for a particular DVI.

W_i is the weight attached to 'i' th DVI

Data and Methodology…..

Indicators used

Table: Indicators of composite drought vulnerability index (CDVI) at the block level

Sl. No.	Bio-physical Indicators of Drought Vulnerability			Sl. No.	Socio-economic Indicators of Drought Vulnerability		
	Indicators	**Proxy for Indicator**	**Weights**		**Indicators**	**Proxy for Indicator**	**Weights**
1	Drought Frequency	Frequency of Occurrence of Drought (%)	0.1	7	Irrigation	% Area without any irrigation potential	0.1
2	Drought Intensity	% Decrease in precipitation from long-term normal in Drought Years (%)	0.1	8		% Unirrigated area to total cultivable area	0.005
3	Rainfall	Average annual rainfall variability (CV %)	0.05	9	Major crop production	Paddy area variability (CV %)	0.005
4	Soil	Available water holding capacity of soil (Rank*)	0.05	10		Paddy yield variability (CV %)	0.045
5	Land topography	Land slope (%)	0.05	11	Poverty	% Households below poverty line	0.075
6	Ground water table	% Decline in post monsoon water level in drought year compared to normal	0.05	12	Social factors	% Landless and marginal labourers to total main workers	0.1
				13		% People illiterate	0.1
				14		% People living in rural area	0.05
				15		Population density (per sq. km)	0.05
				16	Land use pattern	% of geographical area not covered under forest	0.05
				17		% Barren uncultivable and other fallows	0.007
				18	Institutional factors	% Farmers not covered under crop insurance	0.005
				19		% People not benefited by IRDP	0.008

Data and Methodology…..

Initial and Conditional Probability of Rainfall

The initial and conditional probabilities of dry and wet weeks are defined as follows.

$$P(\mathrm{D}) = \frac{F(\mathrm{D})}{N} \qquad P(W) = \frac{F(W)}{N}$$

$$P(\mathrm{DD}) = \frac{F(\mathrm{DD})}{F(\mathrm{D})} \qquad P(\mathrm{WW}) = \frac{F(\mathrm{WW})}{F(W)}$$

Where,

- P (D) = Probability of a week being dry
- F (D) = Total number of dry weeks
- P (DD) = Conditional Probability of a dry week preceded by another dry week
- F (DD) = Total number of dry weeks which are preceded by dry weeks also.
- N = Total number of weeks taken for analysis.
- P(W), F(W), P(WW) and F(WW) have the same meaning as P(D), F(D), P(DD) and F(DD) respectively except that here the dry (D) is replaced by wet (W). If weekly rainfall is 20 mm or more, it is considered wet.

The computer program written in **FORTRAN-77** was used to find out the initial and conditional probabilities of rainfall in the study blocks.

Data and Methodology.....

Livelihood Sensitivity Matrices*

- The method has been used at household level for assessing the dependencies, i.e., the linkages of different intensities of drought and other climatic risks with different livelihood activities or outcomes, that have been displayed with the help of interaction matrices.

- The method uses scores of 5,4,3,2, and 1 to denote very strong, strong, moderate, weak and no influence respectively.

- With the help of semi product function in EXCEL, the weighted exposure indices and weighted impact scores have been generated on the basis of which the extent of sensitivity is determined.

(*Detailed explanation will be presented later on during analysis of the matrices)

CONCEPTS : DROUGHT VULNERABILITY, COPING CAPACITY AND RESIDUAL RISK

- **Vulnerability in broader sense** implies susceptibility of a social or natural system to an event or combination of events those may be natural or human induced.
- **Chamber (1989):** Vulnerability has two sides: an external side of risks, shocks to which an individual or household is subject; and an internal side, which is defenselessness, meaning a lack of means to cope with hazards. While one side indicates the exposure, other side emphasizes the coping capacity.
- **UNDHA (1992); NDMC (2000):**

➤ **The risk associated with drought** for any region is a product of the region's exposure to the hazard and vulnerability of societies within the region to the event.

➤ **Vulnerability to drought**, which is determined by mainly socio-economic and political factors can be altered to reduce the level of drought risk.

CONCEPTS : DROUGHT VULNERABILITY, COPING CAPACITY AND RESIDUAL RISK .....

- **In this paper, the drought vulnerability, coping capacity and residual risk have been defined as follows:**
- **Drought vulnerability** is defined as a composite of conditions and exposure to adverse processes that increase the level of susceptibility of populations and their habitations to drought.
- **Drought adaptability or coping capacity** refers to the composite of all those conditions and responses that are helpful to reduce the level of drought vulnerability.
- **The risk associated with drought episodes otherwise termed as 'residual drought risk'** is defined as the product of drought hazard and drought vulnerability, relative to (i.e., divided by) a variable that proxies coping capacity.

NATURE AND CAUSES OF DROUGHT VULNERABILITY AND RISK IN BOLANGIR

- Drought is a recurring and single most insidious phenomenon in Bolangir district of Orissa. The recurrent drought in the district is mostly responsible for its ‘chronic backwardness’.

- **The increasing frequency of occurrence of the hazard** is one of the major factors behind the rising level of drought vulnerability in the region, which is mainly due to “wide variability of rainfall from season to season”, not as a result of deficiency of annual rainfall .

- One of the prime reasons for increasing drought frequency and vulnerability in the study region is the neglect of the traditional water-harvesting structures and poor development of irrigation facilities.

- Disappearance of drought-resistant indigenous crop varieties and loss of bio-diversity
- Poor governance and poor socio-economic status

Some Observed Impacts of Climate Change in the Region

- The intensity and frequency of the drought episodes appear to be increasing with each passing year.

- The trend in the major climatic variables such as rainfall and temperature exhibits significant changes.

Some Observed Impacts of Climate Change in the Region…

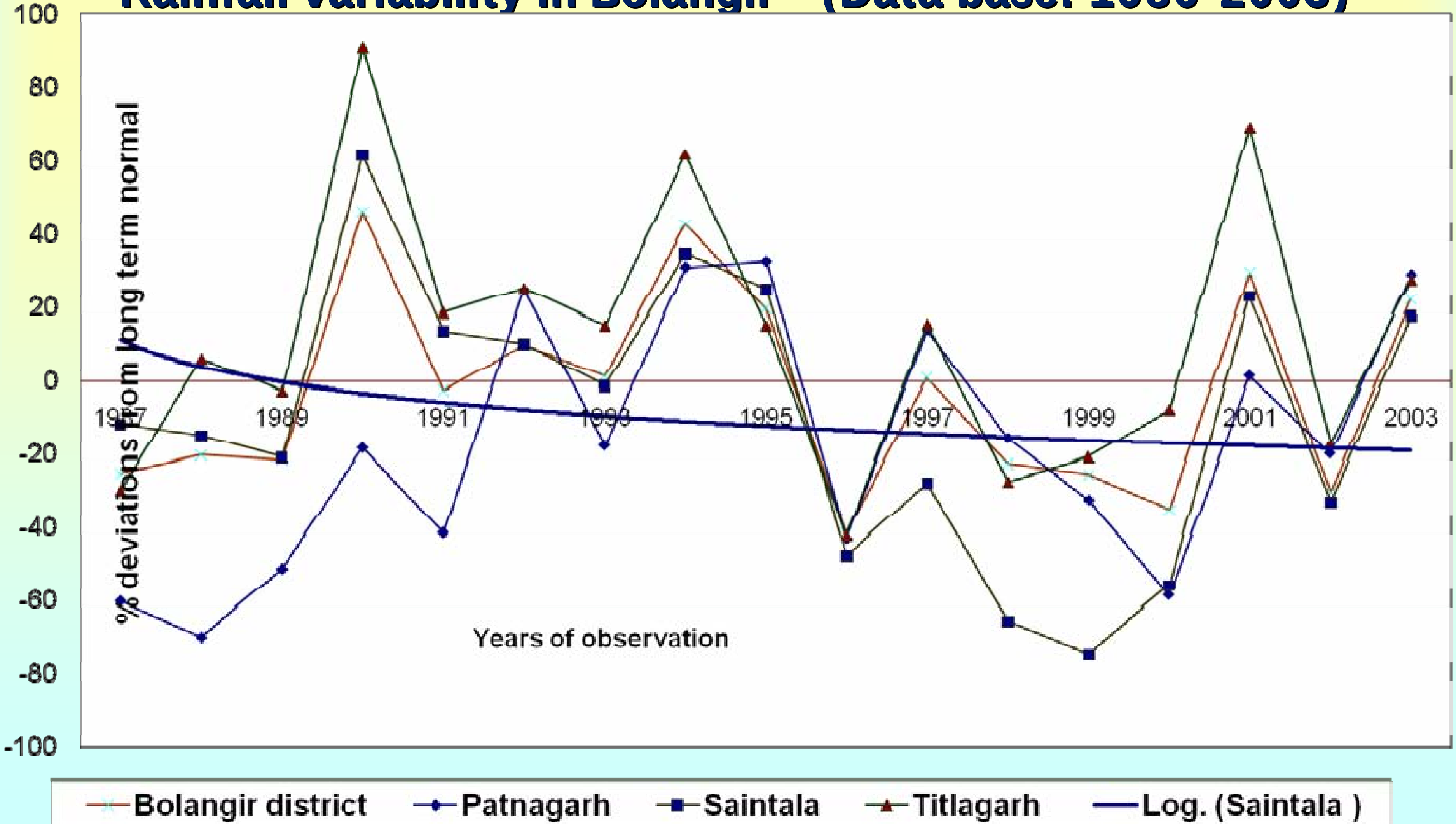
- Mishra (2008) by taking into account 100 years of rainfall data (1880 – 1980) found that there were 120 rainy days a year in early 1880s, which has declined to about 50 days during 1980s which is less than 2 months.
- Particularly in Bolangir district, the average number of rainy days per annum during last 18 years (1986-2003) was 53.8 (Swain, 2007). So there has been a decline of approximately 66 rainy days during last century in Bolangir district.

Some Observed Impacts of Climate Change in the Region…

- The long-term normal rainfall in the district is also gradually declining. For example, average annual rainfall of Bolangir has declined by 14.8 per cent from 1901-1950 (1443.5mm) to 1951-2000 (1230mm) and further to 1206.7mm during the period 1986-2003 (Swain, 2006a).
- On the other hand**, the variability in rainfall distribution** is gradually increasing for which the district is facing recurrent drought .

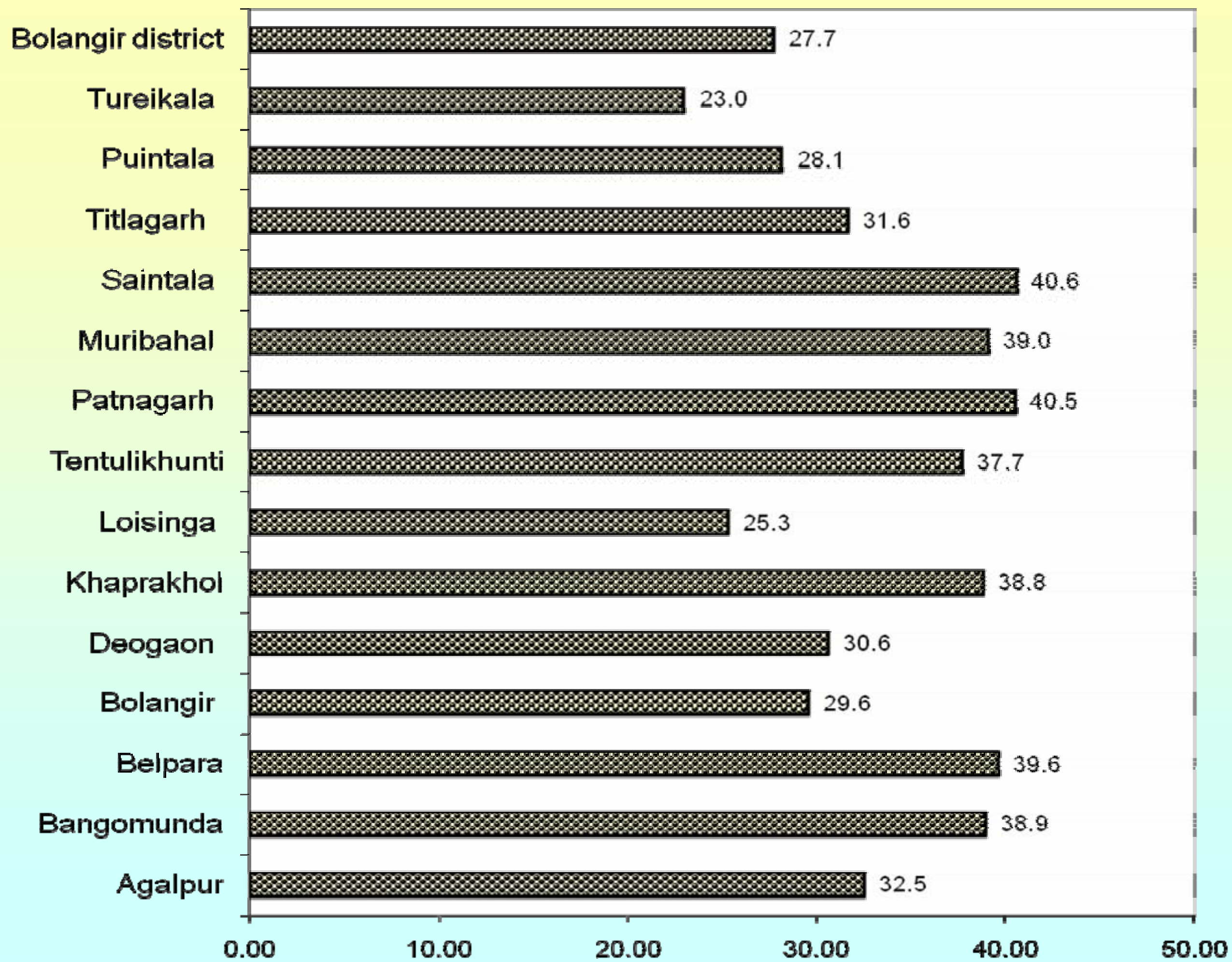
Some Observed Impacts of Climate Change in the Region…

Rainfall variability in Bolangir (Data base: 1986-2003)



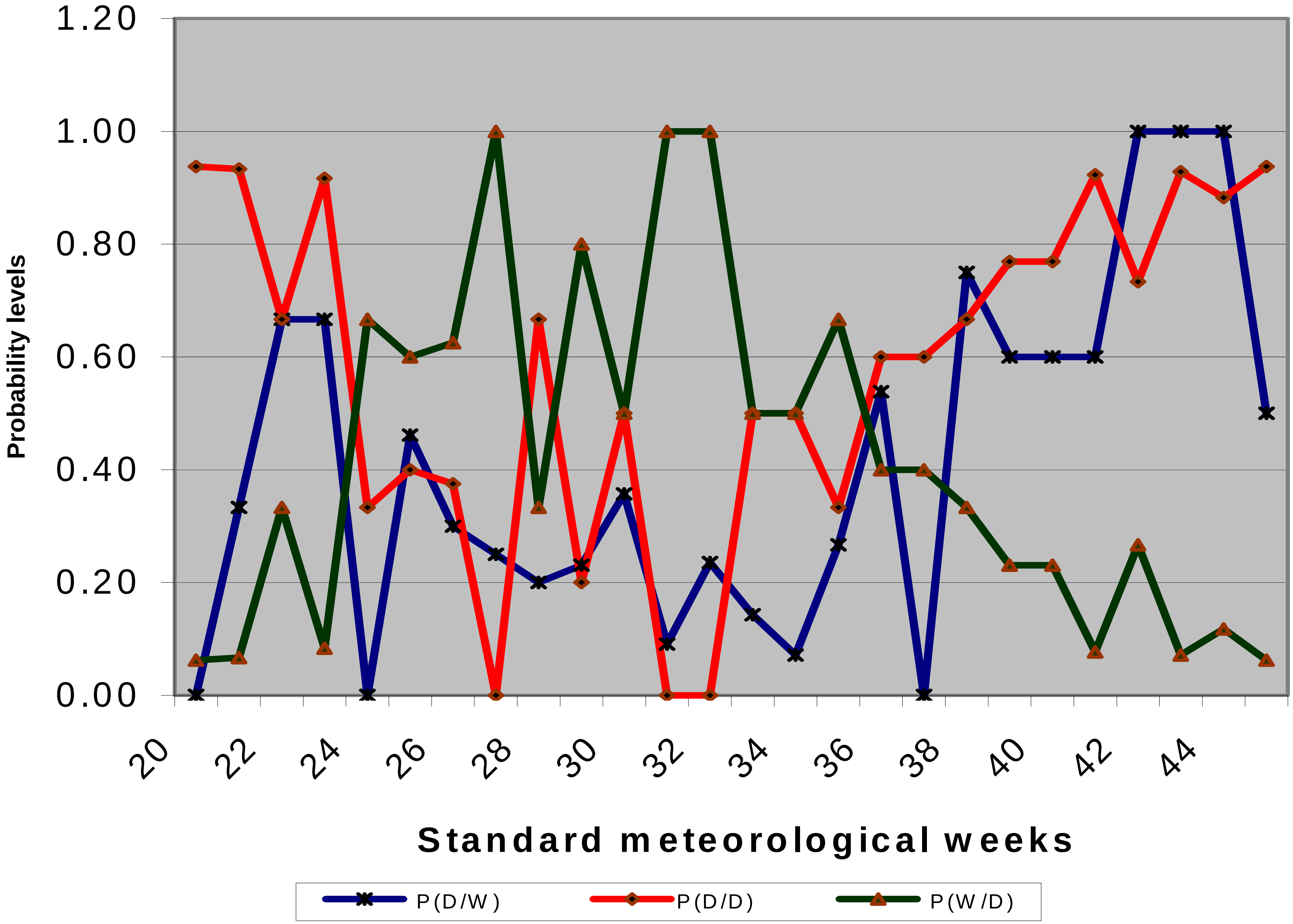
Some Observed Impacts of Climate Change in the Region…

Coefficient of Variation of Annual Rainfall

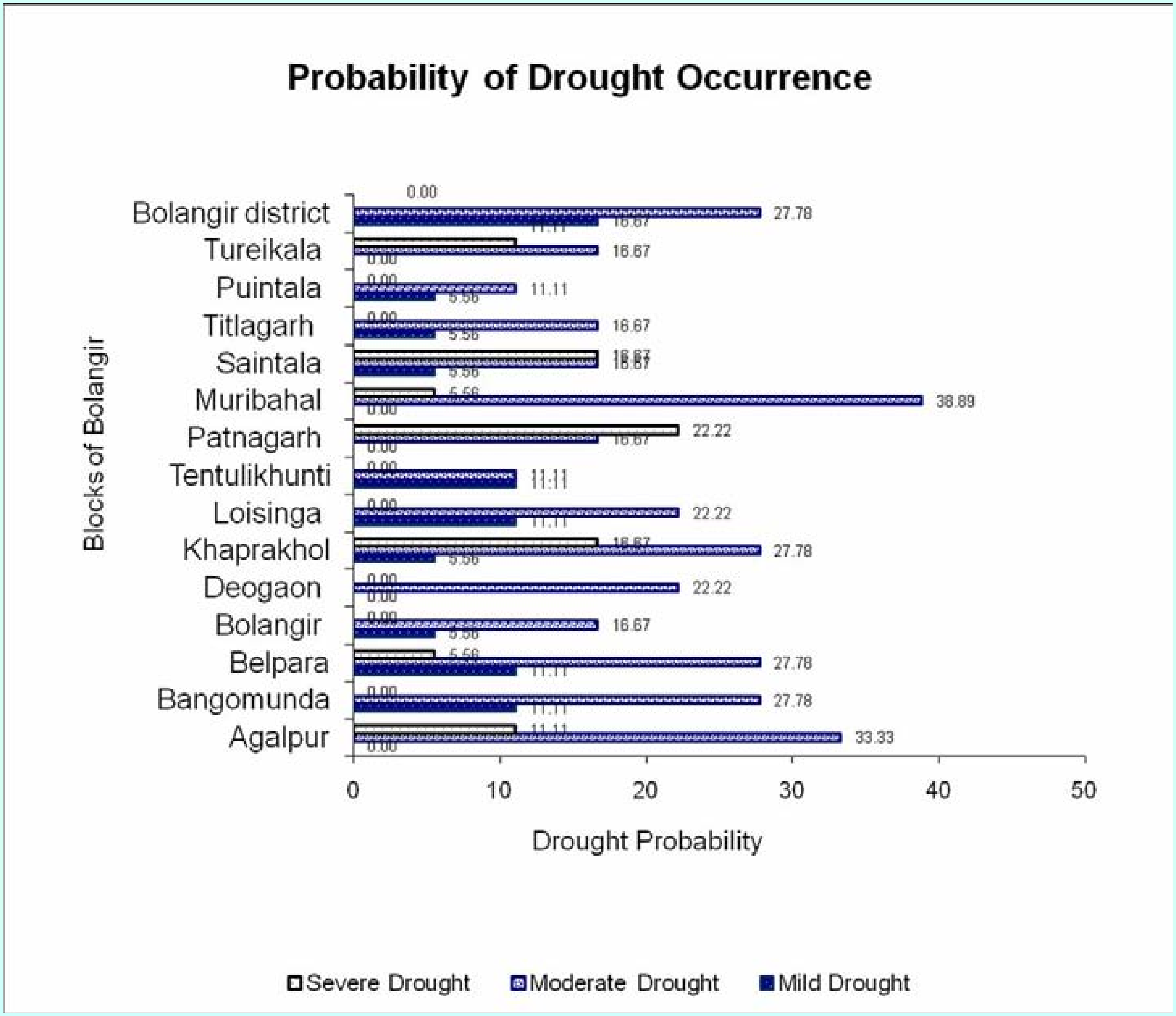


Some Observed Impacts of Climate Change in the Region...

Fig.6 : Conditional probability of weekly rainfall at Saintala



Some Observed Impacts of Climate Change in the Region...



Some Observed Impacts of Climate Change in the Region…

- The mean maximum temperature of the district has steadily increased and the mean minimum temperature has fallen during the period of 1934-1980 (Pradhan, 1994).

Some Observed Impacts of Climate Change in the Region...

Depletion of Forest Resources in the Region

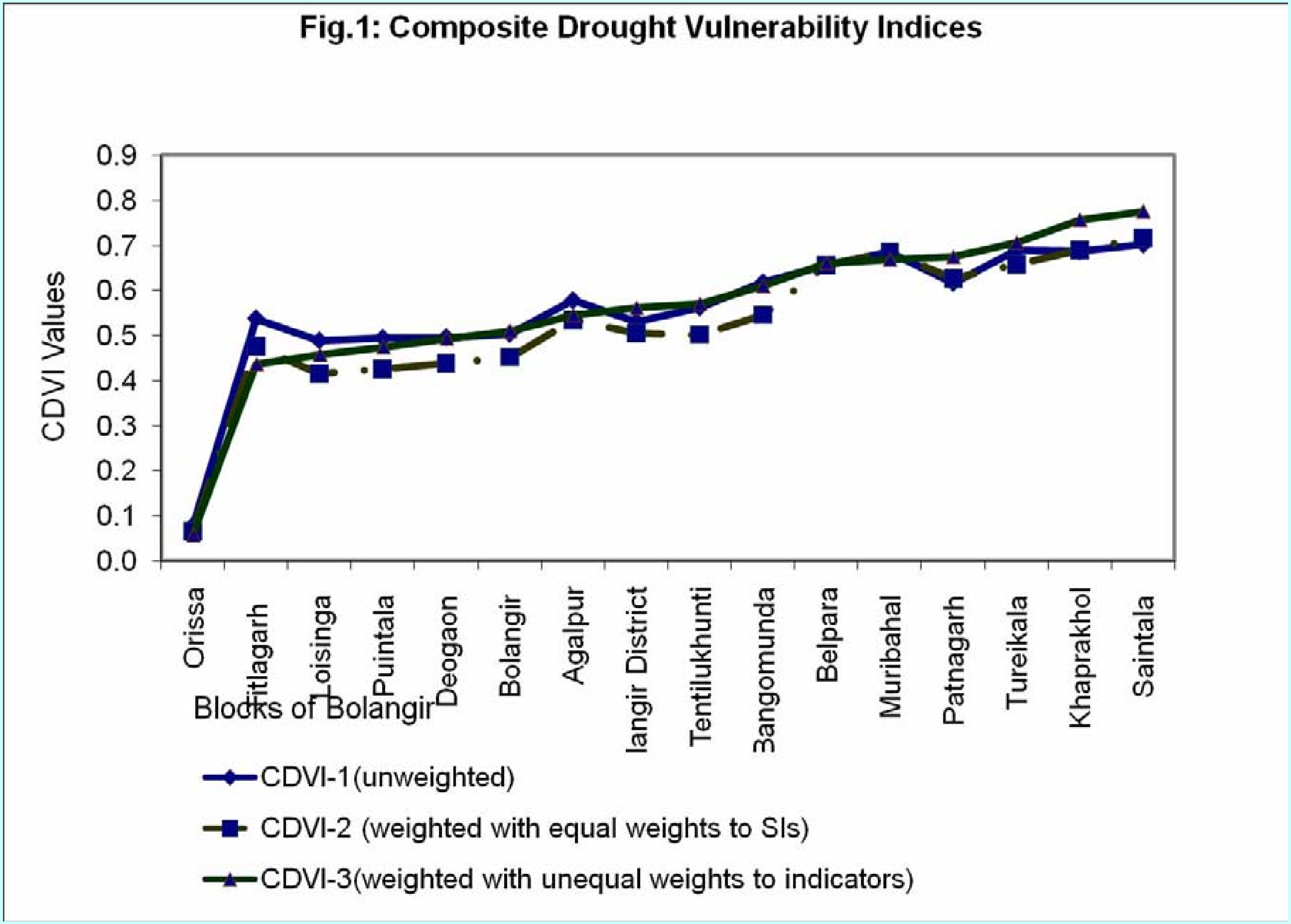
- The vegetation has been reduced by 50 per cent during the period of 1934-1980 (Pradhan, 1994). From satellite imageries and other quantitative information, Mishra (2008) also finds that 50% of the reserve forest, i.e., the government protected forests in the catchment areas of reservoirs has been deforested.

Some Observed Impacts of Climate Change in the Region…

Depletion of Forest Resources in the Region

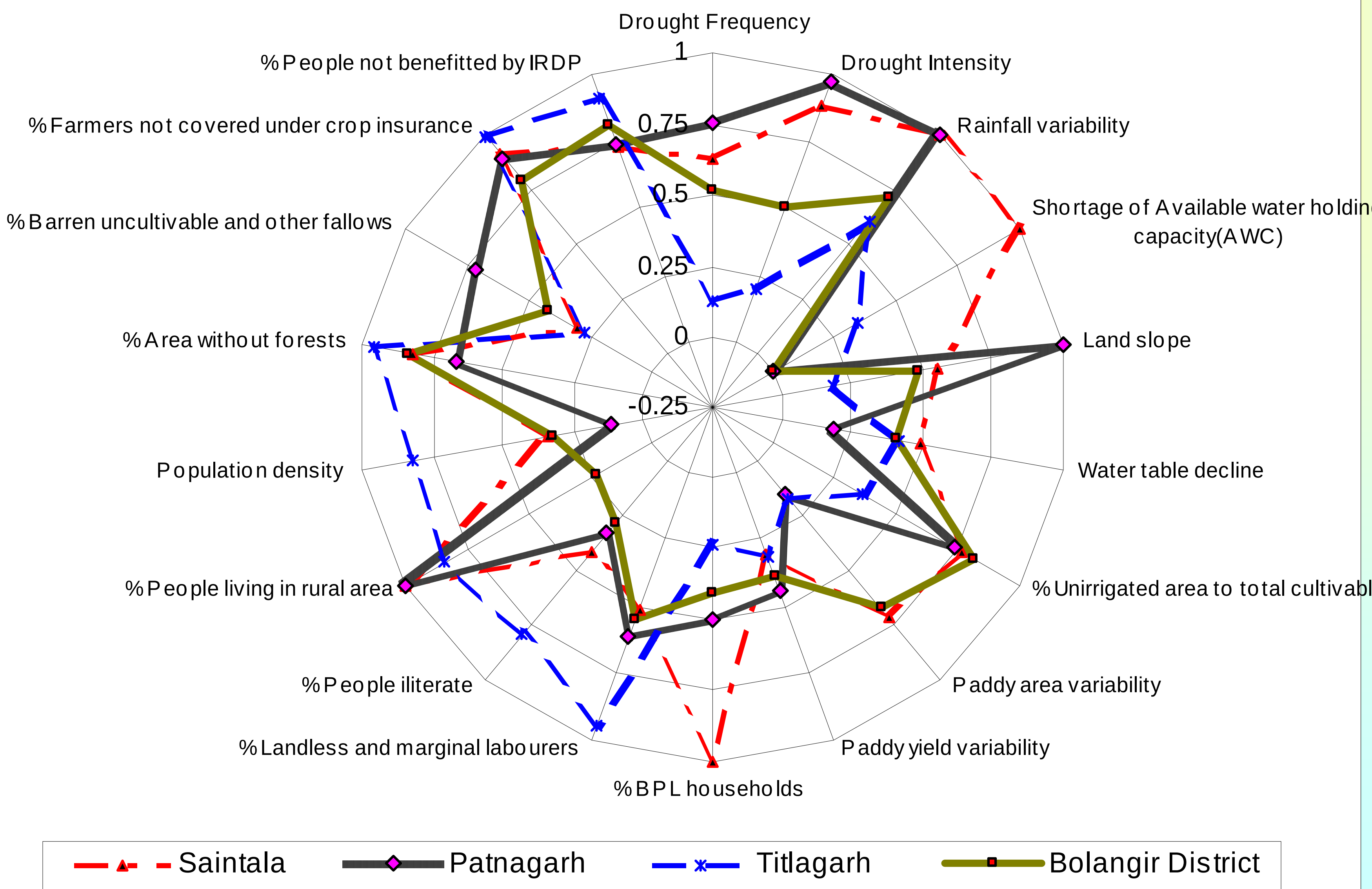
Type of NTFP	Name of produces	Nature of use	% increase in use in drought year 2002
Trees	Mahul, Char, Kendu, Sal, Sahaj, Phalsa, Karla, Neem, Mango, Tentuli, Sajana, Kusanga, and emblic myrebalan (Amla), Black myrebalan(harida) ,Bahada, Jamba, Palm	Self consumption and sale of fruits, flower, extracted oil, fuel wood, resin, kendu leaves, leaf plates, seeds, tole; vegetables and other eatables	25.8%
Grass	Kala, Duba, Samana, Charana grass, Kaensa, Panesh, Shukuna and Kanchei, etc.	Rope, sweeping mop, broom etc.	17.3%
Bushes	Bamboo, date palm, and other bushes	Straw, rope, scuttle, basket, broom	24.6%

DROUGHT VULNERABILITY & RISK AT BLOCKS

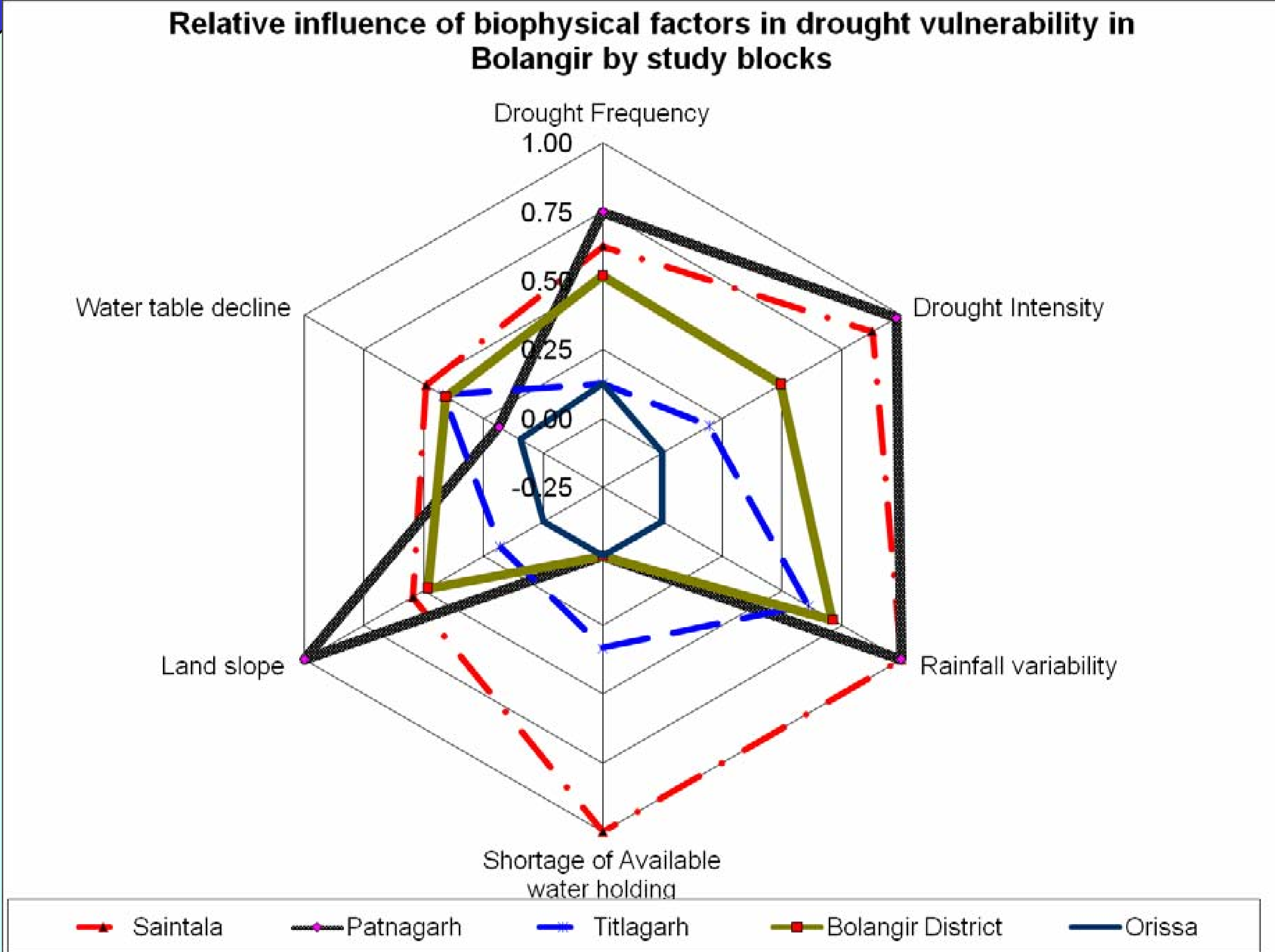


DROUGHT VULNERABILITY & RISK AT STUDY BLOCKS…

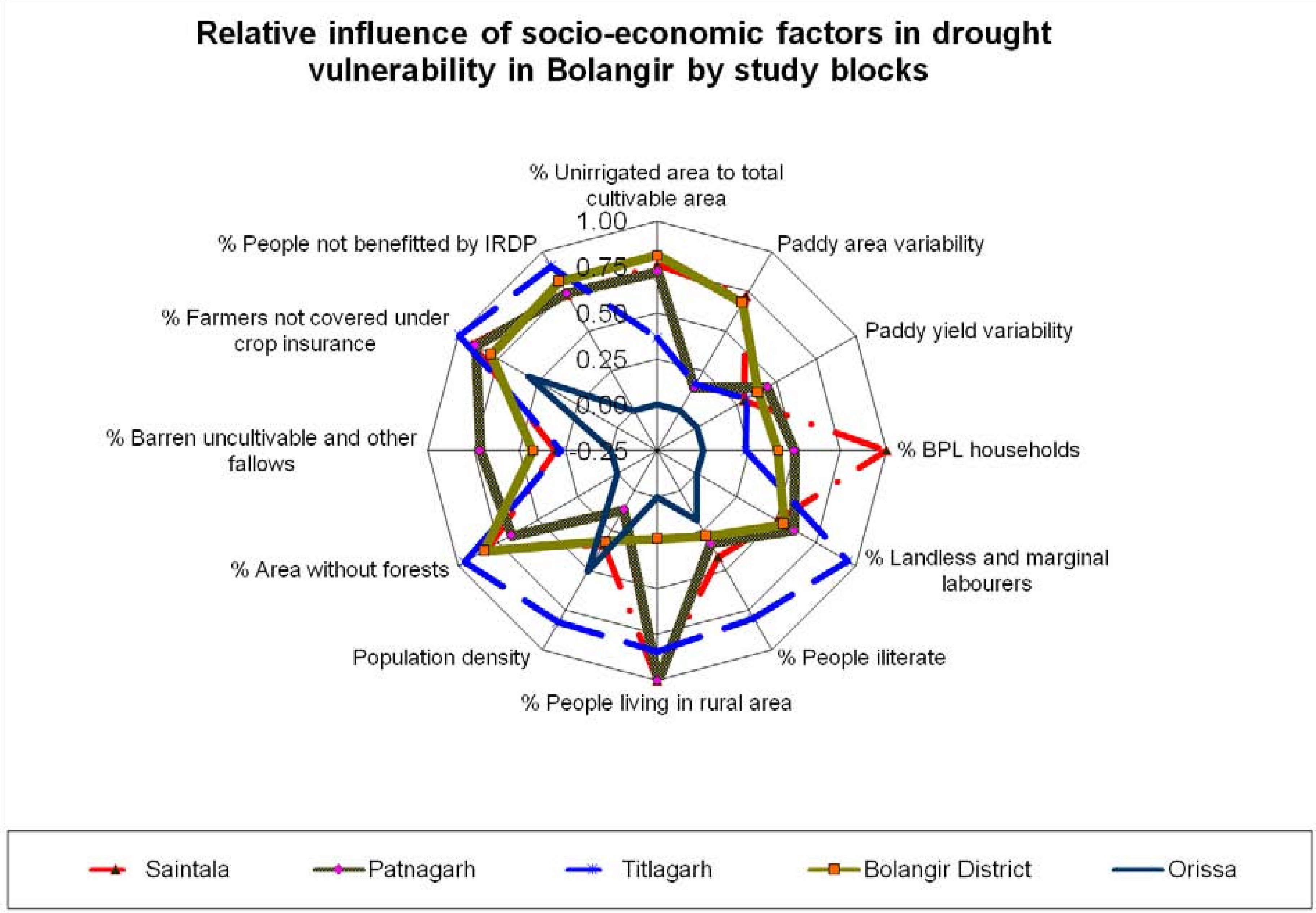
Fig.2: Drought vulnerability radar of study blocks in Bolangir



DROUGHT VULNERABILITY & RISK AT STUDY BLOCKS…



DROUGHT VULNERABILITY & RISK AT STUDY BLOCKS...



COMPUTATION OF RESIDUAL DROUGHT RISK FOR BLOCKS

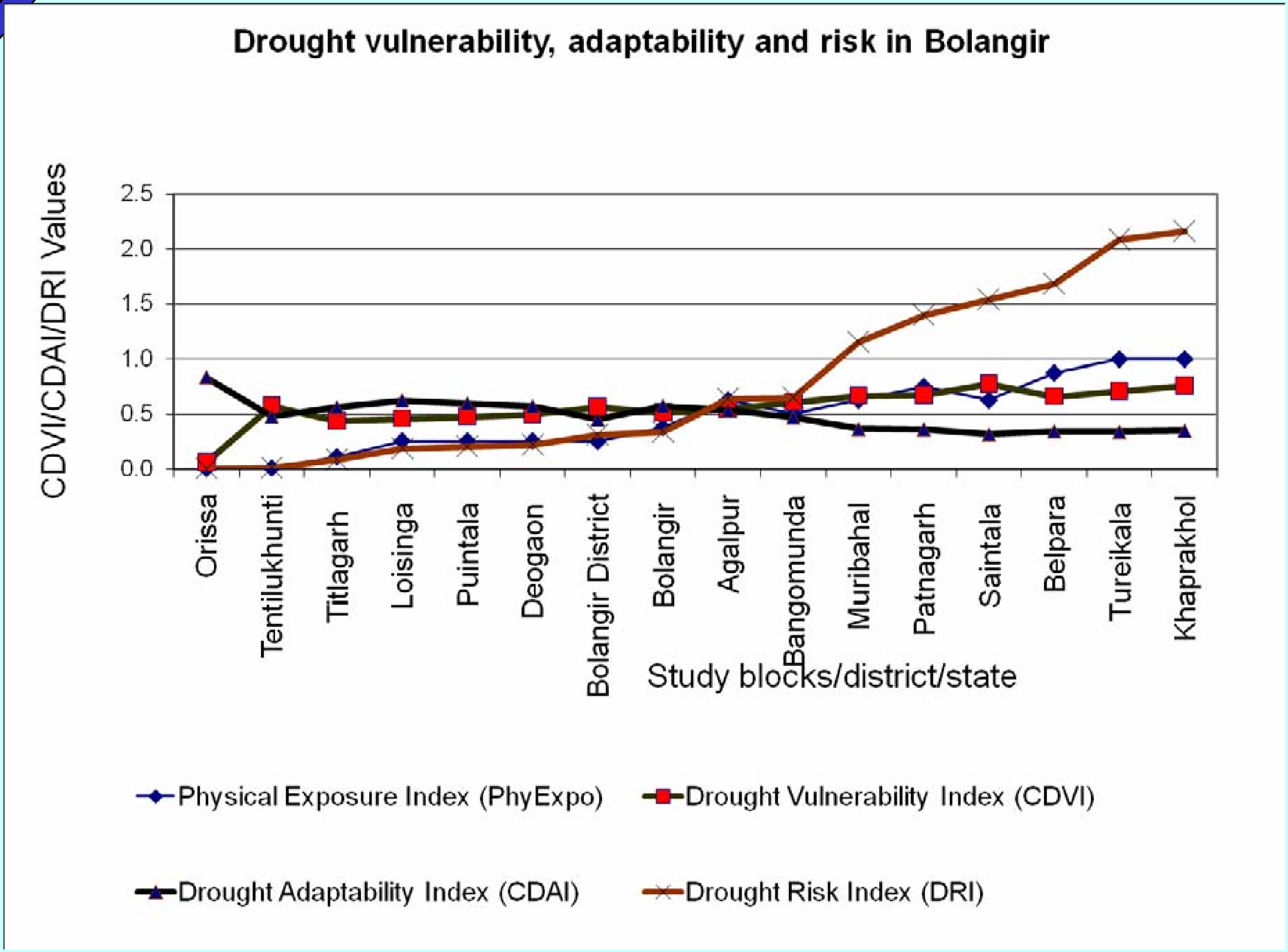
	Physical Exposure		Composite Drought Vulnerability Index			Composite Drought Adaptability Index			Drought Risk Index
Blocks/district/State	PhyExpo-1 Prob*Rural Pop	PhyExpo-2 Prob* PopDen	CDVI-1 (Simple average)	CDVI-2 (weighted with equal weights)	CDVI-3 (weighted with unequal weights)	CDAI-1 (Simple average)	CDAI-2 (weighted with equal weights)	CDAI-3 (weighted with unequal weights)	DRI PhyExpo-1 × CDVI-3 /CDAI-1
1	2	3	4	5	6	7	8	9	10
Agalpur	0.627	1.000	0.578	0.534	0.545	**0.667**	0.683	0.920	0.513
Bolangir	0.379	0.111	0.503	0.452	0.511	0.618	0.653	0.815	0.313
Deogaon	0.254	0.054	0.496	0.438	0.494	0.476	0.579	0.656	0.264
Tentilukhunti	<u>*0.006*</u>	0.000	0.562	0.502	0.570	0.497	0.602	0.786	<u>*0.007*</u>
Loisinga	0.254	0.355	0.488	0.416	0.458	0.577	0.626	0.787	0.202
Puintala	0.254	0.618	0.494	0.426	0.475	0.568	0.637	0.789	0.213
Belpara	0.876	0.240	0.654	0.655	0.661	0.540	0.607	0.755	1.072
Khaprakhol	**1.000**	0.376	0.686	0.690	0.757	0.611	0.642	0.743	1.240
Patnagarh	0.751	0.296	0.616	0.626	0.675	0.478	0.531	0.604	1.062
Bangomunda	0.503	0.791	0.617	0.546	0.610	0.551	0.636	0.741	0.557
Muribahal	0.627	0.595	0.684	0.685	0.669	0.490	0.550	0.609	0.857
Saintala	0.627	0.439	0.701	0.716	**0.776**	0.505	0.565	0.676	0.963
Titlagarh	0.109	0.313	0.537	0.476	<u>*0.437*</u>	0.557	0.613	0.746	0.086
Tureikala	**1.000**	0.677	0.688	0.657	0.707	<u>*0.451*</u>	0.519	0.618	**1.566**
Bolangir District	0.250	0.190	0.531	0.505	0.561	0.538	0.601	0.728	0.260
Orissa	0.000	0.089	0.077	0.066	0.058	0.959	0.901	1.214	0.000

Notes: 1) ‘Prob’ stands for probability of drought; ‘rural pop’ stands for rural population; and ‘PopDen’ stands for population density.

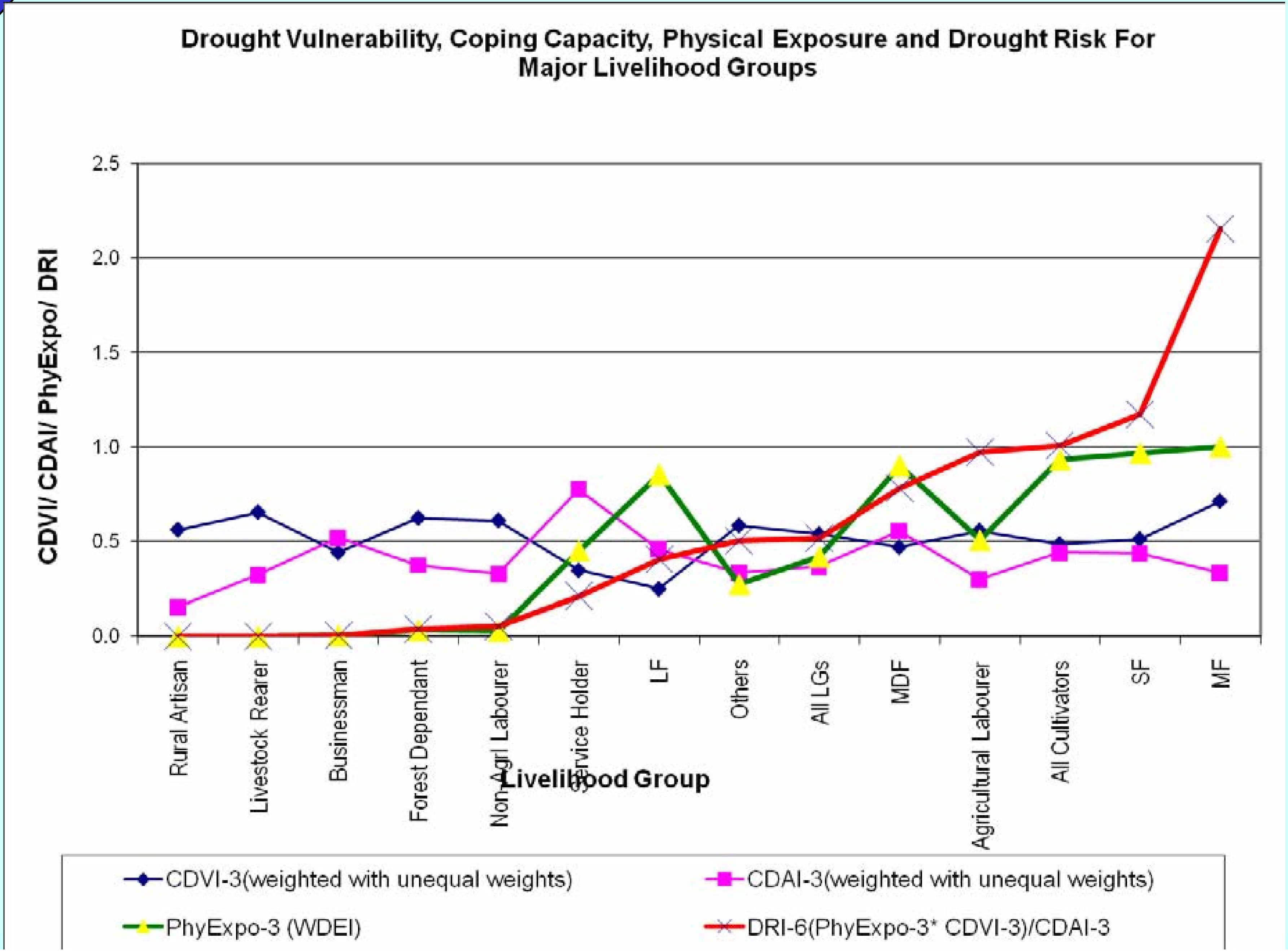
2) The blocks with **bold** figures are ranked as the highest and the blocks with <u>*underlined italics*</u> are ranked as the lowest among different blocks.

Source: Computed from data collected from secondary sources as mentioned

DROUGHT VULNERABILITY & RISK AT STUDY BLOCKS…



DROUGHT VULNERABILITY & RISK FOR LIVELIHOOD GROUPS



RESULTS FROM LIVELIHOOD SENSITIVITY MATRICES

- The Livelihood Sensitivity Matrix which analyses the sensitivity of different livelihood activities to drought risk factors and other climatic risks reveals that:

- Crop farming under rainfed condition is highly exposed to different intensities of drought along with other drought risk factors with highest exposure index value of 84.2 and weighted index value of 4.3 out of 5.

- Next to crop farming, rural labour works and migration are observed to be highly sensitive to different drought risk factors.

- All other climatic risks besides drought and drought risk factors played insignificant role in influencing different livelihood activities in the region.

Major Findings :Who Are Vulnerable?

Indicators of:	Most Scored	Least scored	Moderately scored
Among Study Blocks			
Drought Vulnerability(CDVI)	Saintala	Titlagarh	Patnagarh
Drought Adaptability(CDAI)	Titlagarh	Patnagarh	Saintala
Physical Exposure to Drought (PhyExpo)	Patnagarh	Titlagarh	Saintala
Drought Risk (DRI= CDVI * PhyExpo/ CDAI)	Patnagarh	Titlagarh	Saintala
Among Livelihood Groups			
Drought Vulnerability(CDVI)	Small Farmers	Large Farmers	Livestock Rearers
Drought Adaptability (CDAI)	Service Holders	Marginal Farmers	Forest Resource Dependants
Physical Exposure to Drought (PhyExpo)	Marginal Farmers	Rural Artisans	Agricultural Labourers
Drought Risk (DRI= CDVI * PhyExpo/ CDAI)	Marginal Farmers	Rural Artisans	Agricultural Labourers

Major Findings: Causes of Vulnerability

Case of Study Blocks:

- Major causes of vulnerability of Saintala (most vulnerable) were high level of rainfall variability, low AWHC of soil, higher poverty level, low level of crop insurance coverage, high level of unirrigated area and lower forest coverage.
- Major causes of vulnerability of Titlagarh (least vulnerable) were low level of crop insurance coverage, higher percentage of landless and marginal labourers, and higher population density.
- Major causes of vulnerability of Patnagarh (moderately vulnerable) were higher land slope, high level of rainfall variability and drought intensity, lower crop insurance coverage, larger proportion of barren, uncultivable and other fallows, and high level of unirrigated area.

Case of Livelihood Groups:

- Major causes of vulnerability of marginal and small farmers (most vulnerable) were larger decline in cultivated area, larger expenditure decline, high level of poverty, lower crop insurance coverage, high level of illiteracy, and low irrigation coverage.
- Major causes of vulnerability of large farmers (least vulnerable) were lower crop insurance coverage, low irrigation coverage, larger decline in cultivated area, income and expenditure, and higher proportion of upland and wasteland.

CONCLUSIONS

- The analysis reveals that while the drought risk level varies widely across the blocks and the extent of drought vulnerability and physical exposure to drought vary moderately, the coping capacity of different blocks vary marginally.
- However, the coping capacity in the study blocks was considerably lower than the extent of drought risk and vulnerability.

- Firstly, the irrigation coverage has to be raised in the region through developing micro level water resources since most of the bio-physical and socio-economic factors are conducive.

- The ground water resources remained underutilized due to inadequate power supply. The delivery of electricity at farmers' field needs to be assured so as to encourage the use of ground water.

CONCLUSIONS

- Institutional support system is required to be strengthened. Marketing facilities, increasing crop insurance coverage and streamlining institutional credit to agriculture sector are some of the vital steps for reducing the level of drought risk and vulnerability in the region

- The income and crop diversification process has not yet been successful for reducing the risks. Occupational diversification at local level has to be given due importance so as to check the extent of out migration. Other livelihood generating activities like artisanship, livestock rearing, small businesses should be encouraged through proper policy instruments.

- Restoration of bio-diversity by safeguarding indigenous crop varieties, sustained R & D efforts for developing drought resistant crop varieties and revival of traditional WHSs require urgent policy attention for reducing the extent of drought vulnerability and risk in one of the most poverty stricken districts of India.

THANK YOU