SUBJECT II
AGRARIAN DISTRESS, FAMILY FARMING, LAND MANAGEMENT AND OTHER ISSUES

Assessment of Risk Due to Exposure to Drought: A Study of Farm Households of Nagaland

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ABSTRACT

Nagaland state has registered 60 per cent, 30 per cent and 58 per cent deficit in monsoon rainfall during 2013, 2014 and 2015, respectively. The increasing vulnerability has made farming highly risky. Hence, the present study was conducted to calculate the level of exposure of the farms to drought, to estimate the sensitivity, adaptive capacity and the risk of the farm households to drought. A random sample of 120 farmers was interviewed at Phek and Dimapur district. For estimating the frequency of drought, Reconnaissance Drought Index (RDI) was calculated using daily gridded temperature and rainfall data for the period of 1975-2013. Vulnerability of the farm households to drought was worked out and risk of the farm households was estimated. Out of the 39 years, 21 and 31 of the years were drought years at Phek and Dimapur, respectively. The majority of the households belonged to medium risk (38.33 per cent) category, followed by high risk (33.34 per cent) and moderate (28.33 per cent) risk category. The high sensitivity and low adaptive capacity of the farm households had resulted into high vulnerability of farm households to drought and ultimately led to risk. The study recommended that drought tolerant varieties should be developed by the research institutes and initiatives must be taken by the government to improve water harvesting, irrigation infrastructures and drinking water facilities.

Keywords: RDI, Sensitivity, Adaptive capacity, Vulnerability, Risk, Nagaland.

JEL: Q10, Q19, Q54

I

INTRODUCTION

Drought is a phenomenon expressed in terms of severity, duration and affected area. The occurrence of drought has been increasing over the years (IPCC, 2007); hence, making the farmers more vulnerable. Late monsoon or decreased access to water supplies will have a great impact in a country like ours where 80 per cent of the farmers are small and marginal land holders. Farmers are most concerned with the occurrence of drought when available water supplies are not able to meet crop water demands. The yield of C_3 plants such as rice and wheat are expected to become low and for the C_4 plants, viz., maize, initially the yield may increase but after a certain point will result a decrease in yield (Feroze *et al.*, 2014). *Kharif* production declines if the rainfall is lower between June to September (Webster *et al.*, 1998; Selvaraju,

2003; Kumar *et al*., 2004). Cereal growers are likely to be affected the most due to occurrence of drought; leading to increase in the food insecurity and will greatly affect the vulnerable group of people, *i.e.*, the poor. Farm households are sensitive to drought exposure and this will affect their agricultural production, livestock, and their daily activities but at the same time, the farming community will try to cushion themselves with their able initiatives to the situation. Overall, this will signify the vulnerability of farm households to drought. *Prima facie*, hazards would occur with continuous exposure of the farms to drought over a period of years. With vulnerability and hazard, risk will be ultimately on the farm households. Thus, farmers are not only concerned with the production and price risk but also the drought risk which may lead to food insecurity, indebtedness, poverty etc., and to the overall deterioration in their livelihood.

The Central Research Institute for Dryland Agriculture (CRIDA) has identified 100 districts vulnerable to climate change in India, out of which, three districts of Nagaland state of Northeast India are vulnerable to drought (Venkateswarlu *et al.*, 2012). The state has registered 32 per cent, 60 per cent, 30 per cent and 58 per cent deficit in monsoon rainfall during 2012, 2013, 2014 and 2015, respectively (Government of India, 2015). The resource poor and the vulnerable people of the state are expected to suffer the most in situations of climatic stress especially drought. Thus, against this background this paper has studied the exposure level of the farms to drought, the sensitivity and adaptive capacity of the farm households and ultimately the risk of the farm households to drought in Nagaland.

II

METHODOLOGY AND DATA

The study was conducted in the state of Nagaland (25.6°N and 27.4°N latitude and 93.20°E and 95.15°E longitude), one of the seven North-Eastern (NE) states of India. Among the three districts vulnerable to drought, Dimapur and Phek districts were randomly selected. Dhansiripar block of Dimapur and Kikruma block of Phek were selected purposively as they have been identified as most drought stressed (Venkateswarlu *et al.*, 2012). Singrijan and Thipizumi village were selected randomly from Dhansiripar and Kikruma block, respectively. From each village, 60 farm households were selected randomly from the complete list of farmers. Hence, a sample of 120 farmers was drawn from the two districts of Nagaland.

Data

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 rainfall (0.25° X 0.25°) and temperature (0.1° X 0.1°) data were retrieved from gridded India Meteorological

Department (IMD) data set for the period of 1975-2013 to estimate the exposure level of the farms to drought in Nagaland.

Analytical Techniques

Exposure of the Farms to Drought

To calculate the exposure of the farm to drought Reconnaissance Drought Index (RDI) was used as it is more sensitive and suitable in case of changing environment (Tsakiris *et al.*, 2006). The RDI (α_k) was calculated for the i-th year based on the monthly rainfall or seasonal rainfall and the formula is given as,

$$\text{Reconnaisance Drought Index } (\alpha_i) = \frac{\sum_{j=1}^{k} P_{ij}}{\sum_{j=1}^{k} PET_{ij}} \text{ , i=1 to n} \qquad ....(1)$$

i= year ($1 \le i \le 39$), j= months ($1 \le k \le 12$)
where, P_{ij}= Precipitation (j-th month in i-th year), PET_{ij}= Potential Evapo-transpiration (j-th month in i-th year) and n= Number of years of the available data.

The PET was calculated using Hargreaves equation as suggested by Hargreaves and Allen (2003) and the formula is given as:

$$ET_0 = 0.0023 H_0 (T_{max} - T_{min})^{0.5} (T_{mean} + 17.8) \qquad ....(2)$$

where, ET_0= Potential evapo-transpiration (mm/day), H_0= Extra-terrestrial radiation (mm/day), T_{max}= Daily maximum temperature, T_{min}= Daily minimum temperature, T_{mean} = Daily mean temperature.

Then, Standardised RDI (RDI_{std}) was calculated using the following formula:

$$RDI_{std} = \frac{Y_k - \square_k}{\square_k} \qquad ....(3)$$

where, Y_k= ln α_k, $\square_k$= Arithmetic mean, $\square_k$= Standard deviation
Based on the RDI_{std}, drought years were classified as below:

Sl. No.	Category	RDI std values
(1)	(2)	(3)
1.	Extremely wet	> 2.00
2.	Very wet	to 1.99
3.	Moderately wet	to 1.49
4.	Normal condition-wet	to 0.99
5.	Normal condition-dry	to -0.99
6.	Moderate drought	-1.00 to -1.49
7.	Severe drought	-1.50 to -1.99
8.	Extreme drought	≤ -2.00

Source: Kusre and Lalringliana (2014).

The values from -0.50 to -0.99 were characterised as "mild drought" and >0.1 was regarded as "no drought" (McKee *et al*., 1993). After standardisation, 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.

Sensitivity and Adaptive Capacity 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). 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 based on the primary data which was collected from the farm households. Sensitivity and adaptive capacity of the sample households were estimated by studying the relevant indicators and constructing indices.

Vulnerability, Hazard and Risk of the Farm Households to Drought

To assess the vulnerability of individual farm households to drought, vulnerability indices were calculated as:

$$\text{Vulnerability} = (\text{exposure} + \text{sensitivity}) - \text{adaptive capacity} \qquad ....(4)$$

Higher value of vulnerability index will indicate higher vulnerability. The households were categorised according to the vulnerability index.
Thus, hazard was calculated as:

$$\text{Hazard} = \frac{\text{number of drought years}}{\text{total number of years}} \qquad ....(5)$$

Risk was estimated as:

$$\text{Risk} = \text{vulnerability} \times \text{hazard} \qquad ....(6)$$

The indices were constructed using the method used by Feroze *et al.* (2014) and the weights for different indices were calculated by using the method used by Iyenger and Sudarshan (1982). The weights were multiplied with their respective normalised indicator values and summed up to get the indices.

$$Y = W_1 S_i + W_2 S_i + ... + W j_k S_{ik} \qquad ....(7)$$

where, 'Y' is the exposure, sensitivity or adaptive capacity indices.

The households were classified based upon the estimated risk index by calculating cumulative square root of the frequencies.

III

RESULTS AND DISCUSSIONS

Exposure of the Farms to Drought

Phek was relatively warmer than Dimapur district. The maximum normal temperature was 25.03 °C and 23.75 °C at Phek and Dimapur, respectively. Phek has registered comparatively higher rainfall than Dimapur and the rainfall was not even in all the years in both the districts. Calculation of H_0 depends on latitude and as both the districts falls under the same latitude, thus, experienced the same extra-terrestrial radiation. The average PET was higher at Phek than Dimapur. The exposure index was estimated to be higher at Dimapur than Phek (Table 1).

TABLE 1. SUMMARY STATISTICS OF ANNUAL TEMPERATURES, RAINFALL, H_O, PET, AND EXPOSURE INDEX AT PHEK AND DIMAPUR DURING 1975-2013, RESPECTIVELY

Summary statistics (1)	Normal temperature (°C)		Normal rainfall (mm)		Ho (mm/day) (6)	Normal PET (mm/day)		Exposure index	
	Phek (2)	Dimapur (3)	Phek (4)	Dimapur (5)		Phek (7)	Dimapur (8)	Phek (9)	Dimapur (10)
Mean	23.98	22.81	1630.67	1491.88	13.38	1509.14	1441.05		
Minimum	23.11	21.97	1154.70	948.20	9.17	1425.97	1359.53	0.45	0.53
Maximum	25.03	23.75	2521.40	2248.80	16.61	1678.90	1570.54		
CV (per cent)	2.03	1.96	18.42	19.20	19.95	3.22	3.10		

Severe droughts occurred at Dimapur in six years (1976, 1979, 1984, 1998, 2005 and 2009), out of the total 39 years under study but no severe drought was registered at Phek during the same period. The extreme drought was experienced at Phek in 2006 and at Dimapur during the years 2006 and 2012. Out of the 39 years, 21 of the years were drought years at Phek whereas in Dimapur, 31 of the years were drought years (Figure 1). Thus, the hazard estimates were 0.54 and 0.79 for Phek and Dimapur, respectively.
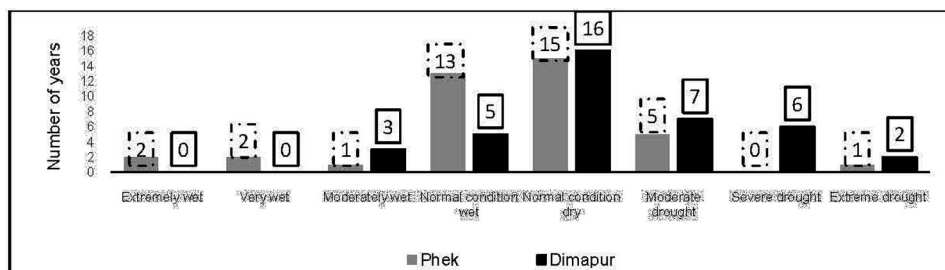

Figure 1. Different Types of Droughts at Phek and Dimapur during 1975-2013.

Sensitivity and Adaptive Capacity of the Farm Households to Drought

Sensitivity

Sensitivity of the households to drought is one of the strong determinants to understand the vulnerability and ultimately the risk to them. Productivity of the major crop, which is rice in the study area, is one of the indicators to measure the sensitivity. The average productivity of rice is calculated to be very low during the drought periods and it was comparatively higher at Dimapur than at Phek. The main rice varieties grown in the study area were ranjeet, gaya, *luit*, and other local varieties. Per household average annual return from livestock and poultry is calculated to be Rs. 17781 and it is significantly higher at Phek in comparison to Dimapur district due to higher per household livestock and poultry population at Phek. The households also earned their incomes from non-farm activities like carpentry, stone crushing, handicrafts, teaching and some of them were also in government services. The average income per household from non-farm sector was higher at Dimapur than at Phek as Dimapur being the business hub in Nagaland thus, opportunities for alternative non-farm activities were available and profitable too (Table 2).

TABLE 2. SUMMARY STATISTICS OF THE SENSITIVITY AND ADAPTIVE CAPACITY INDICATORS

Indicator (1)		Variable (2)	Unit (3)	Phek (4)	Dimapur (5)	Nagaland (6)
Sensitivity		Productivity of rice during drought	kg/ha	960.78	1306.21	1133.50
		Annual income from livestock and poultry	Rs./household	26083	9479	17781
		Annual income from non-farm sector	Rs./household	61948	106494	84221
		Time spent to fetch drinking water	Minutes/day	0.00	52.20	52.20
		Irrigation availability	Percentage	68.33	0.00	68.33
		Food availability	Months/year	9.38	8.05	8.72
		Fuel availability	Decrease percentage	0.00	60.00	60.00
			No change	100.00	40.00	70.00
Adaptive capacity	Human asset	Age of household head	Years	57.38	45.83	51.61
		Family size	Number/household	4.88	6.30	5.59
		Gender of the household head	Percentage female	20.00	37.00	36.50
			male	80.00	53.00	58.50
		Literacy rate	Percentage	100.00	91.67	95.83
		Earners over total family members	Earners : family size	0.43	0.43	0.43
	Physical asset	Household structure *Kaccha**	Percentage	46.67	21.67	34.17
		semi-*Pucca*		50.00	53.33	51.67
		Pucca[†]		3.33	25.00	14.17
		Operational land holding	ha	0.76	1.57	1.17
		Herd strength (cattle, pigs and poultry)	Numbers	13.00	2.00	8.00
		Modern farm equipments use	Percentage	0.00	0.00	0.00

(Contd.)

TABLE 2. CONCLD.

Indicator (1)		Variable (2)	Unit (3)	Phek (4)	Dimapur (5)	Nagaland (6)
		Land under irrigation	Ha	0.58	0.00	0.58
		Crop diversification	percentage	63.33	21.67	42.50
	Financial asset	Income from rice	Rs. household	24019	28529	26274
		Income from livestock	Rs./household	26083	9479	17781
		Income from other source	Rs./ household	61948	106494	84221
		Other source of income apart from farm income	percentage	100.00	60.00	80.00
		Employment generation schemes	number of employment days	24.60	90.00	57.30
		Access to credit	percentage	0.00	18.33	18.33
	Social asset	Extension contact	percentage	61.67	91.67	76.67
		Farmer to farmer contact	percentage	78.33	65.00	71.67
		Access to climatic information	percentage	60.00	68.33	65.00
		Distance of household from main market	Km	24.13	4.77	14.45
		Migration	percentage	0.00	31.67	31.67

Notes: *The walls or roof are made of either burnt bricks, bamboos, mud, grass, reeds, thatch, loosely packed stone. †The walls and roof are made of burnt bricks, stones (packed with lime or cement), cement concrete and timber.

The households at Dimapur fetched drinking water from bore-well and spent almost 1 hour daily for this purpose, but at Phek, the households enjoyed tap water supply throughout the year. None of the respondents reported to have irrigation facility at Dimapur, whereas, about 68.33 per cent of the sample farmers at Phek irrigated their farms through channels from the perennial streams flowing at the foot hill. The rice availability from own farm produce fell short during the stress periods in both the districts under study which is a matter of concern for the farmers to meet the year round consumption requirements. About 60.00 per cent of the respondents reported a decrease in the fuel availability in Dimapur during drought but it was not an issue at Phek where the sample villages still had dense forest nearby, from where they collected firewood easily.

Adaptive Capacity

Human Asset

The average age of the sample household heads at Phek was higher than at Dimapur. Deressa *et al.* (2009) reported that the age of the household head represents farm experience which may enhance adaptation to climate change and male-headed households adapt more to climate change. Phek is mainly inhabited by the *Chakhesangs* which is a male dominated tribe and was found that 80.00 per cent of the households head in Phek were males. Majority of the respondent farmers were literate in both the districts and had the same ratio of earner over total family size (0.43). A household having more earners is hypothesised to have more adaptive capacity than the other households (Table 2).

Physical Asset

Most of the sample farmers in Nagaland resided in either semi-*pucca* houses or '*kaccha'* houses and they were primarily small and marginal farmers. The average herd strength was significantly higher in Phek than Dimapur. In both the districts, no modern farm equipments were used for agricultural purposes and the works were done manually. The average land holding per household under irrigation was 0.58 ha in Phek. Apart from rice, the farmers also cultivated other crops like maize, naga dal and various vegetables and fruits. It was found that about 63.33 per cent of the farmers diversified their farms in Phek whereas, only 21.67 per cent of the farmers had diversified their farms in Dimapur which may be due to no irrigation facility in the district (Table 2).

Financial Asset

Comparatively lesser return from rice at Phek was mainly due to lower size of land holdings in the district. In Dimapur, 60 per cent of the farmers earned their livelihood from sources other than farms and employment schemes, but in Phek, all the households earned small amount of returns from other non-farm sources such as bamboo crafts, carpentry, stone crushing, small business like shops *etc.* The farmers in Dimapur registered 90 days of employment last year in Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) scheme but in Phek it was abysmally low. Only about 18.33 per cent of the sample farmers in Dimapur had accessed credit from village money lender, neighbours, friends and banks through Kisan Credit Cards (Table 2).

Social Asset

Contacts with extension agents or organisations were quite high in the study area. They had contacted the officials of State Agricultural Department, Kisan Call Centre (KCC) and Krishi Vigyan Kendras (KVKs) for getting solutions to their agricultural problems and to know about ongoing developmental schemes. They also benefitted from seminars, exhibitions and farmers' exposure visits through Agricultural Technology Mission Agency (ATMA). The National Innovation in Climate Resilient Agriculture (NICRA) has been running at some of the villages at Phek districts. This had benefitted the farmers through trainings, demonstrations *etc*.

The farmers in Phek developed common timing for daily agricultural activities which was also favourable for inter personal communication. Market not only served as a place for exchange of commodities but it was also a place where the farmers met and exchanged information. It was found that the main market was very far (24.13 km) from the sample villages at Phek. About 31.67 per cent of the sample households reported about migration to other villages and towns in search of jobs at Dimapur but no migration was reported by the sample households at Phek (Table 2).

The very low level of physical and financial asset structures in the study area was the reason behind the low adaptive capacity of the households. It was found that the land holdings were small, irrigation facility was not available at Dimapur and none of the farmers used any modern farm equipments in the study area. The farmers at Dimapur cultivated only rice crop and even hardly reared livestock. Moreover, the availability of employment opportunities in employment generation scheme at Phek and access to credit was very poor. Human asset and social asset were the two assets which contributed maximum to the adaptive capacity of the sample households to drought. The reason was that the literacy rate was very high among the sample farmers and on an average two earners were there in a household. It was also observed that the farmer to farmer contacts as well as contacts with extension agents were high in the study area.

Vulnerability, Hazard and Risk of the Farm Households to Drought

In the study area, the sensitivity of the farm households was high and exposure was moderate but the adaptive capacity was very low which led to high vulnerability of the households to drought.

The sample households were classified on the basis of risk index. The majority of the households were in medium risk (38.33 per cent) category, followed by high risk (33.34 per cent) and 28.33 per cent of them were in moderate risk category (Table 3).

TABLE 3. FREQUENCY DISTRIBUTION OF THE FARM HOUSEHOLDS ACROSS RISK CATEGORIES

Category	Class (index value)	Frequency (per cent)
(1)	(2)	(3)
Risk		
Medium	0.12-0.40	38.33
Moderate	0.41-0.60	28.33
High	0.61-0.80	33.34

The concentration of households at Dimapur was higher in high and moderate risk categories than that of households at Phek due to higher level of sensitivity, exposure and hazard along with low adaptive capacity of households at Dimapur. Similarly, Ligon and Schechter (2003) found out that the high risk of the family is mainly due to limited resources *i.e.*, lower financial asset. Hence, the probability of substantial loss is higher in Dimapur in comparison to Phek.

IV

CONCLUSIONS

The temperature had increased and rainfall had declined and been erratic in nature during the study period in the area of study. It was observed that after 1994, majority of the years were drought years. Comparatively, the frequencies of droughts were higher at Dimapur than Phek. Most of the households were very sensitive to drought due to low productivity of rice, unavailability of irrigation facility and no

drinking water facility at Dimapur, and insufficiency of rice produced at farmer's own farm during drought. Adaptive capacity was very low in the area of study due to low physical and financial assets among the farm households. The high sensitivity and low adaptive capacity of the farm households had resulted into high vulnerability of farm households to drought and ultimately led to risk. Farm households at Dimapur were more riskier to drought than at Phek. The study recommended that drought tolerant varieties must be developed by the research institutes and initiatives should be taken by the government to improve the water harvesting, irrigation infrastructures and drinking water facilities.

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