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ASSESS THE VULNERABILITY OF CLIMATE CHANGE IN KRISHNA RIVER BASIN OF ANDHRA PRADESH

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ABSTRACT

Climate change is essentially a long term phenomenon and is supposed to be gradual in its impact for most part. Integrated assessment combining insights of many disciplines is used as a primary tool in order to follow the causal chain of events from perturbations in the environment to the final outcomes. This can be done by first assessing the vulnerability of different regions to climatic change and then quantifying its impact on agriculture using the long term data. The present paper applies a statistical methodology to rank the districts of Krishna river basin in terms of vulnerability and to classify them into different levels of vulnerability by constructing composite vulnerability indices.

INTRODUCTION

Climate change (CC) or global warming is an important issue on which research is being carried out globally now. CC will have multi-dimensional effect on humanity in terms of several socio-economic parameters. Any scientific study on CC should take into account vulnerabilities of the different regions and then it has to study its impacts on several sectors. IPCC (2007) defines vulnerability as '*the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity*'. The purpose of the present paper is two-fold. First an attempt has been made to apply a statistical methodology for assessing vulnerability of Krishna river basin of Andhra Pradesh. Among the different sectors, agriculture is the most important sector which will be clearly affected by CC. Hence, the second objective is to study the impact of CC on agriculture in Krishna river basin of Andhra Pradesh using an econometric model.

MATERIALS AND METHODS

Vulnerability Index: Vulnerability to climate change (CC) is a comprehensive multidimensional concept affected by large number of related indicators and hence it is necessary to measure the quantum of vulnerability by constructing a vulnerability index for each district. This index is a composite one constructed on the basis of several factors, which are prone to be affected by climatic change. Following Patnaik and Narayanan (2005), these factors can be grouped into five components namely, 1.Demographic 2. Climatic 3. Agriculture 4. Occupational and 5. Geographic. Each one of these components can have several sub-indicators. Using the methodology developed by Iyengar and Sudharshan (1982), a composite index from multivariate data was worked out and based on the index, all the districts falling within the river basin were ranked in terms of their vulnerability to climate change into five different categories namely, less vulnerable, moderately vulnerable, vulnerable, highly vulnerable and very highly vulnerable. There are 10 districts within the river basin namely, Anatapur, Kurnool, Prakasam, Guntur, Krishna, Khammam, Nalgonda, Warangal, Mahboobnagar and Rangareddy. But due to lack of time series data for Prakasm district it was not included in the analysis. In the present study the following indicators were employed for the construction of vulnerability index.

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Demographic vulnerability

There are three components involved in this index to explain the demographic patterns of the people living in the respective district.

i. Density of population (persons per square kilometer)
ii. Literacy rate (percentage)
iii. Infant mortality rate (deaths per '000 infants)

Climatic vulnerability

This index tries to take into account basic climatic variability. It combines six separate indices which are the variances of

i. Annual rainfall (mm^2)
ii. South west monsoon (mm^2)
iii. North east monsoon (mm^2)
iv. Maximum temperature ($(^oC)^2$)
v. Minimum temperature ($(^oC)^2$)
vi. Diurnal temperature variation ($(^oC)^2$)

Agricultural vulnerability

This includes the following variables to predict the vulnerability related to agricultural activities.
i. Production of food grains (tonnes / hectare)
ii. Productivity of major crops (tonnes/ hectare)
iii. Cropping intensity (percentage)
iv. Irrigation intensity (percentage)
v. Livestock population (Number per hectare of net sown area)
vi. Forest area (percentage geographic area)

Occupational vulnerability

Six indicators were taken to calculate the vulnerability related to occupational characteristics of people and all these variables are converted into per hectare of net sown area.
i. Number of cultivators
ii. Total main workers
iii. Agricultural labourers
iv. Marginal workers
v. Industrial workers
vi. Non workers

Geographic vulnerability

i. Coastal length (kilometer)
ii. Geographical area (hectare)

Iyengar and Sudarshan (1982) developed to work out a composite index from multivariate data and it was used to rank the districts in terms of their economic performance. This methodology is well suited for the development of composite index of vulnerability to CC also. A brief discussion of the methodology is given below. It is assumed that there are *M* regions/districts, K components for vulnerability and C_k is the number of variables in component *k* so that *kic X* is the value of the variable c_k of the k^{th} component for the i^{th} region(). First, these values of vulnerability indicators which may be in different units of measurement are standardized. When the observed values are related positively to the vulnerability, the standardization is achieved by employing the formula

$$y_{id} = (X_{id} - Min\ X_{id})/(Max\ X_{id} - Min\ X_{id})$$

When the values of X_{id} are negatively related to the vulnerability, the standardized values would be computed by

$$y_{id} = (Max\ X_{id} - X_{id})/(Max\ X_{id} - Min\ X_{id})$$

where $Min\ X_{id}$ and $Max\ X_{id}$ are the minimum and maximum of $(X_{i1}, X_{i2}, ...X_{in})$ respectively. Obviously these standardized indices lie between 0 and 1. The level or stage of development of d^{th} zone is assumed to be a linear sum of y_{id} as

$$\overline{y_d} = \sum_{i=1}^{m} w_i y_{id}$$

Where w's $(0 < w < 1\ and \sum_{i=1}^{n} w_i = 1)$ are the weights determined by

$$w_i = \frac{k}{\sqrt{\text{var}\ (y_i)}}$$

$$k = \left[\sum_{i=1}^{n} \frac{1}{\sqrt{Var(y_i)}}\right]^{-1}$$

The choice of the weights in this manner would ensure that large variation in any one of the indicators would not unduly dominate the contribution of the rest of the indicators and distort inter zone comparisons. For classificatory purposes, a simple ranking of the zone indices viz., y_d would be enough. However for a meaningful characterization of the different stages of vulnerability, suitable fractile classification from an assumed distribution is needed. Probability distribution which is widely used is the Beta distribution. This distribution is defined by

$$f(z) = x^{a-1}(1-x)^{b-1} / b(a,b),\ \ 0 £ x £ 1\ and\ a,b > 0.$$

This distribution has two parameters *a* and *b*. They can be estimated by using the method given by Iyengar and Sudharshan (1982). The Beta distribution is skewed. Let $(0,z_1),(z_1,z_2),(z_2,z_2),(z_3,z_4)$ and $(z_4,1)$ be the linear intervals and each interval has the same probability weight of 20 per cent. These fractile intervals can be used to characterize the various stages of vulnerability.

1.	Less vulnerable	If	$0 < y_d < z_1$
2.	Moderately Vulnerable	If	$z_1 < y_d < z_2$
3.	Vulnerable	If	$z_2 < y_d < z_3$
4.	Highly vulnerable	If	$z_3 < y_d < z_4$
5.	Very highly vulnerable	If	$z_4 < y_d < 1$

RESULTS AND DISCUSSION

Measuring Vulnerability of districts under Krishna river basin

The vulnerability indices for all the 10 districts were constructed as per the methodology described earlier. Based on the indices, the districts were ranked and the rankings are given in Table 1. The vulnerability indices were subjected to further statistical analysis for classifying them into different categories. For this Beta probability distribution was fitted to the observed indices and the percentile values at 20, 40, 60, and 80 were taken as cut-off points for the five groups. This resulted in the classification as given in Table 2. The table indicates that out of the 9 districts, Anantapur district occupies rank 1 in term of vulnerability under all the three components and also overall vulnerability. The second rank is occupied by Ranga Reddy in terms of vulnerability. Warangal district is least vulnerable among the districts of Krishna basin. It has a very vulnerability index of 0.3706.

Table 1. Vulnerability Index and ranks for districts under Krishna river basin

	Districts	Vulnerability index	Rank
1	Anantapur	0.614	1
2	Guntur	0.437	6
3	Hyderabad (Ranga Reddy)	0.510	2
4	Khammam	0.412	7
5	Krishna	0.465	4
6	Kurnool	0.439	5
7	Mahabubnagar	0.481	3
8	Nalgonda	0.393	8
9	Warangal	0.370	9

Table 2. Classification of districts under Krishna river basin in terms of Vulnerability

S. No	Classification	Districts
1	Less vulnerable	Nalgonda Warangal
2	Moderately vulnerable	Kurnool, Guntur Khammam
3	Vulnerable	Krishna
4	Highly vulnerable	Hyderabad (Ranga Reddy) Mahabubnagar
5	Very high vulnerable	Anantapur

Conclusions

The present paper provides the classification of districts of Krishna river basin into different categories of vulnerability. The study has identified Anantapur district as very highly vulnerable and two districts namely Nalgonda and Warangal as least vulnerable. This conclusion will very much useful for planning suitable remedial measures to mitigate the effects of climate change

Recommendations

The Vulnerability Index is emerging as a promising planning tool for climate change adaptation at river basin level. Using the results of the Vulnerability index (VI) of the districts, the adaptation practices being practiced in the extreme situations has to be documented. This would provide indications to similar currently non-vulnerable districts of locations in which to study successful societal adaptation. Awareness has to be created on climate change and adaptation methods to overcome the extremities of climate change. Facilitating the availability of credit to the farmers during the critical climatic conditions to go for new technologies or adaptations. In case of individual farm level measures such as early sowing at farm ponds, soil moisture conservation by in-situ green manure crops etc can be very useful to conserve water. To achieve better results, participatory approach involving all possible stake holders' viz., farmer's organizations, water users associations, department of agriculture, department of irrigation, district water management agency, NGOs etc. has to deserve special attention. This facilitates the researchers to plan the water management strategies more effectively and efficiently so as to combat the declining economic efficiency of irrigation water resources in NSP right canal command area.

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