Climate Smart Agriculture: ~~An option for l~~Learning experiences from indigenous communities in arid region of Rajasthan, India

Abstract

Climate change directly affects arid region farming community's economy, due to heavy dependence of the agricultural sector on climate in India. A decrease of rainfall[12] and rise in temperature has been increasing the exposure of the whole community to frequent droughts. This study examined arid region farmers' perception about climate change. Farmers' perceptions about climate change, therefore, strongly affects how they understand and deal with climate induced risks and uncertainties, and undertake specific measures to mitigate the adverse impact of climate change on agriculturetraditionally. The study was conducted in Bikaner western district of Rajasthan (India) which was deemed to be vulnerable to climate change. Both primary and secondary data were used for the study purpose. The multistage sampling methods were employed to select farmers in western district of Rajasthan. The study sample comprised of 200 farmers selected randomly. Our findings showed that farmers have high level of perception about the distribution of rainfall, rise in temperature, increase in frequency of heat waves and droughts in the region. Further climate adaptation measures, farmers resorted to heat tolerant varieties and water conservation techniques. Moreover, lack of access to institutional credit, poorly defined property rights, inadequate infrastructure and information gaps were some of the major barriers to climate adaptation in the region. Many cultural, social and religious beliefs and superstitious activities pertaining to the prediction of weather prevail since generations. From time immemorial farmers have predicted the weather on the basis of these beliefs/activities. Hence, an appropriate policy framework and specific programmes for sustainable agriculture growth are needed for enhancing farmers' perception towards climate change and for promoting climate smart agriculture.

Comment [LA1]: Include reference to the Vulnerability Sensitivity Map for the region that supports this claim

Keywords: Adoption, Arid Region, Climate Change, Knowledge, Rainfall and Strategies,

Introduction

Climate change refers to long-term changes and statistical variability persisting for an extended period (typically decades) in weather conditions[1]. Globally, climate change is becoming a major challenge to agricultural development efforts and human welfare. However, agricultural production activities in Africa are generally more vulnerable to climate change than other socio-economic sectors[2].

One of the key determinants of agricultural productivity is the climate. Climate change, according to the United Nations as well as some national governments, may threaten global food security. According to studies, India is particularly vulnerable to climate change, and agriculture production, food and water security, human health, and livestock populations all are likely to suffer the consequences. While science provides the tools to understand and manage water resources, it is also vital to understand how rural

people perceive local water scarcity and how this is socially differentiated[3]. A failure to appreciate how people perceive the magnitude of environmental and climatic risks or their implications for livelihoods has been identified as significant barriers to adaptation[4]. Perceptions shape the responses people undertake[5] to cope, adapt, not adapt or maladapt. In recent years, there have been an increasing number of studies capturing farmer perceptions of risk.

As a result, governments of developing ~~-~~countriesy ~~governments~~ are more concerned about the negative impact and its consequences. Furthermore, agriculture is essential to people's livelihoods, particularly in rural regions, and climate change poses a direct and serious threat to the livelihoods of millions of Indians.Consequently, the present study was undertaken to learn fromi~~n~~g experience ~~from~~ of indigenous farmi~~n~~ger~~s~~ communities about their knowledge of local methods about climate in arid region of Rajasthan".

Methodology

The study was conducted in Bikaner district in the state of Rajasthan. Primary data was used for the study purpose. The multistage sampling method was employed to select the farmers in Bikaner district which are located in arid part of India. Out of eight tehsil four tehsil were selected randomly. From each selected tehsil, two village were selected randomly. A list of all farmers was prepared with the help of agriculture supervisor, patwari and other government officers, twenty-five farmers were selected randomly in each tehsil. Thus, a total number of selected farmers were two hundred. The study sample comprised of 200 farmers which was selected randomly. The chi-square test was chosen because collected data are expressed as frequency counts or percentages.

Comment [LA2]: How was the views of the farmers collected was it via Questionnaires, Interviews, Focused Group Discussion, workshop or a combination of both

Results and Discussion

Bikaner district is a part of the arid region of Rajasthan, thus there are extreme climatic conditions. In the district, high temperature and low humidity prevail for most of the months of the year. The impact of climate change is highly conspicuous in the arid region of India, given its geo-ecological fragility reflected by low and erratic rainfall pattern and poor soil fertility. Although the impacts of climate change are inimical to agriculture and food security, they can be restricted by implementing adaptation strategies.

Comment [LA3]: Describe Bikaner district more succinctly i.e. is the population dense or less, what is the predominant land use pattern, is its socio economic attributes

Socio-demographic characteristics

From the table no.1, it was inferred that 42 percent of the farmers belonged to middle age category followed by 34 percent in the old age and rest 24 percent found in the young age. Almost half of farmers (50 per cent) completed their education up to matriculation and above, one third (33 per cent) of the respondents had undergone primary to middle school level education and rest 17 per cent were found illiterate and informally literate. This is showing the lowest transition rate from primary to upper primary

level and secondary to higher secondary level of education. This is because the dropout rate is also high among them. As regarding their caste, nearly half of the farmers (49 percent) belonged to upper castes, followed by 45 percent of the farmers comes under other backward castes and only 6 percent belong to SC/ST in the study area. As regarding land holding, 35 percent farmers were belonging to semi-medium category, 27 per cent under medium category and 17 percent small farmers. In case of marginal farmers only 16 percent farmers and 5 percent farmers were large.

Farmers' perception on causes and learning opportunities ofclimate change

From table 2, it was observed that farmers identified many causes of climate change. The farmers perceived that deforestation (93%) followed by soil degradation (88%) are the main causes of climate change. The chi-square test showed significant differences in the proportion of farmers who identified deforestation and soil degradation as causes of climate change as compared to these who did not recognize them. Other researchers also reported that deforestation has been recognized globally as a major cause of climate change[7]. Because more deforestation means more carbon dioxide build-up in the atmosphere which affects the carbon emission cycle, the most important gas that contributes to global warming[8]. The chi-square test analysis detected that the proportion of respondents who identified the causes of climate change were significantly higher than those who did not perceive such causes. A non-significant difference was showed between the proportions of farmers who suggested the use of excess agrochemicals on farmlands to be the cause of climate change (47%) and those who did not know about this (53%) (Table 3). In contrast to this result, however, Farauta, Egbule, Idrisa, and Agu (2011) reported for Nigeria a significantly higher proportion of respondents perceived that excess agrochemicals could cause climate change. A significantly few farmers (7%) believed that the cause of climate change is related to god's plan to change nature as a result of the sinful action of man. In contrast to this finding, higher proportion of respondents (50%) from a study in Zambia perceived that supernatural factor such as God is the cause of climate change[9]. Regardless of this, other researchers[10] noted that agriculture produces a significantly higher contribution to climate change, primarily through the release of greenhouse gases such as carbon dioxide, methane, and nitrous oxide. For example, livestock byproducts accounted to 51% of annual worldwide greenhouse gasses emission[11]. Despite of this, farmers of the study catchment could not perceive the contribution of such agricultural practices on climate change, indicating that awareness creation for farmers on this issue is too essential. According to the farmers' view, there are sources of awareness on the causes of climate change (Table 2). A significantly higher number of respondents (88%) learned the causes of climate change from extension services advisory services, followed by personal experiences from effects on agriculture (crop, livestock) and environment (frequent droughts, flooding) (83%). The respondents (53%) also added that they learned about the causes

of climate change from media mainly radio, kisan mela exhibition and sometimes from television, but such proportions of farmers were non-significantly differed. In opposite to these results, Tologbonse et al. (2010) and Nzeadibe et al. (2011) reported for West Africa that the main source of information for farmers on causes of climate change is related to personal experiences, followed by radio and advisory services by extension agents.

Farmers' perception on indicators of climate change

From table 3 it was observed that the most commonly perceived things of climate change by the farmers included: uneven rainfall distribution (92%), rainfall amount (90%), length of rainfall season (90.00%), rate of soil erosion (90.00%), late start of rainy season (88.00%), temperature (85.00%), early cease of rainy season (85.00%), agricultural output (85.00%), frequent droughts (78.00%), climate borne diseases and pests (75.00%), change in soil health condition (75.00%), excessive lightening in rainy season (67.00%), frequent floods (62.00%) and 08.00 per cent of the famers has said that they don't perceived indications that shows or showed the climate change. Most indicators of climate change mentioned in this study have already identified by previous reports[12], regardless of their statistical differences across the reports. Accordingly, changes in rainfall and temperature were identified as the most frequently used climate change indicators as perceived by the farmers in the study area, which are consistent with the present results.

ITK for weather prediction

Out of various factors which control agricultural production, weather is the only factor over which man has no control and hence it has an overwhelming dominance over the success or failure of agricultural enterprise[13]. It is reported that weather induced variability of food production is more than 50 per cent of the normal production in respect of smaller areas situated in arid and semi-arid regions[14]. In order to reduce risks of loss in food production due to the vagaries of weather should be taken into account as one of the major inputs in agricultural planning. In present times we have many improved technologies for making weather forecasts as well as for their dissemination. Previously when there were no such technologies available farmers based their prediction on many natural, cultural and social phenomena. Many cultural, social and religious beliefs and superstitious activities pertaining to the prediction of weather prevail since generations. From time immemorial farmers have predicted the weather on the basis of these beliefs/activities. The following are some examples from the western area of Rajasthan. Table no 4 shows that 82 percent farmers believes that eggs lying on the tree by the lapwing bird is a "sign of good rainfall year". 78 percent farmers believe that if ants carry their eggs in safe place there are imminent rain. Farmers also predict weather by observing closely the different activities like excessive flowering in Neem tree, loud chirping of bird in group and taking dip in water, and snake climbing on Khejri *(Prosopis*

Cineraria) tree. Further it is also believed that if wind direction is east and Holi flames go straight up the forthcoming rainy season is good. Each of these ITKs was ranked based on the degree of their use and relevance under changing climate conditions. The study revealed that these ITKs were highly useful for the local community to manage climate change induced stresses.

Discussion

Agriculture is essential to people's livelihoods, particularly in rural regions, and climate change poses a direct and serious threat to the livelihood of millions of Indians especially in arid part. At present time the main source of climate related information for farmers are radio and advisory services by extension agents and any other government/private agencies. But if we see the past Indian farming, there were a number of traditional methods like: Eggs laying on the tree by the lapwing bird, wind direction is east, Excessive flowering in Neem tree and Snake climbing on Khejri *(Prosopis Cineraria)*, are related to personal experiences. In present study, there are many practices which use as indicator of good rainy seasons. Changes in rainfall and temperature were identified as the most frequently used climate change indicators as perceived by the farmers in the study area, which are consistent with the present results. The present study revealed that these ITKs were highly useful for the local community to manage climate change induced stresses. This study also revealed that past knowledge and ITKs are useful to reduce climatic threat.

Conclusions

This study shows that farmer's household heads socio-demographic profile and farm biophysical characteristics significantly varied in the study area. Most farmers perceived that deforestationfollowed by land degradation are the main causes for climate change. The majority of the respondents learned about the causes of climate change from the information that have been given by extension services and personal experiences acquired from agricultural practices and their rich heritage. This study also revealed that majority of farmers uses their past knowledge to know about rain. Uneven rainfall distribution and temperature are the most frequently noted indicators of climate change by the farmers.

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Table1 Distribution of respondents according to their socio-demographic profile

S.N.	Variables	Frequency	Percentage
1	**Age**		
	Young (<30years)	48	24.00
	Middle (31 to 45 years)	84	42.00
	Old (>46 years)	68	34.00
2	**Education**		
	Illiterate & informally literate	34	17.00
	Less than Primary to Middle	66	33.00
	Matriculate and above	100	50.00
3	**Caste**		
	Upper Castes	98	49.00
	Other Backward Castes (OBC)	90	45.00
	SC/ST	12	06.00
4	**Land holding**		
	Marginal (Land holding<1ha)	32	16.00
	Small (1 ha to 2 ha)	34	17.00
	Semi-Medium (2 ha to 4 ha)	70	35.00
	Medium (4 ha to 10 ha)	54	27.00
	Large (Land holding> 10 ha)	10	05.00

Table 2 Farmers perception on causes and source of awareness of climate change

Sl.No.		Farmers'Response

	Causes of climate change	Yes (%)	No (%)	Chi-square (p value)
1	Deforestation	186 (93%)	14 (07%)	0.001
2	Soil degradation by erosion	166 (83.00%)	34 (17.00%)	0.006
3	Climate change	146 (73.00%)	54 (27.00%)	0.027
4	Continuous cropping (successive cropping in the same piece of land.)	140 (70.00%)	60 (30.00%)	0.03
5	Overgrazing	134 (67.00%)	66 (33.00%)	0.0039
6	Urbanization	116 (58.00%)	84 (42.00%)	0.27NS
7	Excess agrochemicals use on farms	94 (47.00%)	106 (53.00%)	0.37NS
Source of Awareness of climate change				
1	Extension services such as advisory services, training, seminars	176 (88.00%)	24 (12.00%)	0.002
2	Personal experience such as effects on agriculture (crop, livestock), environment	166 (83.00%)	34 (17.00%)	0.001
3	Mass media such as TV, radio, exhibition, etc.	106 (53.00%)	94 (47.00%)	0.29ns

$\varkappa^2$, Chi-square (two-tailed test); significant at probability level, $p<0.05$; ns, not significant at $p > 0.05$.

a. The percentage total in a column is more than 100% because each respondent used more than one cause of climate change.

b. Values in parentheses are percentage of respondents.

c. Teff (Eragrostistef) mono-cropping is common in the study catchment.

d. The percentage total in a column is more than 100% because each respondent used more than one learning opportunities of climate change.

e. Values in parentheses are referred to percentage of respondents whereas without are referred to number of respondents.

Fig 1

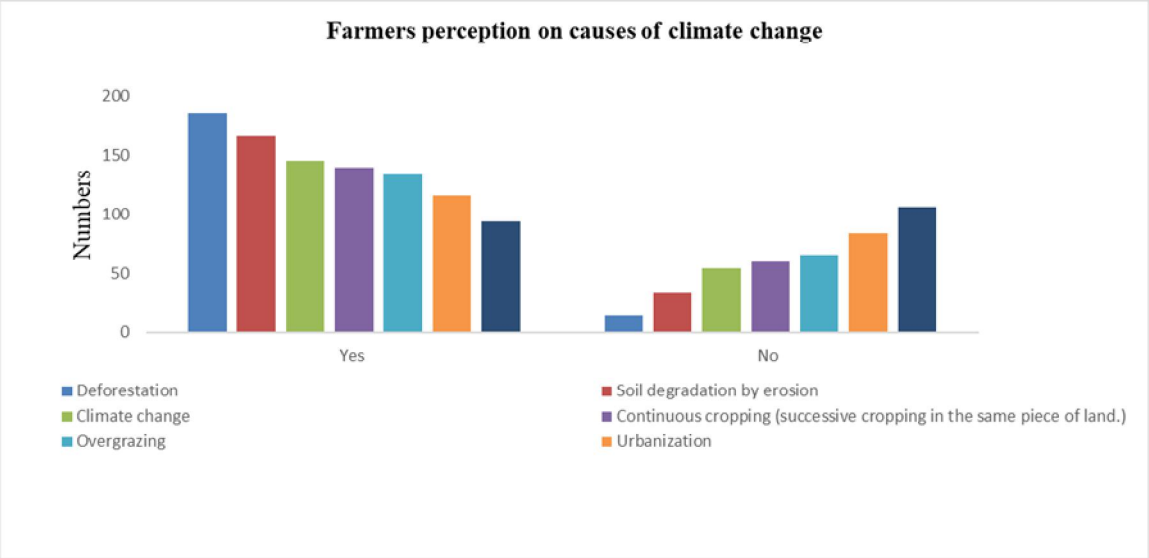

Table 3 Distribution of the farmers according to perception about climate change

Sl.No.	Climatechangeindicators	Farmers'Perception	
		Yes (%)	No (%)
1	Rainfall amount	180 (90.00)	20 (10.00)
2	Change in temperature	170 (85.00)	30 (15.00)
3	Climate borne diseases and pests	150 (75.00)	50 (25.00)
4	Uneven rainfall distribution	184 (92.00)	16 (08.00)
5	Frequent droughts	156 (78.00)	44 (22.00)
6	Frequent floods	124 (62.00)	76 (38.00)

7	Late start of rainy season	176 (88.00)	24 (12.00)
8	Early cease of rainy season	170 (85.00)	30 (15.00)
9	Change in rainfall season length	180 (90.00)	20 (10.00)
10	Excessive lightening in rainy season	134 (67.00)	66 (33.00)
11	Change in rate of soil erosion	180 (90.00)	20 (10.00)
12	Change in agricultural output	170 (85.00)	30 (15.00)
13	Change in soil health condition	150 (75.00)	50 (25.00)
14	Don't know any of the above	16 (08.00)	184 (92.00)

$\varkappa^2$, Chi-square (two-tailed test); N/A, not applicable; significant at probability level, $p < 0.05$; ns, not significant at $p > 0.05$.

a. The percentage total in a column is more than 100% because each respondent used more than one learning opportunities of climate change.

b. Values in parentheses are referred to percentage of respondents whereas without are number of respondents.

Source: Own Survey data (2020).

Table 4 Indigenous climate and weather forecast practices used by the farmers

Indigenous practices/beliefs	Indicators	Per cent
Eggs laying on the tree by the lapwing bird	Forthcoming good rain	82
Ants carry eggs to safe place	Imminent rain	78
Appearance of winged termites after a dry spell of some days	Indicates rains	73
Karva (clay pot) made of clay is broken by filled with water	Heavy rainfall in rainy season	72
Wind direction is east	Possibility of rain	69
Loud chirping of birds in group and taking dip in water	High humidity, imminent rain	68
Excessive flowering in Neem tree	Forthcoming good rainy season	67
Dust bathing by birds	High humidity, imminent rain	61
Snake climbing on Khejri	Possibility of rain	61
Crow making sound	Imminent rain	60

Holi flames go straight up	Forthcoming good rainy season	54

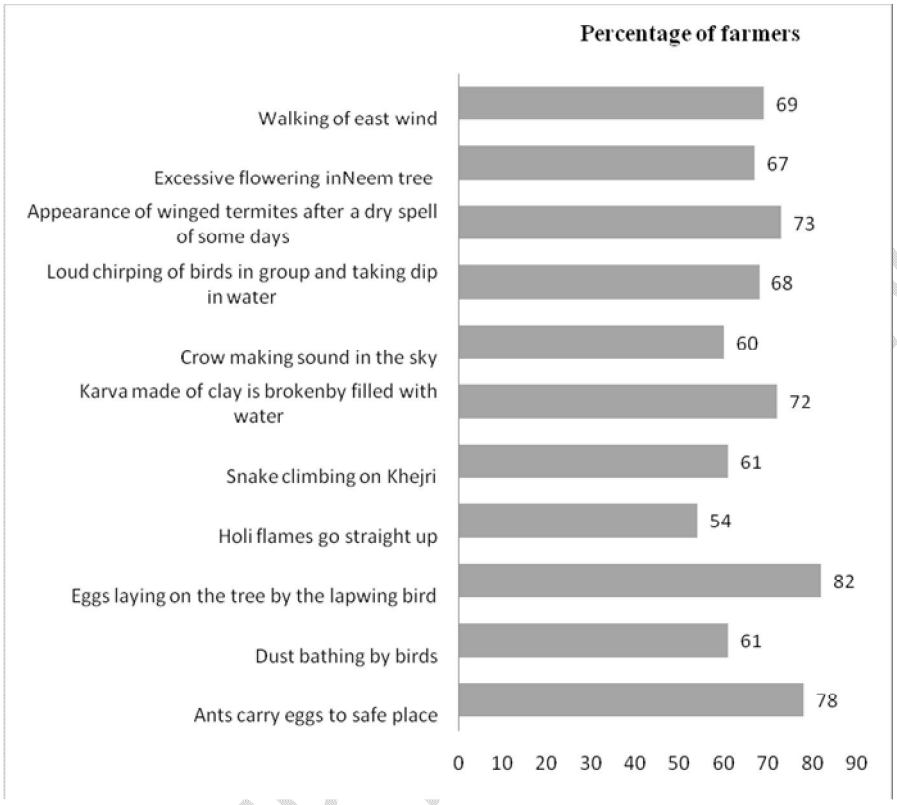

Fig 2. Indigenous practices/beliefs

Source: Field survey, 2020