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DEVELOPMENT OF A VULNERABILITY INDEX TO ASSESS VULNERABILITY STATUS OF THE FARMERS AND DISTRICT DUE TO CLIMATE CHANGE

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ABSTRACT
Climate change poses a major threat which is characterized by scanty and uncertain rainfall, infertile soils, poor infrastructure, extreme poverty and rapid population growth. These conditions present serious environmental, economic and social impacts on the agricultural community. In recent years, adaptation to climate change has become a major concern to farmers, researchers and policy makers alike. To enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have knowledge on their vulnerability status to climate change and factors affecting it. An attempt has been made to develop a vulnerability index to assess the vulnerability status of the farmers and districts to climate change in Hyderabad Karnataka region. Based on the review of literature and discussion with experts, three dimensions of vulnerability due to climate change were identified. The relevancy rating was obtained from 60 judges in the concerned area. Based on the relevancy percentage the indicators with relevancy coefficient of 0.80 and above were considered for inclusion in the vulnerability index. To compute the scale values for each of the identified dimensions, their relative importance in the vulnerability was worked out by adopting normalized ranking method recommended by Guilford (1954).

KEYWORDS: rainfall, infertile soils, poor infrastructure, extreme poverty, rapid population growth.

INTRODUCTION
Climate change poses a major threat which is characterized by scanty and uncertain rainfall, infertile soils, poor infrastructure, extreme poverty and rapid population growth. These conditions present serious environmental, economic and social impacts on the agricultural community. In recent years, adaptation to climate change has become a major concern to farmers, researchers and policy makers alike. To enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have knowledge on their vulnerability status to climate change and factors affecting it. The effects of global climate change are many folds and there is a need to create awareness and its impact on various sectors of economy. Agriculture and Climate are mutually dependent. There is a need to understand the influence of climate change on agricultural sector both at Global and as well as at regional level, especially from the point of view of providing food to vulnerable section of the population. Changing climatic conditions can have the big effect on our life and our environment. In fact, it is the greatest environmental threat faced by the planet earth. The climate has changed and the major environmental problem in crop production is recurrent droughts, hailstorms, floods and pest incidence (Befekadu and Berhanu, 2000).

The various studies show the overall loss in the crop production in the country in the last few years due to the anticipated rise in the temperature. It is expected that in the near future India is going to face the challenges that includes unwanted pressure from the growing population, and changing scenario of world trade in agriculture. With unpredictable weather, farmers keep changing crop management practices by growing resistant varieties and are prepared for constant change in the farming practices (UNFCCC, 1992).

In case of Karnataka, national-level projections on climate change impacts have shown that the state is highly vulnerable to climate change uncertainties which could affect millions in rural and urban areas, in addition to adversely impacting food production, water resources, fisheries, biodiversity and livelihoods of the communities dependent on the natural resources. Agriculture in Karnataka has occupied around 19 million hectares of land, out of which about 10.6 million hectares of land is being cultivated in all the three seasons in a year. The main season for agriculture in Karnataka is monsoon as irrigation is done below 28 per cent of the total cropped area. Thus, the agriculture sector is likely to be more affected by climate change. This poses a challenge to the state due to its dependence on climate-sensitive economic activities and predominantly in practicing rain- sustained agricultural activities. Micro level studies on effect of climate change on people’s livelihood at farm level and their consequent responses are relatively few.

Overwhelming scientific research and evidence have shown that the climate is changing. While there is still ongoing scientific exploration into climate change, IRRI recognizes two universal trends predicted by all climate change models:

- Temperatures will increase, resulting in more heat stress and rising sea levels.
- There will be more frequent and severe climate extremes

Vulnerability is a multidimensional concept (Thornton et al., 2006) which varies across temporal and spatial scales and depends on economic, social, geographic, demographic, cultural, institutional, governance and environmental factors. "Vulnerability is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity." Thus vulnerability of any system is frequently considered as a function of three elements: exposed to a hazard, sensitivity to that hazard and the capacity of the system to cope with and adapt or recover from the effects of those conditions (Reed et al., 2013; Smit and Wandel, 2006) which are mostly referred to as adaptive capacity. Also, Chinwendu at al. (2017) argued that vulnerability is a degree of risk and inability to resist to climate deviations.

Exposure is defined as the level and extent to which a farmer and district is exposed to major climate change. Sensitivity refers to direct or indirect changes due to climate change for which a farmer and district is affected either adversely or beneficially. Adaptive capacity is the ability or potential of a farmer and district to respond successfully to climate change including adjustments in behaviour. Resource and technologies.

Operationalization of Vulnerability of farmers: Vulnerability is operationally defined as the degree to which farmers are susceptible, or unable to cope with adverse effect of climate change, including climate variability and extremes.

Operationalization of Vulnerability of Districts: Vulnerability is operationally defined as the degree to which districts are susceptible, or unable to cope with adverse effect of climate change, including climate variability and extremes.

METHODOLOGY

The present index was developed by following the procedure as given below:

Step1: Identification of Dimensions

The vulnerability to climate change of the district and farmers was identified as a dependent variable. Based on a thorough review of literature related to vulnerability to climate change, three dimensions were identified viz.,

- Exposure,
- Sensitivity and
- Adaptive capacity.

Further the different indicators were framed under each component.

Step 2: Collection of indicators

A large number of draft indicators on each dimension of vulnerability of climate change were collected based on review of literature, discussion with concerned specialists. These indicators were carefully edited, revised and restructured.

Step 3: Relevancy weightage

The components were mailed to 100 experts in the agricultural extension and other related fields to critically evaluate the relevancy of each component in the four-point continuum viz., Most Relevant (MR), Relevant (R), Somewhat Relevant (SWR) and Not Relevant (NR) with the score of 4, 3, 2 and 1 respectively. A total of 67 judges returned the questionnaires duly completed and 60 were considered for further processing. From the data gathered, Relevancy Percentage, Relevancy weightage and Mean Relevancy Score were worked out for all the indicators by using the formula.

$$\mathrm{R.W} = \frac{\mathrm{MRX\ 4 + R\ X\ 3 + SWR\ X\ 2 + NR\ X\ 1}}{\mathrm{No.\ of\ judge\ respond\ x\ Maximum\ score}} x\ 100$$

$$\mathrm{MRS} = \frac{\mathrm{MR\ X\ 4 + R\ X\ 3 + SWR\ X\ 2 + NR\ X\ 1}}{\mathrm{No.\ of\ judge\ respond}}$$

R.W- Relevancy weightage
MRS – Mean Relevancy Score

Taking into consideration the overall values, the items having relevancy percentage of equal and more than 80.00 per cent, relevancy weightage of equal and more than 0.80 were considered for the inclusion in further analysis. Thus, indicators were considered for further processing and suitably modified as per the comments of experts wherever applicable. The indicators that have passed the criteria are presented below.

TABLE 1: Relevancy weightage on vulnerability index indicators for farmer's level

Sl. No.	Components	Relevancy Percentage	Relevancy Coefficient	Mean Relevancy Score
I EXPOSURE				
1	Change in annual rainfall	95.42	0.95	3.82
2	Change in number of rainy days	89.58	0.90	3.58
3	Change in maximum temperature	89.58	0.90	3.58
4	Change in minimum temperature	85.83	0.86	3.43
5	Change in April-May Rainfall	86.25	0.86	3.45
6	Change in June-July Rainfall	87.92	0.88	3.52
7	Change in October-November Rainfall	83.75	0.84	3.35
II SENSITIVITY				
A	Demographic			
8	Number Adult members Unemployed in the family	80.83	0.81	3.23
9	Family member involved in agriculture and subsidiary occupations	87.50	0.88	3.50
B	Land			
10	Land size	90.83	0.91	3.63
11	Uncultivated land area	85.00	0.85	3.40
12	Rainfed land	92.50	0.93	3.70
13	Irrigated land	91.25	0.91	3.65
C	Agricultural Components			
14	Cropping Intensity	87.92	0.88	3.52
15	Crop Diversified	90.42	0.90	3.62
16	Chemical fertilizer consumption	82.92	0.83	3.32
17	Irrigation Intensity	90.83	0.91	3.63
18	Economic Yield	93.33	0.93	3.73
19	Groundwater Availability	91.67	0.92	3.67
20	Area Under Drought resistant Variety	88.33	0.88	3.53
III ADAPTIVE CAPACITY				
A	ECONOMICAL CAPABILITY			
21	Availability of credit	91.25	0.91	3.65
22	Crop insurance	92.92	0.93	3.72
23	Livestock units	86.67	0.87	3.47
24	Ratio of Irrigated to rainfed land	87.50	0.88	3.50
25	Income from all source	91.25	0.91	3.65
26	Land ownership	82.92	0.83	3.32
27	Habit of Savings	84.58	0.85	3.38
28	Proportion of household expenditure to Agriculture and allied activities	84.58	0.85	3.38
B	SOCAIL CAPABILITY			
29	Extension Contact	89.58	0.90	3.58
30	Social Participation	86.67	0.87	3.47
31	Social Migration	83.33	0.83	3.33
32	Community Participation	88.75	0.89	3.55
33	Assistance from external agency	88.33	0.88	3.53
34	Farmer to farmer extension	89.58	0.90	3.58
C	HUMAN RESOURCE CAPABILITY			
35	Number of Adult Family member	81.67	0.82	3.27
36	Household head education	85.83	0.86	3.43
37	Family Education Status	83.75	0.84	3.35
D	INSTITUTIONAL CAPABILITY			
38	Access to nearest health center	86.25	0.86	3.45
39	Access to main road	84.17	0.84	3.37
40	Access to healthy drinking water	83.33	0.83	3.33
41	Access to market	90.83	0.91	3.63
42	Sources of climatic information	89.58	0.90	3.58
43	Access to educational facilities	86.67	0.87	3.47
44	Access to communication channels	88.75	0.89	3.55
45	Access to Agricultural inputs	92.08	0.92	3.68
46	Access to Technology	94.17	0.94	3.77

TABLE 2: Relevancy weightage on vulnerability index indicators for district level

Sl.No.	Components	Relevancy Percentage	Relevancy Coefficient	Mean Relevancy Score
I EXPOSURE				
1	Change in annual rainfall	95.42	0.95	3.82
2	Change in number of rainy days	89.58	0.90	3.58
3	Change in maximum temperature	89.58	0.90	3.58
4	Change in minimum temperature	85.83	0.86	3.43
5	Change in April-May Rainfall	86.25	0.86	3.45
6	Change in June-July Rainfall	87.92	0.88	3.52
7	Change in October-November Rainfall	83.75	0.84	3.35
II SENSITIVITY				
8	Net sown area	86.25	0.86	3.45
9	Degraded or Waste Land	86.25	0.86	3.45
10	Annual rainfall	90.00	0.90	3.60
11	Flood proneness	80.42	0.80	3.22
12	Drought proneness	92.92	0.93	3.72
13	Available water holding capacity of soil	90.42	0.90	3.62
14	Rural population density	80.42	0.80	3.22
15	Small and Marginal farmers	79.58	0.80	3.18
16	Forest Area	87.50	0.88	3.50
III ADAPTIVE CAPACITY				
17	Rural poor	84.58	0.85	3.38
18	Agricultural Workers	83.75	0.84	3.35
19	Total literacy	86.25	0.86	3.45
20	Access to markets	89.17	0.89	3.57
21	Road connectivity	87.92	0.88	3.52
22	Rural electrification	86.67	0.87	3.47
23	Net irrigated area	90.83	0.91	3.63
24	Livestock population	87.50	0.88	3.50
25	Groundwater availability	88.33	0.88	3.53

Step 4: Computation of Scale Values

In order to compute the scale values for each of the identified dimensions based on the relevancy percentage, the vulnerability for the district and farmers was worked out by adopting normalized ranking method recommended by Guilford (1954).

A list of experts was prepared and considered for seeking opinion. The judges were requested to give rank order based on the relative importance of the dimensions. After receiving ratings from the judges, they were used in calculation of scale values. Ranking the components based on their relative importance. Ranks were converted to rank values using the formula:

Ri= (n-ri+1)

Where, Ri = Rank values
n = Number of dimensions
ri = Ranks given by judges to three dimensions.

$$P = \frac{(Ri - 0.5)100}{n}$$

Where, P= Centile position
Ri = Rank value
n = Number of indicators

The calculation of scale values was done by working out the ‘P’ based on the formula recommended by Guilford (1954), working out ‘C’ scale values based on hull table (Hull, 1928), calculating ‘Rj’ value and finally determining the scale values (Rc).

Rj=∑fjiC
Rc= 2.357*Rj – 7.01

Where
Rc= scale value
C= Values determined to each centile value
Ri = Rank value

TABLE 3: Calculation of scale values for dimensions of vulnerability to climate change of farmer’s level on the judges rating

Ri	Ri	D1	D2	D3	Total	P	C
1	3	21	17	22	60	83.33	7
2	2	22	26	12	60	50.00	5
3	1	17	17	26	60	16.67	3
∑fji		60	60	60	180		
Rj=∑fjiC		308	300	292	900		
R=Rj/∑fji		5.13	5.00	4.87	5.00		
Rc*		5.09	4.78	4.46	4.78		

TABLE 4: Scale values of vulnerability to climate change of farmer level

Sl.No.	Components	Final Scale Values	Ranks
1	Exposure	5.09	I
2	Sensitivity	4.78	II
3	Adaptive Capacity	4.46	III

TABLE 5: Calculation of scale values for dimensions of vulnerability to climate change of district level on the judges rating

Ri	Ri	D1	D2	D3	Total	P	C
1	3	20	17	23	60	83.33	7
2	2	25	22	13	60	50.00	5
3	1	15	21	24	60	16.67	3
∑fji		60	60	60	180		
Rj=∑fjiC		310	292	298	900		
R=Rj/∑fji		5.17	4.87	4.97	5.00		
Rc*		5.17	4.46	4.70	4.78		

TABLE 6: Scale values of vulnerability to climate change of district level

Sl. No.	Components	Final Scale Values	Ranks
1	Exposure	5.17	I
2	Sensitivity	4.46	III
3	Adaptive Capacity	4.70	II

Step 5: Measurement procedures of indicators

As the index developed was composite in nature, the indicator measures include both quantitative and qualitative procedures. Under each indicator, suitable sub indicators and variables are identified and levels of measurement were fixed for variables.

Step 6: Schedule development

For all the indicators, a schedule was prepared to elicit appropriate variability for vulnerability of Farmers. A pilot study was conducted among 30 respondents in non-sample to test the reliability and validity.

Testing for reliability

The coefficient of equivalence (split-half method) was employed to measure the reliability of the index.

Split-half method of reliability

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

Spearmen-Brown prophecy formula was employed to study the reliability of the original length from the value of Split half reliability.

$$r11 = \frac{2 * r}{1 + r}$$

The reliability coefficient was found to be **0.86**, which is higher than the standard of 0.70, indicating higher reliability of the index.

Validity of the index

The data were subjected to statistical validity, which was found to be **0.96**, for vulnerability to climate change index, which is higher than the standard of 0.70. Hence, the validity co-efficient was also found to be most appropriate.

Validity $=\sqrt{r11}$

Where r11= test reliability

Calculation of the vulnerability index

The normalized indicators are then multiplied with the assigned weights to construct the indices separately for each component of vulnerability viz. exposure, sensitivity and adaptive capacity separately. Finally, vulnerability index for farmers and each district is calculated as:

VI = (EI+SI) – AI

Where,
VI is the Vulnerability index,
AI is the Adaptive Capacity index,
EI is the Exposure Index and
SI is the Sensitivity index

CONCLUSION

An index consisting three dimensions will serve as a handy tool to assess the vulnerability to climate change of the farmer's level and district level and it will enable the researchers to take up studies on vulnerability to climate change of the farmers as well as a districts of Hyderabad-Karnataka region. The scale values will be used to identify the level of vulnerability to climate change of each district and each farmer.

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