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Assessing the socio-economic impacts of climate change in arid ecosystem of India

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Abstract
The present study was conducted with the objective of assessing the socio-economic impacts of climate change in arid ecosystem of India. A sample of one hundred farmers from Rajasthan representing Arid ecosystem, were purposively selected. Randomly data were collected through personal interview and focused group discussion with both structured and unstructured schedule. Data were analyzed using statistical tools like mean, standard deviation, frequency etc. In Rajasthan, 86 per cent farmers reported delayed and irregular rainfall and 73% farmers reported about rising temperature. Seventy nine per cent farmers reported low frequency of storm and 83% reported increased frequency and intensity of heat wave. Moila disease (sucking pest) in guar, yellowing of leaves of mustard plant, sweet borer's attack in pearl millet etc. was reported in high magnitude. About two-third (67%) farmers reported about decline in population of desi neem (*Azadirachta indica*), khejri (*Prosopis sp.*), desi babul, (*Acacia nilotica*), amla (*Phyllanthus emblica*) and deshi ber (*Ziziphus sp.*) plant. Seventy two per cent farmers reported about heavy migration of people. So, impacts of climate change were felt in all aspects of life.

Key words: Adaptation, Arid ecosystem, Climate change, Socio-economic impacts

Introduction

Climate-related disasters have brought widespread misery and huge economic losses to India, while adversely affecting public health, food security, agriculture, water resources and biodiversity. The late arrival of monsoon and erratic behavior of rainfall have already drawn the attention of national media as more than 80 per cent farmers depend on arrival of monsoon to start cultivation. The country also recently experienced changes in rainfall pattern and temperature. All these changes pose a serious threat to agriculture, and therefore to country's economy and food security. Indeed climate change is and will increasingly have dramatic impacts on ecological and social systems (IPCC, 2001; 2007). The Rajasthan state comes under one of the most vulnerable region under changing climatic condition due to overall reduction in rainfall, increase in temperature and evapotranspiration. Even 1% increase in temperature could result in an increase in evapotranspiration by 15 mm, resulting into additional water requirement of 34.27 million cubic meter for Jodhpur district alone and 313.12 million cubic meter for entire arid zone of Rajasthan (Goyal, 2004). There will be significant increase in desertification over India in next 100 years due to climate change (Goswami, 2008). Duration of rainy season declined from 101 days to 46 days between 1973 to 2010 and average rainfall is declined by 1.5% in September month in Rajasthan (Rathore and Verma, 2013). The impacts have been felt in all aspects of livelihood *i.e.* agriculture, livestock and health.

The quantitative assessment (Schmidhuber and Tubiello, 2007) suggests that the socio-economic setting in which climate change is likely to evolve is more important than the impact that can be expected from the biophysical change of climate variability. Many social scientists argue that impact of climate change will be more on poor than rich due to their limited adaptive capacity. The climatic disaster, therefore, makes the livelihood of the small and marginal farmers more susceptible, especially in India as they are already vulnerable to conventional problems like poverty, malnutrition, illiteracy etc. So, there is an emergent need to document the different socio-economic impacts of climate change to formulate appropriate adaptation policy. As of today, only limited scientific research has been carried out on exploring the socio-economic impacts of climate change in India. With this background, the present study was conducted in 2013 to document the diverse socio-economic impacts of recent climate change on the arid ecosystem of India.

Materials and Methods

Sampling: Two districts, Jodhpur and Jaisalmer from Rajasthan were purposively selected representing arid ecosystem. Luni block from Jodhpur and Jaisalmer block from Jaisalmer district were selected purposively to see the level of socio-economic impacts in typical arid region of India. Four villages namely Lonawaskhara, Porkkhawas from Luni block and Bharamser and Pora from Jaisalmer block were selected purposively. Finally 25 farmers were selected randomly from each village for the study and the sample size for the study comprised of a total 100 farmers.

Measuring socio-economic impacts: The impact assessment was done using both quantitative and qualitative techniques. The impacts were generally studied in term of changes in agricultural practices, perceived changes in climatic parameter, changes in bio-diversity, changes in livestock production and productivity and changes in their social and cultural practices. An exploratory research design was adopted to identify the in-depth and unconventional impact of climate change.

Extensive information about the different impacts of climate change on the livelihood of farmers of Rajasthan was collected to represent the universe. Then the relevant information was selected based on the recommendation of the experts. The different sub-areas of impacts were identified and statements were organized theme-wise. The major themes identified were climatic and physical, agriculture, livestock, forestry, health and socio-cultural impacts. The whole questionnaire was divided into three parts *viz*., areas of impacts, kind of impacts and factors associated with the impacts. All the information was collected through open ended questionnaire with extensive use of 'probing' technique and 'funnel technique' of data collection. The data were quantified using frequency and percentage analysis.

Results and Discussion

Perceived impacts on climatic and physical parameters: Majority of the famers agreed that temperature was increasing in the area (Table 1). The frequency and intensity of heat wave had increased significantly and soil was becoming dry and rough making them unsuitable for cultivation. Winter season was also delayed by one month. Earlier the winter used to start before diwali (November) but now it is started from December and extended upto March. As a result, the yield of *rabi* season crops like vegetables, pulses and mustard got affected. The meteorological data also supported the perceived impacts of the respondents.

Table 1. Perceived impacts on climatic and physical parameters (n=100)

Area of change	Kind of change	Factors associated with change	Percentage
Temperature	Increase in temperature	Deforestation, increased vehicle, tourism, industrialization.	73
Rainfall	Rainfall is coming late, which affect the sowing of *kharif* crops	Due to decline in vegetations and forest area, change in wind circulation pattern etc.	86
Drought	Frequency and duration of drought have increased.	Due to increased temperature and irregular rainfall.	57
Fog	Less fog was reported from the area and as a result low soil moisture in the field was also reported.	Due to high temperature at the atmosphere.	44
Sandstorm	Low frequency of storm was reported from both Jodhpur and Jaisalmer.	Obstructed by *sevan* grasses and vegetations.	79
Heat wave	The frequency and intensity of heat wave have increased significantly. It makes soil dry and rough.	Due to rise in atmospheric temperature.	83
Wind	Frequency and speed of wind was less compare to earlier days.	Due to deforestation.	48

Area of change	Kind of change	Factors associated with change	Percentage
Cold	Winter season is delayed by one month. This is affecting the rabi season crop like mustard, vegetables etc.	Due to rise in temperature.	72
Sand dunes	Phenomenon of sand dunes is reported to be low.	Due to less wind.	49
Desertification	Increasing	Due to high temperature	42
	Decreasing	Due to introduction of some resistant grass and plants like *Prosopis juliflora* (*Vilayati babul*) and *Sevan* grass.	58

The farmers reported late rainfall in the area for the last few years. Earlier rainfall used to start by the end of June or within the first week of July. But now it is started between 15th to 30th August and affected the sowing of *kharif* crops. The respondents reported heavy rainfall within few days leaving rest of the season dry and rainless. They shared that the winter monsoon was delayed by one month from mid November to December in the area. Recently the farmers experienced less fogy condition, due to which, low soil moisture was reported from the area. The rainfall data from Jodhpur also supported the observation of the farmers which showed high variation in *kharif* season rainfall (Fig. 1). Prasad *et al*. (2014) also reported that farmers of Bundelkhand region from Madhya Pradesh perceived changes in rainfall pattern and 68 per cent farmers believed that onset of monsoon were delayed. In 2006, the farmers received high rainfall whereas, in 2005 and 2007, they experienced drought like situation. Overall amount of rainfall for rest of the months showed a declining trend indicating skewed distribution of rainfall across the season. Similarly the rainfall in Jaisalmer fluctuated at extreme degree. For three consecutive years (2002-2004), the farmers faced drought like situation followed by heavy rainfall (Fig. 2) in three consecutive years (2006-2008). As a result, frequent crop failure was reported and sometime they adopted double sowing method to arrest crop failure. So, all these data suggested that farmers were highly affected by recent climatic variability.

The farmers reported low frequency of storm in recent times in both Jodhpur and Jaisalmer. Earlier, storm continued over two-month period but now for hardly 10-15 days storms were experienced by the people. The storm had both positive and negative effect on their livelihood. The speed and strength of wind was also reported to be low as compared to the earlier days. The phenomenon of sand dunes had decreased in the area and regarding the expansion of desertification, the farmers were divided in their views. Few of them were of the opinion that desertification will increase under changing climatic condition while other sections told that it will decline.

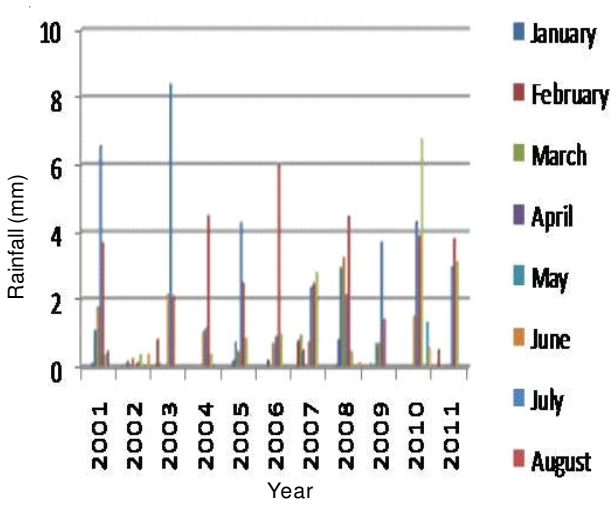

Fig 2. Rainfall pattern in Jodhpur

Fig 2. Rainfall pattern in Jaisalmer

Table 2. Impacts on agriculture (n=100)

Area of change	Kind of change	Factors associated with change	Percentage
Decline in production	Production of all the major crops has declined.	Due to late rainfall and increased temperature.	100
Change in cropping season	*Kharif* season has shifted from July to August.	Due to changes in rainfall.	45
Change in sowing time	Sowing was reported to be delayed	Due to advancement in winter season and delayed rainfall.	38
Change in harvesting time	Earlier harvesting was done by last week of September or by first week of October but now it is delayed to mid November	For advancement in winter season and early maturity of the crops.	42
Change in cropping pattern	Farmers were adopting intercropping like moong and *mat* (*Vigna aconitifolia)*and *sesame* etc.	To reduce the risk of crop failure and more income.	36
	Intercropping of *khejri (Prosopis sp.), aak* (*Calotropi*s sp.) and *gonda (Cordia sp.)* plant	To supplement the income from waste land.	64
	Intercropping of cluster bean and *matira*.	To reduce the risk of crop failure under changing climatic conditions.	51
Change in soil fertility	Decline in soil fertility.	Excessive use of chemical fertilizers.	74
Decline in production of major crops	Production of pearl millet, mustard, amla went down and area under moong has decreased.	Due to extreme weather and erratic rainfall.	46
Change in level of groundwater	Water level went down significantly.	Excessive irrigation, low rainfall etc.	86
Change in pollination	Pollination of ber plant is affected due to high temperature	Behavior of pollinator has changed in high temperature.	23
Crop diversification	Now farmer were growing *Cordia s*p. (gunda plant), guggal, *capris desidua*(for pickles and vegetable), date palm, *khair* , pilu (desert grape), *dhaman* grass ber and amla orchard.	To adapt to changing climatic situations and for more income.	69
Change in disease and insect attack	Whitening of leaves of moong plant.	Late rainfall.	73
	Moila diseases (sucking pest) in guar, yellowing of leaves of mustard plant etc. were reported to be occurring in high magnitude.	Rise in temperature.	64
	Sweet borer's attack in pearl millet and green ear in pearl millet reported to be increased in the area.	Rise in temperature, less storm and less rainfall.	71
	Burning of flower, no fruiting, and dropping of flower in ber plant.	Due to high temperature.	43
	Problem of termite increased to a large extent in the area.	Changing weather.	89
Change in flowering period of different tree and crops	Flowering is also delayed due to late sowing.	Late sowing.	58

Area of change	Kind of change	Factors associated with change	Percentage
Change in soil salinity level	Problem of salinity had started.	Due to excessive irrigation, a layer of salt appears above the soil under high temperature.	89
Impact on forage crop	Invasion of *Prospis juliflora* replacing native *Prosopis cineraria*, Low population of most productive and palatable *Lasiurus-Cenchrus* based rangeland, problem of low pollination, free fall of flower and fruit in ber plant.	The *Prosopis juliflora* can survive in extreme drought condition and is invasive in nature.	78

Impact on agriculture: A majority of the farmers reported low yield of pearl millet, mustard and maize under increased temperature and low rainfall conditions (Table 2). The *kharif* season had shifted from July to August in the study area. Sowing of *kharif* crop was reported to be late by one month due to late rainfall. Sometimes farmers did go for double sowing to adapt to the crisis period which not only increased their cost of cultivation but also reduced their income. Similarly sowing in *rabi* season was delayed by 15-30 days (November to December) due to late onset of winter season. Now temperature remained high upto December which affected the germination of *rabi* crops. Harvesting of *kharif* crop was also delayed from October to November. If more rainfall then good yield was reported from high yielding variety but under less rainfall condition high yield was reported from local variety.

Fertility level of soil had also declined due to increased use of fertilizer and rising level of salinity. Soil salinity level had increased in all the fields due to increased irrigation and raised temperature. The farmers reported that a layer of salt appeared in the field at extreme high temperatures due to evaporation. The water level had gone down significantly from 150 feet to 200 feet at an interval of 20 years. The pollination of ber plant was highly affected as the behaviour of honey bee had changed with rising temperature. The farmers adopted crop diversification by introducing new crops to adapt to climate variability. Some diseases were also reported at higher frequency and at a larger scale in the area. Flowering and harvesting also delayed due to rise in temperature of major crops. Majority of the farmers (78%) reported low quality of milk and fodder under changing climatic condition. Farmers reported heavy problem of *Prosopis juliflora* which invaded most of the rangeland and agricultural land.

Impact on bio-diversity: Area under some indigenous plants like neem, khejri, babul, amla and ber plant had decreased, which were beneficial for the ecosystem (Table 3). Population of some animal species like cobra snake, black deer, fox etc declined disturbing the ecological balance of the region. Similarly, some bird species like *doddar*, peacock, pigeon, *geet* and *chiria* bird were also under threat. The decline of dodder birds' population was a real example of bio-diversity threat due to human intervention. *Doddar* lived and laid eggs within *Lasiurus sindicus* grass. Now the area under grass had decreased due to grazing and bringing more land under cultivation. With decrease in the area under the grass, the population of doddar bird also decreased over the time.

Impact on livestock and human health: In livestock sector, people reported impacts like decrease in milk production, decline in quality of milk and increased retention of placenta/reproductive disorders in dairy animals. Human health was also affected due to rise in temperature and was expressed through following symptoms like sun burn, heart attack, stroke etc (Table 4).

Impact on socio-cultural systems: Climate change brought rapid changes in the socio-cultural system of the respondents (Table 5). Forty eight per cent farmers affirmed that the rate of poverty increased in the area and 59 per cent told about the increased gap between rich and poor under changing climatic situation. People at large scale were migrating towards Delhi, Chandigarh for employment. There was also a shift in occupational pattern of the area. People (18%) were moving towards non agricultural based activities like tourism, business, rural artisans, private jobs etc. due to high uncertainty involved in agriculture. People (24%) also experienced high level of psychological stress under high variability of climatic condition.

Conclusion

The study showed that the recent changes in climate

impacted the livelihood of farmers both directly and indirectly. The farmers of Rajasthan felt the impacts of climate change in all around their livelihood activities and life. They experienced increased temperature, hot wind, less and delayed rainfall. The higher frequency of diseases like *moila* disease, green ear etc. was reported under changing climatic condition. However, the farmers brought a large scale crop diversification to adapt to the changing climatic conditions. The adverse impacts were felt on livelihood, bio-diversity, and socio-cultural domain. Hence, it was concluded that the arid ecosystem is highly vulnerable to the climate change and it is of immense importance to include the locally identified adaptation measures in the state climate resilient policy for successful adaptation to climate change.

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Table 3. Impacts on bio-diversity (n=100)

Area of change	Kind of change	Factors associated with change	Percentage
Decrease of certain plant species	Neem plant, khejri, desi babul, amla, deshi ber plant etc. is decreasing	Due to deforestation and changed climatic condition.	67
Animal	The population of cobra snake, black deer, deer, fox, *neola* etc. were decreasing	Due to less vegetation.	58
Bird	Pupulation of *Doddar*, Peacock, Pigeon, g*eet, chiria* bird had declined.	Due to less vegetation and changed climatic condition.	63

Table 4. Impact on livestock and human health (n=100)

Area of change	Kind of change	Factors associated with change	Percentage
Production of milk	Production of milk from cow and buffalo had decreased in the area.	Due to high temperature.	77
Milk quality	Decrease in quality.	Due to application of urea in the field which indirectly goes as a feed to the animals.	34
Diseases	Increased retention of placenta/ reproductive disorders.	Due to high temperature.	42
Increase in human diseases	The occurrence of fever, stroke, bone pain, sunburn etc. has increased.	Increase in temperature.	45
Increase in human mortality	The rate of death had also increased to a significant level due to different types of climate change induced diseases.	Extreme temperature.	68

Table 5. Impacts on socio-cultural life of respondents (n=100)

Area of change	Kind of change	Factors associated with change	Percentage
Poverty	Increased rate of poverty.	Most of the people depend on agriculture and livestock for their livelihood but production of crops as well as income had reduced due to negative impact of climate change which led to increase in poverty.	48
Gap between rich and poor	Widening the gap between rich and poor.	As others sector like- service, businesses was less affected by climate change compare to agriculture on which most of the poor people depend.	59
Income	Reduction in farmer's income	Low production and increase in cost of cultivation.	85
Migration of people	Increase in migration	For ensuring job and regular employment.	72
Change in believes	Now, people believed more in the God of nature, like Shiva, Sun etc. for safety against evil and bad consequences.	Self satisfaction and expression of helplessness to the vagaries of nature.	24
Stress level	High level of psychological stress	The climate was highly variable from season to season. So farmers could not predict about the onset of monsoon/climatic variability and suffers from psychological stress.	24
Shift in livelihood options	Migration of workers from agriculture to non agricultural activities	Due to high uncertainty in agriculture sector.	18

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