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Factors softening drought vulnerability of farm households in Nagaland

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ABSTRACT

Droughts have serious implication on vulnerability of farm households through its effect on farming. Hence, this paper attempts to identify the factors softening the farm households' vulnerability in Nagaland. Reconnaissance Drought Index was calculated using gridded daily rainfall (0.25° X 0.25°) and temperature (0.1° X 0.1°) data for the year of 1975-2013. Drought vulnerability index for farm households was calculated deducting the adaptive capacity index from the sum of exposure and sensitivity index. About 38.46% and 41.02% of the 39 years under study were 'Normal condition-dry' in Phek in Dimapur district, respectively. Majority of the households were either highly (59%) or moderately (37%) vulnerable in the study area due to very low adaptive capacity especially in terms of physical and financial assets. Factors like educational status, gender, irrigation facility, crop diversification, income from livestock and non-farm activities, extension contact found to reduce vulnerability. Hence, improvement of the physical assets and financial abilities of the farmers will help them to adapt to drought vulnerability.

1. Introduction

Increase in temperature enhances evapo-transpiration and other physiological processes. This coupled with late monsoon or deviation in rainfall adversely affects the soil moisture content and induces drought like situation. Low moisture or drought reduces the crop yields and severe drought stress during reproductive stage can lead to complete crop failure (Nguyen 2011). Beyond direct economic impacts, prolong drought can threaten drinking water supplies, ecosystems and can even contribute to increased food prices (FAO 2008). At farm level, in India during bad monsoon days the price of food grains increase by 10% and income become unstable (Mooley *et al.,* 1981). Hence the farm households are sensitive to drought exposure and this will affect their agricultural production, livestock and their daily activities. At the same time the farming community will also try to cushion themselves with their initiatives to the situation. Farmers who have more adaptive capacities to drought will be less vulnerable to drought. In overall, this will signify the vulnerability of farm households to drought . The most concerned consequences and steps to overcome the impact of drought and its risk on the farming household is unresolved. The small holders have the least capacity to overcome the consequences due to their poor resource base and knowledge to adapt; hence they are likely to be more affected by the problems of drought. The IPCC in its fourth assessment report defined vulnerability to climate change as ''the degree to which a system is susceptible, or unable to cope with adverse effect of climate change, including climate variability and extremes'' (IPCC 2001). Then it redefined vulnerability by excluding exposure as the "propensity or predisposition to be adversely affected". The IPCC has specified three components of vulnerability in the climate change context: exposure, sensitivity and adaptive capacity (IPCC 2007).

Drought in North Eastern Himalayan region of India

Often many districts of the North Eastern region of India face severe water scarcity during the winter and summer months despite falling in the high rainfall zone. Seven districts of NE state *viz.* Senapati and Imphal East in Manipur; Ri-Bhoi and

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West Garo Hills in Meghalaya; Phek, Dimapur and Mokokchung in Nagaland are vulnerable to drought (Venkateswarlu *et al.,* 2012). Moreover, the state Nagaland has registered 32, 60, 30 and 58% deficit in monsoon rainfall during 2012, 2013, 2014 and 2015, respectively (GoI 2015). Hence, this paper is an attempt to assess vulnerability of farm households and factors capable of softening it in Phek and Dimapur district of Nagaland.

2. Materials and Methods

2.1 Study area

Nagaland is located at 25.6^{0}N and 27.4^{0}N latitude and 93.20^{0}E and 95.15^{0}E longitude in the NE region of India. Topographically, the state is mountainous and the altitude varies from 194 m to 3048 m above mean sea level (AMSL) (GoN 2013). The state is inhabited by 16 major tribes *viz. Ao*, *Angami*, *Chang*, *Konyak*, *Lotha*, *Sumi*, *Chakhesang*, *etc.* with their distinctive languages and cultures. The total population is about 19.80 lakh, out of which 71.14% of the population lives in rural areas (Census 2011). The population density in the state is 119 per sq. km. The sex ratio is at 931: 1000 (female: male) and the literacy rate is at 79.55 % (GoN 2013). Agriculture is the largest source of livelihood for majority of the people of Nagaland. Agriculture contributes 28.71% to the Net State Domestic Product (NSDP) (GoN, 2012) and employs 70% of the population. About 80% of the cropped area is under rice crop (GoN 2013). The total irrigated area is only 0.09 mha which is only 18.92% of the total cultivated area of the state (GoN, 2013).

Sampling and data

For the present study, multistage sampling technique was applied. Dimapur and Phek were selected randomly from the three drought vulnerable districts of Nagaland. In next stage Dhansiripar block of Dimapur and Kikruma block of Phek in Nagaland were selected purposively as they has been identified as the most stressed blocks to drought (Venkateswarlu *et al.,* 2012). A random sample of 120 farmers was drawn from two villages of the selected blocks. Primary data on socio-economic variables, area and productivity of crops, annual income, and availability of food, water, fuel migration *etc*. were collected from the respondents using the pre-tested and structured schedule through personal interview of the households during 2015-2016. The daily gridded rainfall (0.25° X 0.25°) and temperature (1° X 1°) data were retrieved from gridded India Meteorological Department (IMD) data set for the period of 1975-2013 to estimate the drought intensity in Nagaland.

Analytical Techniques

Exposure of the farms to drought

At first Potential evapo-transpiration (PET) was calculated using extra-terrestrial radiation and temperature data. Then Reconnaissance Drought Index (RDI) was calculated for 39 years (1975-2013) using rainfall data and PET estimates. Detailed methodology may be referred from Kusre and Lalringliana (2014) and Nongbri *et al.* (2016). After standardization, the RDI was normalised so as to bring their values under a suitable range *i.e.* 0-1 range. Normalised RDI (RDI_n) is the drought exposure index for the farms. The estimated RDI_{std} were first normalized (RDI_n) and then exposure index was calculated by averaging the RDI_n.

Sensitivity of the farm households to drought

Sensitivity is the degree to which a system is affected either adversely or beneficially by climate related stimuli (IPCC 2001). Sensitivity was studied at farm or household level using seven indicators *viz.* productivity of rice during drought (kg/ha), annual income from livestock and poultry (₹ /household), annual income from non-farm sector (₹ /household), time spent to fetch drinking water (hour/day), irrigation availability (no = 1, yes = 0), rice availability during drought (months/ year) and fuel availability (decrease = 0, no change = 1, increase = 2).

Adaptive capacity of the farm households to drought

Adaptive capacity is the ability of a system to adjust to climate change including climate variability and extremes to moderate the potential damage from it, to take advantage of its opportunities or to cope with its consequences (IPCC 2001). Four livelihood assets *viz.* human, social, financial and physical or natural assets were studied to assess the adaptive capacity of the farm households.

Human assets: It includes those indicators which are related to the skills, knowledge and experience possessed by an individual or family which enhances the adaptive capacity and increase the available livelihood options. Five indicators *viz.* age of the household head (years), gender of the household head (female = 0, male = 1), educational level of the household head (illiterate = 1, primary = 2, middle = 3, secondary = 4, higher secondary = 5 and university = 6), family size (number/household), Earners over total family were used to construct the human asset index.

Physical or natural assets: It includes all the assets owned by a farm household which are used for his agricultural productions and livelihood. The indicators used were household structure (*kaccha* = 0, *semi-pucca* = 1, *pucca*[1] = 2), operational land holding (ha), herd strength (numbers), modern farm equipments used (no = 0, yes = 1), land under irrigation (ha) and crop diversification (no = 0, yes = 1).

Financial assets: It includes the individual's financial assets like income from agriculture and other employment opportunities. The indicators used were income from major crops (₹/ household), income from livestock (₹/ household), other sources of income apart from farm and non farm income (no = 0, yes = 1), employment generation schemes (number of employment days in a year) and access to credit (no = 0, yes = 1).

Social assets: It includes all the indicators which are related to the association ship of an individual with one another or with different institutions in gaining knowledge about the day to day activities related to drought and the like. Through this association and relationship, the individual is able to share and learn about their past and present strategies so as to increase their adaptive knowledge and capacity for the future. The indicators used were extension contact (no = 0, yes = 1), farmer to farmer contact (no = 0, yes = 1), access to climatic information (no = 0, yes = 1), distance of household from nearest market (km) and migration (no = 0, yes = 1).

Vulnerability of the farm households

Vulnerability is a character, magnitude and rate of climatic variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2001). Vulnerability indices for individual farm households were calculated as:

$$\text{Vulnerability} = (\text{exposure} + \text{sensitivity}) - \text{adaptive capacity} \qquad \text{..........} \ (i)$$

3. Results and Discussion

Vulnerability of farm households

Exposure is the nature and degree to which a system is exposed to significant climatic variations (IPCC 2001). Changes or variations in the climatic variables like rainfall and temperature are the indicators of exposure (Table 1). The average annual rainfall was comparatively higher in Phek (1630.67 mm) than in Dimapur (1491.88 mm) district during 1975-2013. The estimated average normalized (RDI_n) were 0.45 for Phek and 0.53 for Dimapur. Mild drought was common in both the districts *i.e.* 38.46% in Phek and 41.02% in Dimapur were in the class of Normal condition-dry. Both the districts also faced moderate droughts, but the frequency of occurrence was relatively higher in Dimapur than Phek.

Six years were severe drought years and two years were extreme drought years in Dimapur; whereas, only one year was extreme drought but no severe drought was registered at Phek during the same period (Table 1). The sensitivity of farm households to drought was high in both the districts due to low productivity of rice (1134 kg/ha) during the drought period, poor irrigation and poor drinking water facility in the sample villages. The sensitivity of the farm households in Dimapur was higher than in Phek (Table 2). The minimum value of the sensitivity index was as high as 0.50 in Dimapur. No sample farmers had any irrigation facility in Dimapur and the farmers spent about 52 minutes per day for fetching drinking water. Majority of the households in the study area fell in moderately (90%) sensitive category (Table 3). The average adaptive capacity of sample households was very low in both the districts (0.27 to 0.29). Even the maximum values for the adaptive capacity index were only 0.40 in Phek and 0.38 in Dimapur (Table 2). Majority of the households had medium adaptive capacity to drought (64%); followed by low (36%) adaptive capacity (Table 3) which was due to extremely poor physical and financial asset conditions of the farm households in the study area (Annexure 1).

Table 1. Average annual temperature, annual rainfall and RD in during 1975-2013

Particulars	Phek	Dimapur
Mean temperature (^{0}C)	23.98	22.81
Rainfall (mm)	1155	948
Reconnaissance Drought Index (normalized)	0.45	0.53
Number of Normal condition-dry years (0.00 to -0.99)	15	16
Number of Moderate drought year (-1.00 to -1.49)	5	7
Number of severe drought year (-1.50 to -1.99)	0	6
Number of extreme drought year ($\leq$ -2.00)	1	2

[1] The walls and roof are made of burnt bricks, stones (packed with lime or cement), cement concrete and timber

Only 14% households possessed *pucca* houses and none of them used modern farm machineries (Nongbri *et al.,* 2016). The annual average return from rice was about ₹26274 only. The respondents got employment of average 57 days in Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) which has a mandate of providing yearly 100 days of employment to poor households (Nongbri *et al.,* 2016). Only about of 11% of them accessed any kind of credit. Legon and Scheter (2003) also reported high risk due to poor resources. The contributions of human and social assets to the overall adaptive capacity of the households were comparatively better (Figure 1). The sample villages in Phek were mostly inhabited by *Chakhesang* tribe; thus, farmer to farmer contact was better in Phek than at Dimapur. The common timing for agricultural activities in the district provided the opportunity for regular inter personal communication too. The farmers accessed climatic information through television, radio and National Innovations for Climate Resilient Agriculture (NICRA) project. The market was about 24 km from the study village in Phek and the lack of transportation facility added to the woes. The mean values of vulnerability index (VI) turned out to be very high in both the districts (Table 2) due to high sensitivity as well as low adaptive capacity of the farm households (Figure 2). The vulnerability was comparatively higher for farm households in Dimapur with maximum VI value of 1.06. Table 8 reveals that majority of the households were either highly (59%) or moderately (37%) vulnerable in the study area. In Dimapur, most of the farm households (83%) were highly vulnerable and about 5% were extremely vulnerable due to higher level of sensitivity. The CV for VI was 14% in Phek and 10% in Dimapur district implying that the inter-household variation in vulnerability was higher in Phek which was due to higher variations in adaptive capacities of the sample households (Table 2).

Factors affecting vulnerability of the farm households

The descriptive statistics for the explanatory variables are presented in Table 4. The average age of the respondents was about 52 years. Though the literacy rate was excellent they had only average four years of schooling. About 63% of the households were headed by female. This does not mean that male were absent in all of those households but in terms of managing the household, taking day to day decisions and sharing the household expenditure female elders were leaders. Most of the adult family members contributed something to the total household income which is evident from the ratio of earner to household size which was 0.43. Though the average land holding was 1.17 ha we have to remember that much of the land was on the hill slope especially in Phek district. The area under irrigation was about 25% of the average operational holding. The average yield of rice crop was only 1134 kg/ha which was much lower than other NE states like Tripura and Manipur. Crop diversification was found in case of 43% of the sample farms. Income from livestock and especially non-farm income was significant. The market was about 24 km in Phek but in case of the sample villages in Dimapur the market was nearer (5-6 km). Taking loan was not the tradition among these farmers. We saw good presence of extension machinery and farmers also availed weather information from different sources *viz.* newspaper, TV, NICRA project *etc.* Majority of the factors turned out to be negatively significant (Table 5) which indicate that the increase in the level of these variables will reduce vulnerability of farm households. Higher the productivity of rice lower is the vulnerability due to better household food security. The female headed households were less vulnerable as women are the backbone of households in the NE states which are inhabited by different tribes. They managed better the farm and household resources and also contributed financially to the household expenditure.

Table 2. Sensitivity, adaptive capacity and vulnerability indices for the farm households

Category	Sensitivity			Adaptive capacity			Vulnerability		
	Phek	Dimapur	Nagaland	Phek	Dimapur	Nagaland	Phek	Dimapur	Nagaland
Mean	0.55	0.64	0.60	0.27	0.29	0.28	0.73	0.88	0.81
Minimum	0.30	0.50	0.30	0.19	0.20	0.19	0.37	0.69	0.37
Maximum	0.67	0.76	0.76	0.40	0.38	0.40	0.90	1.06	1.06
CV (%)	12.59	9.92	13.48	17.17	15.64	16.52	14.08	10.17	15.29

Table 3. Frequency distribution (%) of the farm households across sensitivity, adaptive capacity and vulnerability categories

Category	Class (index value)	Sensitivity			Adaptive capacity			Vulnerability		
		Phek	Dimapur	Nagaland	Phek	Dimapur	Nagaland	Phek	Dimapur	Nagaland
Low	0.00-0.25	0.00	0.00	0.00	33.33	38.33	35.83	0.00	0.00	0.00
Medium	0.26-0.50	16.67	1.67	9.17	66.67	61.67	64.17	3.33	0.00	1.67
Moderate	0.51-0.75	83.33	96.67	90.00	0.00	0.00	0.00	61.67	11.67	36.67
High	0.76-1.00	0.00	1.67	0.83	0.00	0.00	0.00	35.00	83.33	59.17
Extreme	>1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	2.50

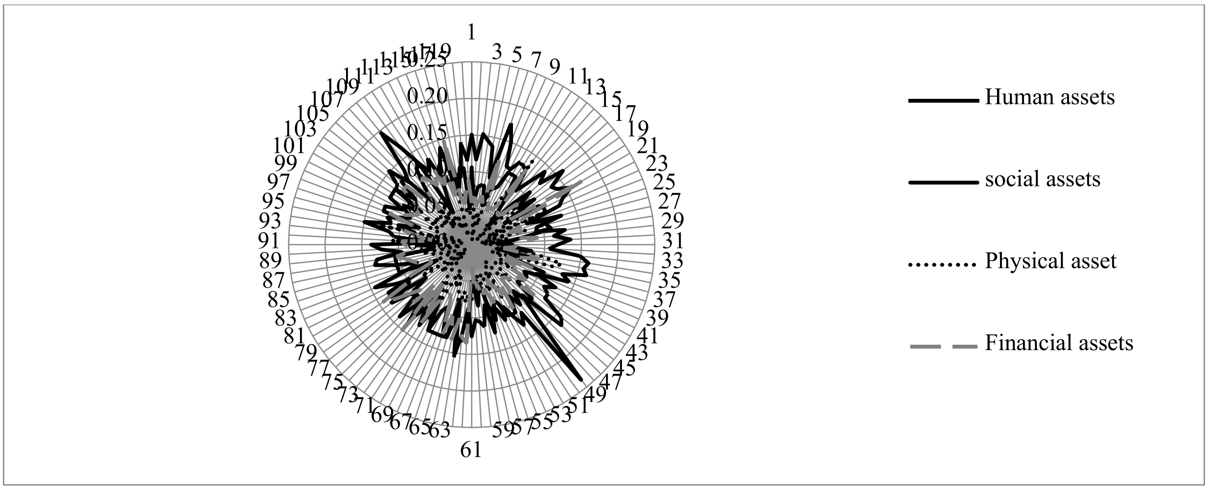

Figure 1. Contribution of different assets to adaptive capacity

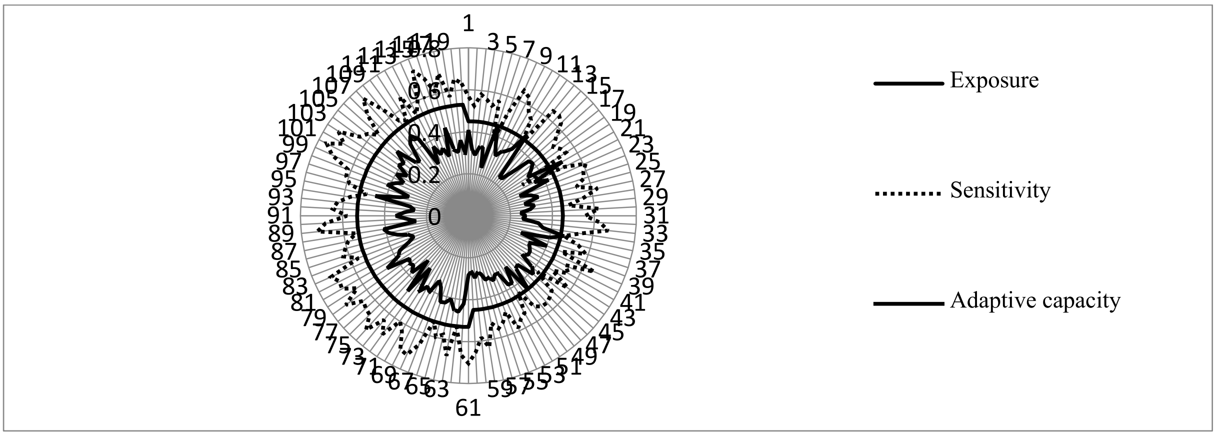

Figure 2. Contribution of exposure, sensitivity and adaptive capacity to vulnerability

Finding of Derressa *et al.* (2009) from Nile Basin of Ethiopia was different; they found male-headed households adapt more to climate change which may be due to different socio-cultural environment of these two regions. The higher level of education of household heads reduced the vulnerability through alternate employment opportunities which is in consonant with findings from Ghana by Ligon and Scheter (2003). Similarly, Inayatuallah *et al.* (2012) reported that educated and older household head is likely to be employed and thus have consistent income. Irrigation facility, crop diversification, the income from livestock enterprise and non-farm sources also helped to enhance the adaptive capacity and reduce the vulnerability of the households. Other studies also acknowledged the role of livestock asset in reducing the vulnerability of households in the event extreme climatic events (Shewmake 2008; Dirway 2010; Bryan *et al.,* 2012 and Inayatuallah *et al.,* 2012). Murthy *et al.* (2014) found that irrigated areas contributed more to adaptive capacity in Andhra Pradesh. Livestock ownership benefits households as they may sell and generate income, get food and manure, and use the animals for power (Inayatuallah *et al.,* 2012). Contact with extension agencies or personnel and access to climatic information helped them to cope up with drought vulnerability in the study area. The farm households with higher number of earners and nearer to market were less vulnerable due to better income security (Table 5).

Conclusions

Most of the years under study were 'Normal Condition-dry'. Moderate and severe drought occurred more frequently in Dimapur than Phek and off let the frequency has increased. The temperature and PET were positively correlated with drought. The regression analysis revealed that the drought years negatively impacted the rice yield in these districts. The households turned out to be highly vulnerable due to very low adaptive capacity especially in terms of physical and financial assets. Factors like educational status, gender, irrigation facility, crop diversification, income from livestock and non-farm activities, extension contact found to reduce vulnerability. Hence, it is suggested to improve the physical and financial abilities of the farmers of the region so as to make them climate ready.

Table 4. Descriptive statistics for the explanatory variables used in regression model

Variables	Unit	Value
Age of the household head	years	51.61
Literacy rate	%	95.83
Educational status of the household head	Number of years of formal education	4.30
Gender of the household head	% of female	63.33
Earners over family size	ratio	0.43
Operational land holding	ha	1.17
Land under irrigation	ha	0.29
Productivity of main crops	kg/farm	1133.50
Crop diversification	% of farmers	42.50
Income from livestock	Rs	17781
None farm income	Rs	84221
Distance of household from market	km	14.45
Access to credit	% of farmers availed	9.17
Extension contact	% of farmers had	76.67
Access to climatic information	% of farmers availed	65.00

Table 5. Factors affecting the vulnerability of farm households

Variables	Slope coefficients	P-value
const	1.26	<0.00***
Age of the household head	−0.00	0.08
Educational status of the household head	−0.01	0.03**
Gender of the household head	−0.04	<0.00***
Earners over family size	−0.06	0.01**
Operational land holding	−0.01	0.18
Land under irrigation	−0.07	<0.00***
Productivity of main crops	−0.00	<0.00***
Crop diversification	−0.03	<0.00***
Income from livestock	−0.00	<<0.00***
None farm income	−0.00	<0.00***
Distance of household from market	−0.01	<0.00***
Access to credit	−0.00	0.82
Extension contact	−0.04	<0.00***
Access to climatic information	−0.04	<0.00***
Distance of household from market	−0.01	<0.00***
Adjusted R^2	0.86	

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Annexure I

Index values for adaptive capacity indicators

Indicators	Phek			Dimapur		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Human asset	0.13	0.08	0.24	0.12	0.05	0.20
Social asset	0.08	0.03	0.11	0.10	0.05	0.13
Physical asset	0.03	0.00	0.08	0.03	0.01	0.07
Financial asset	0.03	0.02	0.08	0.04	0.01	0.07
Adaptive capacity	0.27	0.19	0.40	0.29	0.20	0.38