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ORIGINAL ARTICLE

Vulnerability of Farmers to Climate Variability and Change

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ABSTRACT

The economic and social differentiation influences the vulnerability of the farmers, switching from one form of vulnerability to another. The determinants of vulnerability are necessarily dynamic, and vary according to the stimulus (climate) in consideration and have place and context specificity, thus the contextual vulnerability is studied with respect to the social background (caste composition) of the households. The index uses primary data from the household survey to construct the similar index, and the results of the vulnerability analysis for both the districts are reported according to the social groups of the household, since analysing vulnerability according to the economic holdings resulted in more obvious and inappropriate interpretations. The size of land holdings is dynamic, as there could be addition or decline in the size of land owned by a household over time, but the caste of the household is a static attribute, which helps in long-term understanding of factors responsible for vulnerability. Thus computing cumulative vulnerability index (CVI) according to farmers category based on the size of the land holdings is not considered in the present paper, instead the caste composition of the 304 farm households from Gulbarga and Kolar Districts in Karnataka state were considered to discern contextual vulnerability.

Key words: *Vulnerability, Farmer, Climate Variability*

INTRODUCTION

Climate change is the result of recent development trends in the field of science, economics and market institutions (external forcings). More the development, less inclusive it has been to the society, particularly poor (Human Development Report, GOK). People dependent on agriculture and allied activities for their livelihoods are often more exposed to any socio-economic changes due to man-made disasters in the environment. In addition, developing economies' agricultural earning often lag behind price rises and non-agricultural wages are notoriously slow in adjusting to rise in the cost of living. In periods when agricultural incomes lag considerably behind price rises, farmers and agricultural labourers are bound to suffer, while large land owners and entrepreneurs operate with an obvious advantage (Longhurst, 1986). Deep economic differentiation influences the state and add to the vulnerability of marginalised farming groups, and also persist in the system making poor become poorer (Adger, 2003), switching from one state of vulnerability to deeper vulnerability.

VULNERABILITY

Vulnerability is defined as the degree to which a system is susceptible to injury, damage, or harm. The third assessment report of IPCC, (2007); defines vulnerability as a function of character, magnitude, and rate of change and variation to which a system is exposed, its sensitivity and its adaptive capacity. Clearly vulnerability to climate change has been defined as "the degree to which a system is susceptible (one-part–detrimental-of sensitivity), or unable to cope with adverse affects of climate change, including climate variability and extremes" (Adger, 2003). Exposure refers to "the nature and the degree to which a system is exposed to", sensitivity refers to "the degree to which a system is affected by stimuli" and adaptive capacity is defined as "the ability of a system to perceive and work towards endowment of mitigating effects of climate change".

METHODS TO ASSESS VULNERABILITY

Regional integration across sectors is required to place vulnerability in the context of local and regional development (IPCC, 1997). As literature describes, there are different approaches for assessing vulnerability to climate change, it ranges from historical narratives, statistical analysis methods, GIS and mapping techniques, comparative analysis, agent-based modelling and indicator based approaches. In spatial analysis, a geographical information system (GIS) is used to locate the vulnerable populations/places, and it is used to summarise and synthesize information for spatially differentiated information. GIS method is visual and dynamic, analyses at various scales, captures location vulnerability, and is a swift and unbiased method, but there are shortcomings in this method as it is expensive, requires highly trained professional, and high quality of huge data. An integrated impact assessment method is used to understand linkages or interactions and feedbacks among complementary systems (atmospheric, economic systems). This method is employed particularly to provide information on the drivers of economic costs and influence of different climatic parameters on the future of an economy or sector (future scenarios and pathways). The strength of this approach lies in quantification of economic costs of climate change over time, to assess potential costs and benefits of adaptation within a consistent economic framework and allows multiple scenario analysis in a given time. Perhaps, integrated impact assessment is technically complex and hence caters to selected audiences, indicating future economic costs (market and non-market) which come with assumptions and uncertainties, and also fails to capture extreme events, cross-sectoral and socially-contingent costs on adaptive capacity.

The indicator-based assessment of vulnerability enables a complex system to be captured in a single measurement. It is used to make comparisons between populations relatively quickly and to identify and communicate priorities and areas of problems succinctly. This method is relatively quick to conduct, allows aggregation through statistical analysis and transparent methodology, which is replicable. This method also come with weaknesses as it cannot capture heterogeneity effectively, and is limited with data availability and scalability. This method is difficult in encompassing social dimension, difficult to derive indicators which are minimal and applicable but also capture the phenomenon accurately. There is no single way to combine and weight indicators.

The participatory assessment of vulnerability uses a qualitative process to understand how vulnerable people view themselves. It is used to bring all stakeholders on a common platform, collaborative process and to directly inform local-level actions and interventions. The strength of this method lies in building capacity and awareness of stakeholders, enables contextual definition of 'vulnerability' to emerge through participation, and has a greater sense of responsibility in conception and implementation of responses. This method attempts to bridge gap between scientific and indigenous knowledge. This method is limited in application because it requires experts for facilitation, and it becomes difficult to explain technical terms, it is time intensive, need to build trust, it is very contextual thus difficult to generalize to other locations.

The landscape of literature on vulnerability has different theoretical and interdisciplinary frameworks. One of the important frameworks is resilience framework, which is a system -based approach bridging social and physical sciences. Recognises scale issues but does not resolve mismatch between ecological and social boundaries (Birkmann, 2006).

An a-temporal or static approach to wellbeing, if strictly adhered to, is of limited use, is it established din the literature that vulnerability is forward-looking and it has prevention characteristics unlike measuring the present poverty status(which is alleviating). Thus *ex ante* measure of wellbeing has greater weight than *ex post* measure of wellbeing. The clarification required for strategizing poverty reduction lies in both preventing and alleviating approaches, thus *ex ante* risk and uncertainty really matters for policy, to take suitable decision on whether a household will, if currently vulnerable, fall below the critical vulnerability level or become less vulnerable to change.

UNDERSTANDING VULNERABILITY

The concept of vulnerability is difficult to define; most often it is conceptualized as consisting of components that include exposure, sensitivity of the system and adaptive capacity. The notion of

vulnerability refers to the degree to which a system or "exposure unit" may be adversely affected by a hazardous event, or series of events. In the context of climate change, vulnerability relates to the susceptibility of a human or economic system to the disruption or damage resulting from environmental change. Assessment of potential impacts of climate change in different parts of the world often using vulnerability as a framing device has increased over the past two decades with greater emphasis on climate change research (Smit, 2005; Salau, 2012). However there is diversity in the definitions and methodologies for assessing vulnerability. Accordingly, several approaches, definitions and methodologies have been used to clarify the knowledge on vulnerability to climate change. Quantitative assessment of vulnerability is achieved by computing an index of vulnerability of regions to climate change. Many studies illustrate the complex index approach to measuring vulnerability. The determinants of vulnerability are necessarily dynamic, and vary according to the stimulus in consideration, and are also scale and system specific. Many studies (Deressa, *et al.,* 2009; Gbetibouo 2009) suggest that vulnerability is a function of households' livelihood profiles under consideration. Thus differential vulnerability which is a case specific approach is addressed in a less empirical way in India, except at the community level (Panda, 2013). The vulnerability is defined as the remaining impacts of climate change after all adaptations are accounted for agriculture. However, based on the definition Sullivan, (2005), developed a formal framework of vulnerability to climate change. For meaningful statements about notion of vulnerability the analyst must clearly specify the entity that is vulnerable, the stimulus to which it is vulnerable and the criteria to evaluate the outcome of concern for the entity. However, different notions about vulnerability is about an outcome (crop failure), and the vulnerability that deals with an input (climate change). How to compute vulnerability of an input is our concern in the present research, because in the Indian context district level data on several indicators to assess the exposure, sensitivity and adaptive capacity components of vulnerability has been utilised (O'Brien *et al,* 2004), perhaps at the households level or community level computing vulnerability index remains unattended.

At present there are efforts to identify regions on the earth that are inherently and acutely vulnerable to environmental perturbations, greater risk of disruption through vulnerability mapping provides information at the global level, but it limits from providing regional details on vulnerability. Also the efforts to reduce vulnerability through these studies have often been pursued via attempts to increase the stability of socio-economic systems, at autonomous level by the state, irrespective of the inherited heterogeneity of the households and the society. IPCC (various reports) concluded that, vulnerability depends upon economic circumstances and institutional infrastructure; systems are typically more vulnerable in developing countries where economic conditions and institutional arrangements are accessed with graded inequality in a anti-social manner. For example, the strategies forced on the poor, either because of their vulnerability or as a result of the poor support they receive from service providers and enabling agencies, may have direct negative impacts on the sustainability of their livelihoods system as a whole. It might result in maladaptation and increased adaptation deficit, because lack of cohesion and anti-social approach is drifting away marginalized farmers from gaining the mitigating capacity which mitigates the harmful effects of climate change, and making them suit less to the situation.

DATA AND METHODS

The study region considered for the present research work is two different Agro-Climatic zones of Karnataka, namely North-Eastern Dry and eastern Dry Agro-Climatic zones. The study districts are Gulbarga and Kolar, with a sample size of 304 farm households across nine villages respectively. Inability in the current period to cope with external pressures or changes, such as changing climatic conditions is called as contextual vulnerability (starting-point vulnerability). Similarly the end-point vulnerability is called as outcome vulnerability which is defined as the end point of a sequence of analysis beginning with projections of future emission trends, moving onto the development of climate scenarios, and concluding with biophysical impact studies and the identification of adaptive options. Any residual consequences that remain after adaptation has taken place; defines the levels of vulnerability (Kelly and Adger, 2000; O'Brien, *et al.,* 2007).

Vulnerability is not indifferent, the concept of differential vulnerability is the idea that two people or groups of people, exposed to the same climate stimuli will suffer differently, because of the differences in basic building factors of economic, social and natural assets. As vulnerability is a complex phenomenon and very difficult to measure directly, indicator based approach is useful for capturing the complex relationship with the help of indicators. Indicators are a means of encompassing complex relationship in a single quantifiable or measurable construct.

VULNERABILITY

Quantitative assessment of vulnerability is achieved by computing an index of vulnerability, which is a metric characterizing the vulnerability of a system. A climate vulnerability index is typically derived by combining, with or without weighting, several indicators assumed to represent vulnerability. The determinants of vulnerability are necessarily dynamic, and vary according to the stimulus (climate) in consideration, and have place and context specificity. 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. A climate vulnerability index, given by IPCC (1996) on vulnerability framework consists of three contributing factors –exposure, sensitivity and adaptive capacity. The index uses primary data from the household survey to construct the index.

Climate vulnerability index has exposure, sensitivity and adaptive capacity components, which are divided into sub components by giving an explanation and proxies and aggregated to obtain the main components for particular village/region. The literature provides many possible choices with regard to the methods for aggregation of indicators to compute the index. In the present objective, the Iyengar and Sudarshan (1982) method is adopted, which is widely used by the UNDP for constructing the Human Development Index (HDI). Iyengar and Sudarshan (1982) developed a method to work-out a composite index from multivariate data and it was used to rank the districts in terms of their economic performance. The CVI in the chapter, uses a balanced weighted averages approach (Sullivan, *et al,* 2005), where each sub component contributes equally to the overall index score and equal weights are applied to all the major components. The nature of each component was measured not necessarily on a different scale, thus it is necessary to standardize each as a separate index (Moss *et al*, 2001).

After each component was standardised using maximum and minimum values, social group wise climate vulnerability index is calculated based on the equation given by IPCC and Hanh, *et al.,* (2009), mathematically, vulnerability is expressed as:

$$CVI_h = (Exp_h - ADP_{h)} * Sen_h$$

Where,

CVI= Climate Vulnerability Index of farm households

Exp= Exposure of farm households to climate change

ADP= Adaptive Capacity of farm households to climate change

Sen= Sensitivity of farm households to climate change

The scaling of CVI is according to the results obtained from vulnerability index score ranges from 0.05 (least vulnerable) to 0.20 (most vulnerable).

RESULTS AND DISCUSSIONS

The determinants of vulnerability are necessarily dynamic, and vary according to the stimulus (climate) in consideration, and have place and context specificity, thus the contextual vulnerability is studied with respect to the social background (caste composition) of the households. The index uses primary data from the household survey to construct the similar index, and the results of the vulnerability analysis for both the districts are reported according to the social groups of the household, since analysing vulnerability according to the economic holdings resulted in more obvious and inappropriate interpretations. The size of land holdings is dynamic, as there could be addition or decline in the size of land owned by a household over time, but the caste of the household is a static attribute, which helps in long-term understanding of factors responsible for vulnerability. Thus computing cumulative vulnerability index (CVI) according to farmers category based on the size of the land holdings is not considered in the present paper.

Table 1: Description of sub-components on exposure of farm households to climate change

Perception of farmers on climate change	Implications on exposure
Have you heard of phenomenon called climate change?	Low: Awareness is a pre-condition for altered operation in the farm, thus the negative exposure to climate change is less
Do you think Climate change is an important global issue?	High: The global phenomenon has regionally differentiated impacts, if not considered at the micro level, huge costs have to be incurred by the farm households
Has climate change posed more challenges ever than other issues on your livelihood?	Higher challenges attribute to lack of capabilities and entitlements/ livelihood resources
Do you experience more extreme weather events now?	The residual impacts of extreme weather events are higher due to skewed temporal spacing, because temporal spacing carries implications especially for the scheduling if farm activities.
Drought and scarcity conditions recur every 3-5 years since 20 years	Exposure to more drought entails to persistent losses in agricultural production more frequently and farm households loose draft power
The number of hot days has increased in recent years	The peak rise in temperature affects the critical crop growth period and also livestock productivity
Have you experienced unpredictability in the onset and retreat of monsoon season recently?	Lack of copious rainfall and ill-distribution means declined number of rainy days and affects the yield levels negatively
I have experienced more drought season than normal years in my farming life	When a households perceives drought to a greater extent over heavy rainfall, the households dependency on rainfall is to its entirety for agricultural production, and the household does not have access to supplemental sources of water
There is incidence in new diseases and pests to crops lately	The overlapping tropical weather and season lead to multiplication of disease causing micro-organisms and insects
The length of the growing period has been shrunken in recent years (for Deccan it ranges from 90-150 days)	The number of rainy days and copious rainfall determines the inflorescence and grain setting which is called as critical crop growth stages. Since 10-15 years there is decline in the crop growth period
Do you believe Man made climate change is happening?	Anthropogenic factors can be modified and regulated, if farmers believe that climate change is manmade and not entirely due to natural driving factors.
Climate change is a global problem; do you believe that whatever changes you carry out in your farm is of little use?	High: The global phenomenon has regionally differentiated impacts, if not considered at the micro level; huge costs have to be incurred by the farm households. Changes at the farm level will be private and without ancillary benefits, thus limited in scope.

Quantitative assessment of vulnerability is achieved by computing an index of vulnerability of the study region. Vulnerability index is a metric characterizing the vulnerability of a system, and a climate vulnerability index (CVI), is typically derived by combining, with or without weighting, several indicators assumed to represent vulnerability. A CVI, given by IPCC (1996) on vulnerability framework consists of three contributing factors– exposure, sensitivity and adaptive capacity. The sensitivity, exposure and adaptive capacity indicators show varied CVI values in both the districts across social groups even for the households with similar land holding size.

EXPOSURE TO CLIMATE VARIABILITY AND CHANGE

The incidence of rainfall increase and the heavy monsoons are highly impossible events, according to the sample respondents in the study. From the memory and different timelines, which farmers recollected, they are of the opinion that changing weather conditions has posed biggest external challenge to agriculture, apart from price distortions and support mechanisms in agriculture.

The negative impact due to exposure to the weather vagaries is highly perceived by farmers hailing from scheduled caste and scheduled tribes background (53 per cent), due to poor resource entitlements, they ought to observe and closely monitor the standing crops. Farmers are aware of phenomenon called climate change, and nearly 70 per cent of them attribute the phenomenon as global in nature, thus 60 per cent of the farmers are of the opinion that, whatever little change they carry out in their field will be of less significance. Due to the shrink in the length of growing period (90-150 days to less than 90-100 days), 60 per cent of the farmers observed infestation of new insects and undetectable diseases to their crops. The scarcity period and dry season is no more a rare event, perhaps a regular event, thus 90 per cent of the farmers get negatively impacted by weather extremes more often at present than previous decades.

Table 2: Description of major and sub-components of sensitivity indicators of farm households

Sensitivity indicators	How sensitivity is derived from stated indicators?
Non-operational Agricultural land holdings	Land is incidental to maintaining livelihood; land ensures security and strengthens livelihoods.
Less Farming experience	Higher farming experience reduces the sensitivity of the household to climate change because of the farmers rich traditional knowledge and ability to restructure and reallocate resources in an optimum way.
High number of dependents in the household	Higher the dependency ratio in the households, lower the ability of that households to opt for anticipatory response mechanisms, thus bear the losses due to change in climatic conditions
Lack of Access to formal credit sources	Availing credit from institutionalised sources is beneficial for the households, because it is subjected to waiving in times of weather extremes and also available at rational rates of interest.
Lack of Access to weather insurance	Households with access to weather insurance have demonstrated that, the credit allocation is not diverted to non-productive expenses within the household.
Lack of Access to consistent climate information	Awareness and inter-farmers communication is an intangible social resources, higher the access to information, higher the flexibility in sowing and inter-cultural operations in the agricultural fields.
Lack of Perennial Water Sources apart from the rainfall	Access to supplemental sources of water is the most important factor to decide on types of crops grown, and the crops can be grown in all the three agricultural season. Irrigation declines the idle time and engages households in productive enterprises
Low Proportion of Non agricultural Income to the total households income	The occupational diversification is a safety mechanism and a clear indication of declined agricultural livelihoods
Poor Community representation and political Participation	Higher the participation in community gatherings, sensitivity to weather extremes decreases, because the household is capable of availing the relief measures and schemes by the state, also increases pooling of resources across communities.

PERCEPTION OF FARMERS ON IMPACTS OF CLIMATIC CHANGE

The major share of farmers i.e., 95 per cent are experiencing change in climatic variables in every sowing and growing season, and the change is occurring since long term. Farmers responded to long-term changes in climate and almost 70 percent of the farmers are experiencing changes in climate since long-term. The climate change global phenomena with impacts at the local level, and 75 percent of the farmers do believe that the changes in climate are happening at all the surrounding places. The weather changes is dwindling the length of growing period from 90-150 days to less than 90 days. It will significantly affect the seed setting and productivity levels. The frequency of extreme weather events has increased lately and it is getting complex to differentiate between dry and normal years in the study region. To about 88 percent of the farmers expressed that, dry spells and scarcity of water has created crises and it is persisting over years. The scarcity conditions are part of the life as it is recurring once in 2-3 years.

The negative influences of climatic change on agriculture is seen in various ways by farmers, for instance nearly 50 percent of the farmers observed change in the physiological growth of crops due to weather variations. Nearly 40 percent of the farmers complain that there is poor pod setting and height of the crops like Red gram and Sorghum is reduced. Earlier the height of the plant was a safety net for birds to sit and hunt on insects and larva, which is lacking now, thus as a result the set pods are eaten away by insects. Apart from insect infestations, there are new entomological problems attacking the standing crops, due to overlapping seasons in the tropical regions, which 55 percent of the farmers have witnessed. The pathological organisms reduce the yield of the crops, as there is high unpredictability in the rains; the crops get infested with smut and ash diseases in pre-harvesting stage. Climatic change is leading to lower yield levels, thus affecting the farming negatively. Majority of the farmers i.e., 82 percent state that, climate is a biggest challenge and it a multiplier of threat to their livelihood. As less as 10 percent of the large, upper social group farmers stated that, changing weather variables has given an opportunity to grow new crops and thus increasing the market value.

Table 3: Description of major and sub-components of CVI parameters in the study

Major components	Sub-components	Explanation of sub-components	Potential implications on vulnerability
Physical resources	Cultivated land Holdings (acres)	The size of land owned and cultivated by the household	Land ownership ensures rights to all other related entitlements for livelihood and provides a reasonable standard of living and gives full employment for a household of normal size.
Human resources:	Farming experience(years)	The years spent in making major agricultural decisions and conducting cultivating operations in the field.	Farmers' traditional knowledge develops with farming experience, which is an important element in averting the risks and uncertainties due to weather/climate change.
	Dependency ratio	The ratio of non earning members (<15, >65 age group) to the earning members in the household (16-65 age group).	Less the number of dependents in the household, there will be more savings and high investment.
	Climate information	Whether the head of the household has access to the sources of climate information, from research stations, IMD, media and inter farmers' communication.	The climate information helps in taking timely decisions regarding agricultural operations, and enables the preparedness.
Financial resources	Credit Organization	Formal sources of credit; nationalised banks, co-operative societies, Rural Banks, Primary Agricultural Co-operative societies, and any other formalised societies, self-help groups etc	The formal credit institution does not lend money on irrational rates of interest. The state waives off farmers loan during times of drought and scarcity
	Insurance	Insurance on standing crops, livestock, automobiles, health, and life.	Insurance will safeguard the household from financial risks and uncertainties.
	Proportion of Non agricultural Income	The ratio of non agricultural income to the ratio of agricultural and non-agricultural income	Occupational diversification brings resilience to the livelihood and aids in financial wellbeing, the total household income reflects the overall health of the household in relation to its size, and the productivity of workers.
Natural resources	Perennial Water Sources	Any supplementary sources of water other than rainfall for the production purpose.	Irrigation in the agricultural field means assured crop yields.
Social resources	Community and political Participation	Whether the individual is socially accepted in the community gatherings and given equal opportunity in political forums, irrespective of the social background.	Social networks and connectedness increase people's trust and ability to work together and expand their access to wider institutions, such as political bodies.

As awareness and perception on changing climate is clearly visible in farming communities, nearly 55 percent of the farmers are aware of this global problem, and are also aware of the fact that it is a non-regulating risk with varied/differential impacts at the micro level. Farmers state that, the cause of the global climate change is solely due to manmade disasters and deforestation, which increase the sensitivity of the farming community, thus any mitigating factors at the household level is of little application and importance. The climate data for the study region is available from 1901 till date, but there is a challenge on the credibility of the data, and for the Indian context rainfall is crucial and more influential than temperature. Thus rainfall data trend over these 110 years shows a mixed pattern of both positive and negative, where in majority of the farmers opines that there is certainly decrease in the amount and span of rains, which flows persistently to have varied shocks on the livelihoods of farmers.

Agriculture remuneration is a direct positive function of water, soil and weather; sole dependence of water is rain water because major portion of agriculture has less or no irrigation. An

unproductive land, water scarcity, poor rainfall in recent years has made agriculture most frustrating exercise. The farming communities have a very clear memory of the years dominated by extreme climatic conditions and other significant events leading to disturbances in the production cycle. In some cases, the years were characterized by both drought and excessive rains (2009, October flash floods). Their observation corresponds with the broader scientific projections of the impacts of climate change in the region. The local communities had felt the need to cope up and thereby adapt to the changing climate by altering their livelihoods and cultural practices.

SENSITIVITY OF FARMERS TO CLIMATE VARIABILITY AND CHANGE

Perceiving the change in climate is crucial, because perception is the precondition for adaptation. In order to adapt to the changes many factors determine the capacity to respond and implement the responses. Who will perceive and what will be adapted depends on where they are located i.e., whether it is ecologically fragile landscape, or tropical sub humid region or agriculturally productive perhaps often less immune to droughts.

The indicators influencing sensitivity of the farm households to climatic variability and change is discussed in the present section. The entitlements and assets quantity is a direct equation of social groups in the Indian context, and the results are seen in the table 5. The average land possession and the size of cultivable land is 4 acres for farmers from scheduled castes and scheduled tribes background, whereas for that of other backward classes is an average of 8 acres of agricultural land, and for religious minorities groups it is 10 acres of agricultural land and general category farmers have five times bigger land holding size than that of SC/STs farmers, i.e., an average of 16-18 acres of land available for cultivation.

Table 4: The descriptive statistics of the Exposure questions across social groups for Gulbarga and Kolar districts

Exposure of farmers to climate change	Scheduled castes and scheduled tribes (%)		Other Backward Castes (%)		Minority groups (%)		General castes/ Upper castes (%)	
	Kolar	Gulbarga	Kolar	Gulbarga	Kolar	Gulbarga	Kolar	Gulbarga
Have you heard of phenomenon called climate change?	33.33	43.86%	26.67%	18.42	8.57	6.14	31.43	31.58
Do you think Climate change is an important global issue?	33.33	44.76	26.67	18.10	8.57	7.62	31.43	29.52
Has climate change posed more challenges than other issues ever on your livelihood?	42.31	50.77	26.92	23.08	6.41	6.15	24.36	20.00
Do you experience more extreme weather events now?	44.86	52.81	24.30	15.73	8.41	4.49	22.43	26.97
Drought and scarcity conditions recur every 3-5 years since 20 years	39.76	47.93	27.11	15.70	7.23	5.79	25.90	30.58
The number of hot days has increased in recent years	39.76	48.18	27.11	16.06	7.23	6.57	25.90	29.20
Have you experienced unpredictability in the onset and retreat of monsoon season recently?	39.76	48.18	27.11	16.06	7.23	6.57	25.90	29.20
I have experienced more drought season than normal years in my farming life	40.00	48.18	24.00	16.06	7.33	6.57	28.67	29.20
There is incidence of new diseases and pests to crops lately	47.83	52.38	23.91	19.05	8.70	5.95	19.57	22.62
The length of the growing period has been shrunken in recent years (for Deccan it ranges from 90-150 days)	33.33	47.41	26.67	16.38	8.57	7.76	31.43	28.45
Do you believe Man made climate change is happening?	45.26	48.76	27.74	14.88	6.57	6.61	20.44	29.75
Climate change is a global problem; do you believe that whatever changes you carry out in your farm is of little use?	42.22	44.44	26.67	14.81	6.67	8.64	24.44	32.10

Table 5: The descriptive statistics of the sensitivity indicators across social groups for Gulbarga and Kolar districts

Sensitivity indicators	Scheduled castes and scheduled tribes (%)		Other Backward Castes (%)		Religious Minority groups (%)		General castes/Upper castes (%)	
	Kolar	Gulbarga	Kolar	Gulbarga	Kolar	Gulbarga	Kolar	Gulbarga
Average cultivated Holdings (acres)	4.63	3.85	7.97	9.50	10.48	9.64	14.85	19.64
Farming experience(years)	29.82	26.6	27.64	25.5	20.11	16.2	27.85	25.4
Average no. of dependents	2.77	4.33	3.23	4.96	4.33	5.67	3.70	5.20
Access to formal credit (%)	15.15	32.37	16.67	27.34	7.58	6.47	60.61	33.81
Access to weather insurance (%)	8.11	3.92	13.51	29.41	5.41	5.88	72.97	60.78
Access to climate information(%)	34.50	20.88	13.45	26.10	8.19	6.83	43.86	46.18
Perennial Water Source (%)	31.03	11.11	17.24	33.33	5.17	0.00	46.55	55.56
Proportion of Non agricultural Income (ratio of agricultural income to non-agricultural income)	0.62	0.64	0.58	0.54	0.57	0.52	0.50	0.46
Community Participation (%)	37.84	18.75	14.86	28.13	5.41	6.25	41.89	46.88
Political participation (%)	29.17	19.57	16.67	32.61	5.56	2.17	48.61	45.65

The average farming experience is 30 years for SC/STs farmers, which is the highest and 17 years for religious minority groups, which is the lowest farming experience across categories of farmers. The average number of dependents is high in general castes and low in SC/STs farmers group. The institutional sources of credit is accessed by only 20 per cent of the SC/STs farmers, 20 per cent by OBCs, 7 per cent by minorities and to about an extent of 48 per cent by general caste farmers. Weather insurance is owned by 65 per cent of general castes, 5 per cent by minorities, 15 per cent by OBCs and 6 percent by SC/STs farmers. The formal extension sources for weather information, inter farmers communication regarding weather information is available to general castes to an extent of 45 per cent, and 6 per cent by minorities, 20 per cent by OBCs and 23 per cent by SC/ST farmers. The supplemental sources of water, apart from rain water are lakes, step wells, ponds, streams and also dam water and the access and availability of perennial sources of water is 45 per cent to the general castes, 7 per cent to thee minorities, 24 per cent to the OBCs and 18 per cent to the SC/STs farmers. The descending order of non-agricultural income is SC/STs farmers (0.63), OBCs (0.55), Minorities (0.53) and general castes (0.47). The societal participation and representing the political voice is highest in general castes (46 per cent) followed by OBCs (26 per cent), SC/STs farmers (23 per cent) and at the bottom of the pyramid is minorities (4 per cent).

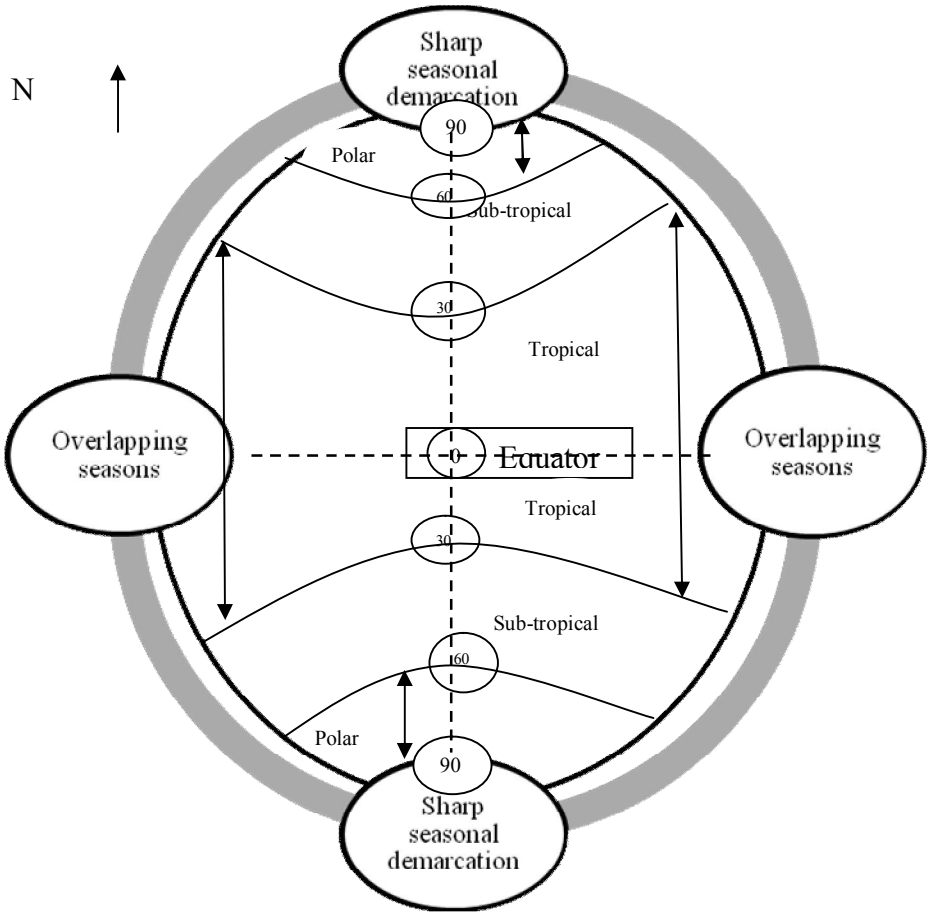
THE REASONS FOR NO-ADAPTATION TO CLIMATE CHANGE BY FARMERS

The suitability of the pulse crop to moisture stress and changes in the weather has paved less towards endowment of folk agronomy (Jodha, 1975) for adaptation strategies. As farmers are able to reduce the impact potential and increase the impact threshold[1] by growing the crop which adjusts to regional specificities in terms of ecology and climate, there is less scope for adaptations and transformational strategies to climate change. The cotton crop is unable to withstand the changes in onset and retreat of monsoon, thus slowly red gram occupied the maximum agricultural land of the region.

Late sowing, erratic rainfall, torrential flash floods (830 mm in October, 2014) and water stagnation leads to more of *phytophthera* infestations and root rot in the low lying areas. Every year due to unpredictability of rainfall and fluctuating temperatures, vast agricultural areas are getting affected and there is decline in the land under cultivation, farmers chose diversifying the

occupation and migrating. Climate change may affect the growing period and decline the length of agricultural seasons in peninsular India, thus negatively impacting on agriculture.

Fig. 1: Differential impacts of climate change



Source: Field insights

Table 6: Climate Vulnerability Index across the social groups of sample farm households from Kolar and Gulbarga districts

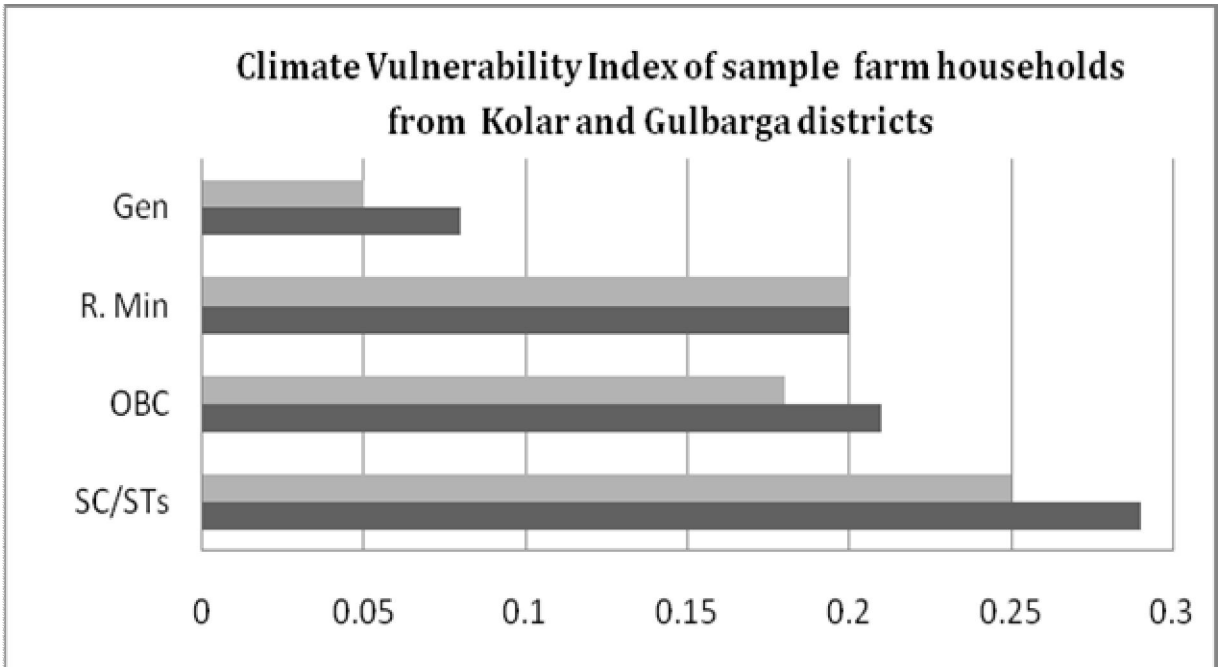
Climate Vulnerability Index of sample farm households from Kolar and Gulbarga districts								
Social Groups	Adaptive Capacity		Sensitivity		Exposure		Vulnerability	
	Kolar	Gulbarga	Kolar	Gulbarga	Kolar	Gulbarga	Kolar	Gulbarga
Scheduled castes and scheduled tribes	0.30	0.30	0.59	0.57	0.79	0.73	0.29	0.25
Other Backward Castes	0.44	0.39	0.54	0.57	0.83	0.71	0.21	0.18
Religious Minority groups	0.44	0.42	0.56	0.57	0.80	0.77	0.20	0.20
General castes/Upper castes	0.65	0.66	0.57	0.61	0.78	0.74	0.08	0.05
Mean	0.43	0.42	0.57	0.58	0.79	0.73	0.21	0.18

Since 20 years the term change in climate is been heard and experienced on a regular basis. According to the sample respondents in the study region, the differential impacts and the influence of differential impacts on adaptation is less. Peninsular South India lies in tropical and North India lies in sub-tropical regions of earth (Fig. 1). In tropical regions climate is overlapping, so there is no clear demarcation between the seasons, and also the seasons are overlapping. As the proximity of the region increases with equator line there will be much less variation in climate (peninsular south India) which allows crops to be grown throughout the year. All year round crops can be grown, whereas in Northern Himalayan states of India all ecological activities will be static during

autumn, due to snow fall. Despite the fact that, at equator and at lower latitudes crop productivity is projected to decrease for even small increase in temperature of 1-2^{0}C, farmers in the study region are less likely to adapt to the changes in climate, because of the added advantage of the extended growing period and adaptability of principal crops to the climate. In the tropical region due to change in the weather variables there is continuous multiplication of insects and pests in an imbricate way. Deviation in the day length affects the inflorescence setting of major pulse crops in the region; still these crops possess resilience towards change in the weather and adjust to sudden changes in the weather, comparatively on a higher scale than other commercial crops. On a balance, regions next to equator are most likely to face negative effects of climate change, since most of them are tropics with semi arid climate (HDR, 2007/2008, IPCC 2007), but because of the adjustments of crops to the region, farmers have constricted range of responses. While global projections appear to be stable, regional differences in crop production are likely to be skewed and stronger through time, leading to a significant polarization effects, with substantial increases in risk of hunger amongst poor.

The ideal adaptive capacity (IAC) value is 0.54 for farm households from both the districts. The adaptive capacity index value for Scheduled castes and scheduled tribes farmers is 0.3 (much lower than ideal IAC), with sensitivity value of 0.58, exposure value of 0.74 and vulnerability index value of 0.28 for both the districts. The sensitivity index value for other backward castes farmers is 0.41, with sensitivity value of 0.55, exposure value of 0.72 and vulnerability index value of 0.19 for both the districts. The adaptive capacity index value for religious minorities group of farmers is 0.41, with sensitivity value of 0.55, exposure value of 0.78 and vulnerability index value of 0.2 for both the districts. The adaptive capacity index value for General castes/Upper castes farmers is 0.65, with sensitivity value of 0.58, exposure value of 0.75 and least vulnerability index value of 0.6 for both Kolar and Gulbarga districts.

Fig. 2: Climate Vulnerability Index of Farm Households Across Social Groups from Kolar and Gulbarga districts



	SC/STs	OBC	R. Min	Gen
Gulbarga	0.25	0.18	0.2	0.05
Kolar	0.29	0.21	0.2	0.08

Table 7: Categorization of social groups of farmers (sample respondents) from both Gulbarga and Kolar districts

Farmers category	Social Group of Kolar and Gulbarga Consolidated (%)			
	Scheduled castes and scheduled tribes (%)	Religious Minority groups (%)	Other Backward Castes (%)	General castes/Upper castes (%)
Marginal	77.5	1.5	15	5.5
Small	34.5	17.5	25.5	22.5
Semi-medium	50.5	4.5	28	16.5
Medium	9.5	1.5	24	65.5
Large	3	10.5	10.5	76
CVI	0.26	0.2	0.19	0.06

The ascending order for climate vulnerability index is; general castes/upper castes with 76 per cent of them are being large farmers, other backward castes with 50 per cent of them are semi-medium farmers, religious minorities groups with 17.5 per cent of them from small farmers' category and scheduled castes and scheduled tribes with 77.5 per cent of them from marginal farmers' category form the caste composition of the sample farm households in the study.

General castes/upper castes farmers have the least vulnerability index value, because of the entitlements to factors (institutional credit, perennial water sources, weather information and weather insurance) which negatively influence the sensitivity, exposure and positively influence the adaptive capacity. Other backward castes with vulnerability index (0.19) do have possessions which can alter the sensitivity and uplift adaptive capacity, followed by religious minority groups (0.2) with high human resources and scheduled castes and scheduled tribes farmers (0.26) with high farming experience.

CONCLUSIONS

Processes at the local level can influence global level processes, local knowledge thence can make valuable contributions in gaining an understanding of global climate change. It can provide information about local conditions and reflect the foci of empirical investigations to issues that have been overlooked, by science and policy circles. Perception influences people's decision on whether to act or not at a given circumstances, and also to the type of questions, explanations, meanings and values that one would give, to the world within which we live. Perceiving the change in climate is crucial as it dynamically structures and orientate multiple possibilities of actions by farmers i.e., local observations and perceptions must be taken into account in efforts to understand vulnerability of households to climate change.

The factors responsible for high vulnerability are inefficiency in management of technological change, natural resources, institutional issues, equity and other human wellbeing dimensions. It is both urban and rural population vulnerable to climate change but the degree of vulnerability varies across regions, with most severely affected would be rural poor who work in agriculture.

Despite the conclusion from IPCC reports (AR1-AR5), with high confidence that anthropogenic climate change is a real and crucial phenomenon, there is a large scepticism and uncertainty relating to the nature of these changes. Whilst, uncertainty is a constant question, there is also incremental nature of climate change in the form of extreme weather events, which influence the vulnerability of the system under consideration. The perception of climate change due to similar exposure need not necessitate the similar vulnerability of the households to climate change, due to varied ability to react to and respond to the changes. The economic, social and physical heterogeneity in the nature and composition of households are the locating factors, which enable researcher to identify the differentiation in the climatic impacts on the households.

The objective of the present chapter is to find out the factors which influence and increase the vulnerability of farm households to climate variability and change. The analysis is made based on the social categorization of the farm households i.e., based on the caste of the household. The

vulnerability of the farm households hailing from scheduled castes and scheduled tribes' background is higher, due to their incapability to get access to perennial sources, their skewed asset base and declined acceptance in the larger societal structures. As Brooks, *et al*. (2005); pertinently points out, 'ultimately it is people, not countries that are vulnerable to climate change', because when social background and caste of the people are considered, it is found that people from lower social background are highly vulnerable to climate change due to lower adaptive capacity and high sensitivity to climate change. One of the major quote is that climate change is seen as problem for society, not of society (Hewitt, 1997), many impacts assessment have thus been impeded by only considering one side of the equation (Cutter, 1996); i.e., by taking only land and resources as the basis for deriving vulnerability and neglecting the social background and importance of caste-based graded inequalities in terms of resources and accessibility to various livelihood capitals, also more than half the sample farm households are marginal scheduled castes and scheduled tribes farm households, with fifty four percent of them working on agricultural land holdings which is less than the state's operational land holdings for marginal farmers which is less than 0.48 hectares. Thus land is not providing the desired livelihood, due to dry-farming and poor conservation of soil.

The second group of farm households which are highly vulnerable to climate change is hailing from other backward communities and religious minority groups. The underlying factors driving vulnerability of these households are majorly skewed political participation and religious non-acceptance for Islamic groups. There is an exclusion of an entire social group from state related relief schemes and programmes, during years in which droughts are declared by the state. The elite capture phenomena by the large and medium farmers, who belong to dominant castes within the villages, exclude socially lower farm households from the community representations and political participation. Despite the relatively lower experience in farming, general caste farm households show low vulnerability to climate change, mainly because of their ability to supplement the agricultural fields with irrigation water and consistent access to authentic climate information sources at various levels.

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