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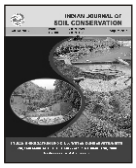

Scientists' perception regarding effect of climate change on agriculture

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ABSTRACT

The present paper analyses the perception of scientists regarding effect of climate change on agriculture and the various adaptation strategies that can help to overcome the effect of climate change in agriculture. The study was undertaken in Punjab state and 138 agricultural scientists of College of Agriculture, Punjab Agricultural University, Ludhiana and 12 Subject Matter Specialists from Krishi Vigyan Kendras of three selected districts of the state were taken as respondents. The data were collected through a well structured questionnaire. The results showed that all the scientists agreed to a large extent over changes in cropping pattern, additional stress on fragile systems in agriculture and effect on crop physiology due to climate change. Scientists perceived that climate change affected the agriculture to some extent. The adaptation strategies suggested by scientists included the development of crop varieties tolerant to heat stress, development of insect pests and disease resistant crop varieties, developing crop-breeding programmes and focusing on adaptability of plants to low-input situations in soils.

1. INTRODUCTION

Rural population depends directly on agriculture, forests, fisheries, and natural resources for their subsistence. Climate change is affecting the entire natural ecosystem as well as socio-economic system of the country. Agriculture may be particularly vulnerable to climate change due to its dependence on natural weather patterns and climate cycles for its productivity. At temperate regions, few degrees rise in temperature will reduce crop yield, while in the tropics, the yield of crops near to their maximum temperature tolerance and production will be decreased. A large decrease in rainfall would have even greater adverse effect on yields. In addition, degradation of soil and a decrease in water resources resulting from climate change have negative impacts on global agriculture (Anonymous, 2001a).

Agricultural facilities contribute approximately 20% of the annual increase in anthropogenic green house gas emissions (Anonymous, 1996a). Climate change can affect agriculture in a variety of ways. Temperature, radiation, rainfall, soil moisture and carbon dioxide (CO_2) concentration are all important variables to determine agricultural productivity, and their relationships are not simply linear. Agricultural adaptation to climate change involves two types of modifications in production systems (Bradshaw *et al.,* 2004). The first is increased diversification that involves engaging in production activities that are drought tolerant or resistant to temperature stress and secondly activities which makes efficient use and take full advantage of the prevailing water table and temperature conditions, among other factors. Climate change itself is still a controversial topic. While many researchers are in favour that it is real and is taking place, there are still others who see it as a normal process that has continued right after the formation of earth's atmosphere. Thus it was felt necessary to analyze the perception of agricultural scientists as to what extent the climate change is actually affecting the agriculture sector.

2. MATERIALS AND METHODS

The study was conducted in Punjab state with the objective of analyzing the perception of scientists regarding the effect of climate change in agriculture sector and the adaptation strategies that can be followed for the same. A total of 138 agricultural scientists were selected from nine departments of College of Agriculture, Punjab Agricultural University, with probability proportional to the number of scientists in each department. All the extension scientists (12) working in the KVKs of the selected districts *viz*., Hoshiarpur, Ludhiana and Bathinda were also taken as respondents for this study. Thus, a total of 150 scientists

were selected. Distributed questionnaire approach was used to collect the data.

3. RESULTS AND DISCUSSION

Perception of the Scientists Regarding the Effect of Climate Change on Environment

Gibson (1959) defined perception as the process by which an individual maintains contact with the environment. The data were collected from the scientists regarding their perception on the effect of climate change on environment, agriculture, soil health, insect-pest and weeds infestation, *etc.* The data given in Table 1 revealed that almost 65% of the scientists agreed to some extent that climate change has reduced biological diversity **(**65.33%), while a little more them 50% of them agreed to some extent that this phenomena has led to endangered ecosystems (53.33%), heavier precipitation owing to occurrence of intensive tropical cyclones (55.33%), and reduced vegetative cover (50.67%). Almost 55% of the scientists agreed to a great extent that there has been loss of fertile, densely populated coastal areas as a result of climate change and it has also affected the natural flora fauna (54.67%) while 54% of them agreed that there is an increase in the frequency of severe weather events to a great extent. The findings have been supported by Bhusal (2009).

Table: 1
Distribution of the scientists according to their perception regarding the effect of climate change on environment (n=150)

Effect of climate change on environment	Perception		
	To great Extent f (%)	To some extent f (%)	Not at all f (%)
Reduces biological diversity	43 (28.67)	98 (65.33)	9 (6.00)
Increase the frequency of severe weather events	81 (54.00)	65 (43.33)	4 (2.67)
Loss of fertile and densely populated coastal areas	83 (55.33)	62 (41.33)	5 (3.33)
Extinction of species	62 (41.33)	73 (48.67)	15 (10.00)
Endangered Ecosystems	65 (43.33)	80 (53.33)	5 (3.33)
Effects natural flora and fauna	82 (54.67)	64 (42.67)	4 (2.67)
Heavier precipitation owing to occurrence of intensive tropical cyclones	51 (34.00)	83 (55.33)	16 (10.67)
Reduced vegetative cover	43 (28.67)	76 (50.67)	31 (20.67)

Note: Figures presented in parentheses are in percentage

Perception of the Scientists Regarding the Effect of Climate Change on Agriculture

It is evident from the data in Table 2 that more than 58% of the scientists agreed to a great extent over changes in cropping pattern (58.67%), followed by 55.33 and 51.33% who agreed to a great extent regarding increased crop water requirements and effect on crop physiology, respectively. More than 50% of the scientists agreed to some extent about aspects such as change in the crop quality (56.00%), change in the harvest indices in crops (54.00%) and reduction in the yield levels of wheat (52.67%) owing to climate change. Similar results were reported by Ashalata *et al.* (2012).

Table: 2
Distribution of the scientists according to their perception regarding effect of climate change on agriculture (n= 150)

Effect of climate change on agriculture	Perception		
	To great extent f (%)	To some extent f (%)	Not at all f (%)
Reduction in the wheat yield levels	68 (45.33)	79 (52.67)	3 (2.00)
Changes in cropping pattern	88 (58.67)	60 (40.00)	2 (1.33)
Additional stress on fragile systems in agriculture	71 (47.33)	68 (45.33)	11 (7.33)
Direct bearing on major plantation crops	71 (47.33)	71 (47.33)	8 (5.33)
Change in the crop quality	46 (30.67)	84 (56.00)	20 (13.33)
Effect on crop physiology	77 (51.33)	69 (46.00)	4 (2.67)
Increased risk of crop failures	72 (48.00)	72 (48.00)	6 (4.00)
Increased crop water requirements	83 (55.33)	62 (41.33)	5 (3.33)
Change in harvest indices in crops	64 (42.67)	81 (54.00)	5 (3.33)

Note: Figures presented in parentheses are in percentage

Perception of the Scientists Regarding Effect of Climate Change on Soil Health

The results presented in Table 3 showed that 62.67% of the scientists agreed to some extent that there is a variation in the composition of soil organic matter because of climate change while increase in soil moisture stress, reduction in soil organic matter, loss of nutrient-rich top soil, variation in the soil micro climate and decline in soil fertility was agreed to some extent by 60.00, 58.00, 55.33, 54.00 and 52.00% of the scientists, respectively. A little less than 50% of the scientists agreed to a great extent regarding increase in soil erosion as a result of climate change.

Table: 3
Distribution of the scientists according to their perception regarding effect of climate change on soil health (n=150)

Impact on soil health	Perception		
	To great Extent f (%)	To some extent f (%)	Not at all f (%)
Soil fertility may decline	60 (40.00)	78 (52.00)	12 (8.00)
Reduction in soil organic matter	54 (36.00)	87 (58.00)	9 (6.00)
Variation in the composition of soil organic matter	54 (36.00)	94 (62.67)	2 (1.33)
Increase in soil moisture stress	52 (34.67)	90 (60.00)	8 (5.33)
Increase in soil erosion	74 (49.33)	71 (47.33)	5 (3.33)
Variation in the soil micro climate	63 (42.00)	81 (54.00)	6 (4.00)
Loss of nutrient-rich top soil	56 (37.33)	83 (55.33)	11 (7.33)

Note: Figures presented in parentheses are in percentage

Perception of the Scientists Regarding the Effect of Climate Change on Livestock

The data in Table 4 revealed that almost 60% of the scientists agreed to some extent that climate change may destroy the habitat for cold water fishes (59.33%), and will affect the livestock and aquatic fauna (58.67%). An equal percentage *i.e.* 56.67% of the scientists agreed to some extent that there may be immigration of fresh water fishes from one place to another place and decreased milk fat as a result of climate change. The scientists agreed that climate change may lead to migration of birds/animals towards favorable climatic conditions (48.00%) and it may also affect the milk production in animals to a great extent (44.00%) The findings are in line with the findings of Adams *et al.* (1998).

Table: 4
Distribution of the scientists according to their perception regarding effect of climate change on livestock (n=150)

Impact on livestock	Perception		
	To great extent f (%)	To some extent f (%)	Not at all f (%)
Effect on animal reproduction	47 (31.33)	81 (54.00)	22 (14.67)
Effect on animal behavior	63 (42.00)	69 (46.00)	18 (12.00)
Migration of birds/animals towards favorable climatic conditions	72 (48.00)	68 (45.33)	10 (6.67)
Effect on livestock and aquatic fauna	58 (38.67)	88 (58.67)	4 (2.67)
Migration of fresh water fishes from one place to another place	43 (28.67)	85 (56.67)	22 (14.67)
Habitat for cold water fishes may be destroyed	44 (29.33)	89 (59.33)	17 (11.33)
Effect on milk production	66 (44.00)	67 (44.67)	17 (11.33)
Reduced fodder for animals	57 (38.00)	71 (47.33)	22 (14.67)
Decrease in milk fat	35 (23.33)	85 (56.67)	30 (20.00)
Increased body temperature or respiration rate reducing feed intake by animals	52 (34.67)	70 (46.67)	28 (18.67)
Increased pest and disease incidence in livestock	58 (38.67)	65 (43.33)	27 (18.00)

Note: Figures presented in parentheses are in percentage

Perception of the Scientists Regarding the Effect of Climate Change on Water Resources

The data regarding the perception of scientists about the effect of climate change on water resources is given in Table 5. More than 66% of the scientists agreed to a great extent that climate change may lead to fall in water table in certain regions while there may be a change in rainfall patterns and increase in evaporative loss from ponds to a great extent as agreed by 54.00% and 50.67% of the scientists, respectively. On the contrary, a little more than 50% of the scientists agreed to some extent that there may be an increase in the availability of water in certain regions.

Perception of the Scientists Regarding Effect of Climate Change on Insect-pest, Diseases and Weeds Infestation

The results presented in Table 6 clearly indicate that an equal percentage of the scientists *i.e.* 60.67% agreed to a great extent that there may be an increased incidence of insect-pest and diseases and a shift may also be observed in the timings of development stages in both hosts and pests as a result of climate change. The scientists agreed to some extent that climate change may increase the weed infestation in crops (52.00%) and change in the spread of wind-borne pests and diseases (50.67%). Mitra and Banerjee (2005) also supported that diseases and pest problems are increasing day by day in the Sunderbans region of West Bengal due to changes in climate.

Table: 5
Distribution of the scientists according to their perception regarding effect of climate change on water resources (n=150)

Impact on available water resources	Perception		
	To great extent f (%)	To some extent f (%)	Not at all f (%)
Increased availability of water in certain regions	40 (26.67)	80 (53.33)	30 (20.00)
Change in rainfall patterns	81 (54.00)	67 (44.67)	2 (1.33)
Increase in evaporative loss from ponds	76 (50.67)	69 (46.00)	5 (3.33)
Falling water table in	100 (66.67)	46 (30.67)	4 (2.67)

Note: Figures presented in parentheses are in percentage

Table: 6
Distribution of the scientists according to their perception regarding effect of climate change on insect-pest diseases and weed infestation (n=150)

Effect of climate change on pest diseases and weeds infestation	Perception		
	To great Extent f (%)	To some extent f (%)	Not at all f (%)
Increased incidence of insect pests and diseases	91 (60.67)	57 (38.00)	2 (1.33)
Change in the spread of wind-borne pests and diseases	69 (46.00)	76 (50.67)	5 (3.33)
Shifting of the timings of Development stages in both hosts and pests	91 (60.67)	51 (34.00)	8 (5.33)
Increase in weed infestation of crops	58 (38.67)	78 (52.00)	14 (9.33)

Note: Figures presented in parentheses are in percentage

Overall Perception of the Scientists Regarding Effect of Climate Change

The data in Table 7 shows an overall perception of the scientists regarding effect of climate change on agriculture. Based on their total scores on various items, scientists were categorized into three groups for their overall perception *i.e.,* low (62-85), moderate (85-108) and high (108-131). More than 50% of the scientists *i.e.,* 54.67% had a moderate perception regarding effect of climate change on various aspects such as environment, agriculture; soil health *etc.* followed by 38.67% who perceived highly for the climate change effects. Only 6.67% of the scientists had a low perception about climate change effects.

Table: 7
Distribution of the scientists according to their overall perception regarding effect of climate change on agriculture
(n=150)

Opinion category (score range)	f	%
Low (62-85)	10	6.67
Moderate (85-108)	82	54.67
High (108-131)	58	38.67

Note: Figures presented in parentheses are in percentage

Adaptation Strategies Suggested by the Scientists

Adaptation refers to those responses or actions that are taken to enhance resilience of vulnerable systems, thereby reducing damages to human and natural systems from climate change and its variability. The perception of the scientists regarding adaptation to climate change on agriculture in terms of plant breeding, natural resources, agronomic practices and general aspects has been presented in Table 8 and discussed subsequently. The data revealed that under plant breeding aspects, an equal percentage of scientists *i.e.,* 96.00% suggested the development of crop varieties that are tolerant to heat stress and resistant to insect-pests and diseases so as to adapt to climate change effects. In case of natural resources, 99.33% of the scientists suggested to adopt conservation of soil moisture as an adaptation strategy (Das *et al.,* 2014) followed by afforestation, development of rain water harvesting methods, development and use of resource conservation technologies and site-specific nutrient management in crops as suggested by 99.33, 97.33, 96.67, 96.00, 95.33 and 94.67%. In case of agronomic practices, an equal percentage of scientists *i.e.,* 97.33% (Singh *et al.,* 2014), suggested to adopt suitable cropping patterns and integrated farming system while 96.67% of them perceived that adjustment in timings of field operations and no tillage or minimum tillage can be useful adaptation strategies to counter climate change in effects. Mulching of crops to reduce water loss (Vashisht *et al.,* 2013) and adjustment in sowing time of crops were some other options as suggested by 96% of the scientists. Weather forecasting, identification of the present vulnerabilities of agricultural system to climate change, crop insurance and use of neem oil and neem cake to reduce nitrification were some of the general suggestions as suggested by 98.67, 97.33, 96.00 and 90.00% of the scientists, respectively to adopt climate change effects. The findings have been supported by Agarwal (2007).

4. CONCLUSIONS

Climate change refers to major changes in temperature, rainfall, snow or wind patterns lasting for decades or longer. Climate change may results from natural factors, such as

Table: 8
Distribution of scientists according to the adaptation strategies suggested to combat climate change on agriculture **(n=150)**

Aspects	Statements	Yes		No	
		f	%	f	%
Plant Breeding	1. Development of crop varieties tolerant to heat stress	144	96.00	6	4.00
	2. Alter option planting time	139	92.67	11	7.33
	3. Developing crop breeding programmes focusing on adaptability of plants to low-input situations in soils	142	94.67	8	5.33
	4. Development of insect pests and disease resistant crop varieties	144	96.00	6	4.00
	5. Genetic manipulations to exploit the beneficial effects of CO_2 enhancement on crop growth and water use	141	94.00	9	6.00
Natural resources	1. Development and use of resource conservation technologies	144	96.00	6	4.00
	2. Development of rainwater harvesting methods	145	96.67	5	3.33
	3. Organic agriculture	136	90.67	14	9.33
	4. Site-specific nutrient management in crops	143	95.33	7	4.67
	5. Afforestation	146	97.33	4	2.67
	6. Restoration of water bodies	142	94.67	8	5.33
	7. Conservation of soil moisture	149	99.33	1	0.67
Agronomic	1. Suitable cropping pattern	146	97.33	4	2.67
Practices	2. Adjustment in sowing time of crops	144	96.00	6	4.00
	3. Integrated farming system	146	97.33	4	2.67
	4. Use of short duration crop varieties	141	94.00	9	6.00
	5. Adoption of multiple cropping system	136	90.67	14	9.33
	6. Reduction in use of chemical fertilizers	135	90.00	15	10.00
	7. Mulching of crops to reduce water loss	144	96.00	6	4.00
	8. Adjustment in timings of field operations	145	96.67	5	3.33
	9. No tillage or minimum tillage	145	96.67	5	3.33
General	1. Use of neem oil and neem cake to reduce nitrification	135	90.00	15	10.00
	2. Identification of the present vulnerabilities of agricultural system to climate change	146	97.33	4	2.67
	3.Weather forecasting	148	98.67	2	1.33
	4. Crop insurance	144	96.00	6	4.00

Note: Figures presented in parentheses are in percentage

changes in the sun's energy or changes of the ocean circulation. The scientists agreed largely that climate change may lead to changes in cropping pattern, additional stress on fragile systems in agriculture, effect on crop physiology and falling water table in certain regions. Majority of the scientists held a moderate perception about effect of climate change on various aspects such as environment, agriculture and soil health *etc.* The adaptation strategies as suggested by majority of the scientists were development of crop varieties tolerant to heat stress and development of insect pests and disease resistant crop varieties, development of rainwater harvesting methods, afforestation and conservation of natural resources, suitable cropping patterns, integrated farming system, adjustment in timings of field operations and no tillage or minimum tillage. Therefore, it is recommended that adequate use of internet, newspaper and print media should be encouraged to create awareness among the agricultural scientists and farmers regarding effect of climate change on agriculture and about reduction in the emission of greenhouse gases. Only few of the scientists had acquired training on climate change. There is a need to organize more such trainings and provide more opportunities to the scientists to attend these trainings. The knowledge of the extensional personnel need to be updated for the new markets especially carbon trading.

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