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Adaptation Strategies of Rice-Wheat Cultivators to Climate Change

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ABSTRACT

It is important to understand the reasons which make farmers more prone for certain coping and adapting mechanism to climate chage. The study was conducted to know the adaption strategies opted by farmers in four districts of Uttar Pradesh in Northern India. Five hundred farmers from 24 villages selected to study the current status of adaptation strategies in the region. Drawing from the existing literature on adaptation in climate change, various adaptation strategies were categorized in to five main sub categories. Adaptation strategies vary across different farmers in the four districts according to size of the landholding. While, large farmers are often more likely to opt for soil conservation practices, small and marginal farmers are more prone to distress adaptation strategies. These understanding from the local level, which bring forward the reason as stated by farmers would be instrumental in developing decentralized adaptation policies for the future.

Keywords : Adaption strategies, rice-wheat cultivation, climate change, local context, indian agriculture

CLIMATE change is one of the most complex challenges in the current times and is going to affect populations across the world (Anon., 2007). There has been an observed change in the pattern of weather cycle, temperature, rainfall, water currents and these be visible more prominently in the future (Challinor and Wheeler, 2008; Subash *et al.,* 2013). The impact of climate change will be prominent on agricultural systems and on individuals dependent on them (Anon., 2007). Existing explorations of the effects of climate change on agriculture have used a variety of modelling approaches to predict the long-run impact. Most of the projection for the futuristic scenario of climate change is done by modelling which may not have a very precise mechanism for predicting situations (Thimme Gowda *et al.,* 2013). But even with limitations of the modelling studies of climatic changes, it is obvious that in the future changing climate will have bearing on farming (Cochrane, 2017). Direct impacts of Climate Change include reduced yield due to excessive heat or insufficient water while extreme events like floods and droughts can significantly impact the harvest, additionally, climate variation can also have an impact on irrigation and soil quality (Gornall *et al.,* 2010).

Rice and wheat are the major food crops being grown in India and a predicted loss in their productivity will definitely have a significant impact on the cultivators as well as consumers. The Indo-Gangetic Plains, which is the foodbowl of India, having rice and wheat as a major cropping system then become an important area for any study. Rice productivity is expected to go down by 3-15 per cent (Masutomi *et al.,* 2009) while in case of wheat productivity losses are expected to be 2-23 per cent (He *et al.,* 2013 and Ortiz *et al.,* 2008) by the end of the next two decades.

Adaptation is undoubtedly an important component of any policy response to climate change specifically while considering agriculture (Bandara and Cai, 2014). Studies show that without adaptation, climate change is generally difficult for agricultural production and for agricultural economies and communities; but with adaptation, the vulnerability can be reduced (Mendelson, 2012) and there are numerous opportunities to be realized.

Adaptation in agriculture is a continuous process, whereas, diversity in agriculture is actually the

manifestation of climatic and also to some extent of socio-economic adaptation. Farmers and society have always adapted to climatic changes when allowed by technological availability, their socio-economic capacity and the economics of producing a given commodity. The induced adaptation options have included changing varieties/crops, altering fertilizer rates to maintain grain quality more suited to the prevailing climate, changing the timings of irrigation and quantity of irrigation water, more effective use of water including rain-water harvesting and conserving soil moisture through different ways including crop residue retention incorporation, altering the timing or location of cropping activities and diversifying income including through animal husbandry (Mendelson, 2012 and Sehgal *et al.*, 2013). The study attempts to find the adaption practices of rice and wheat farmers to the effects of climate change in four districts of Uttar Pradesh.

Methodology

The study was undertaken in four districts of Uttar Pradesh in different vulnerability zones as ranked in the study by Sehgal *et al.* (2013) which uses the indicator-based method of vulnerability assessment and ranks the different districts in the region of Indo-Gangetic plains into four vulnerability zones. One district was selected from each of the vulnerability zones *viz.*, Banda (extreme vulnerability), Gorakhpur (high vulnerability), Kanpur (moderate vulnerability) and Saharanpur (low vulnerability) districts. A total of 500 farmers were selected covering twenty four villages in the four districts. In each district, two representative villages were selected from three blocks within the district. Each of the villages had more than 50 per cent farming households practising rice-wheat cultivation and were not more than three km away from the main connecting road to the village. Within each village, random sample surveys were conducted.

The quantitative data for each practice was cross-tabulated using the IBM SPSS software (20.0). For each of the practices,the response was coded as 1 and 0 for practising and not practising respectively, farmer response against the farmer type within each district. The data was segregated for percentage farmers opting for individual practice, hence the Table I to IV represent only the percentage farmers opting for a practice, therefore the total are not representative for 100 per cent and subsequently, the Kendal tau correlations were checked between the farmer type and each adaptation practice. Each of these correlations was conducted only for the percentage of farmers opting for a particular practice. The quantitative data has been substantiated with help of qualitative data to give a more nuanced reporting of adaptation practices.

Classification according to Census (2010-2011) using landholding sizes has been done in five categories: Marginal farmer, small farmer, small-medium farmer, medium farmer and large farmer. The number of farmers surveyed was 126 in Banda district, 128 in Gorakhpur district, 117 in Kanpur district and 128 in Saharanpur district. Average landholding size was 6.26 ha in Saharanpur, 1.76 ha in Kanpur, in Gorakhpur it was 1.2 ha while it was 3.05 ha in Banda.

As indicated in Fig. 1, more than 20 per cent of farmers in Saharanpur district are large farmers. Most of the larger farmer's cultivated sugarcane, mango and popular farms apart from rice and wheat. Increased profits from commercial farming has resulted in farmer's ability to invest in land and therefore farm size owned by individuals is higher in the district. While in Gorakhpur district more than 50 per cent of farmers are marginal farmers, in both Kanpur and Banda land distribution varied among farmers.

A number of adaptation practices have been recognized in the current literature on climate change as seen along with the sub-categorisation in Fig. 2. The categorisation of adaptation practices is according to currently available literature on various adaptation practices. Category 1 and 2 *i.e.*, shift in cropping type and soil management practices are sometimes clubbed

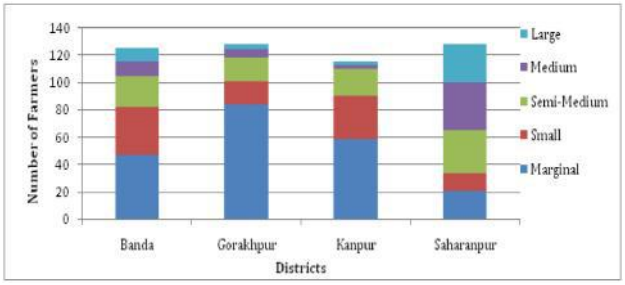

Fig. 1 : Categorization of farmers in sampled four districts according to land holding

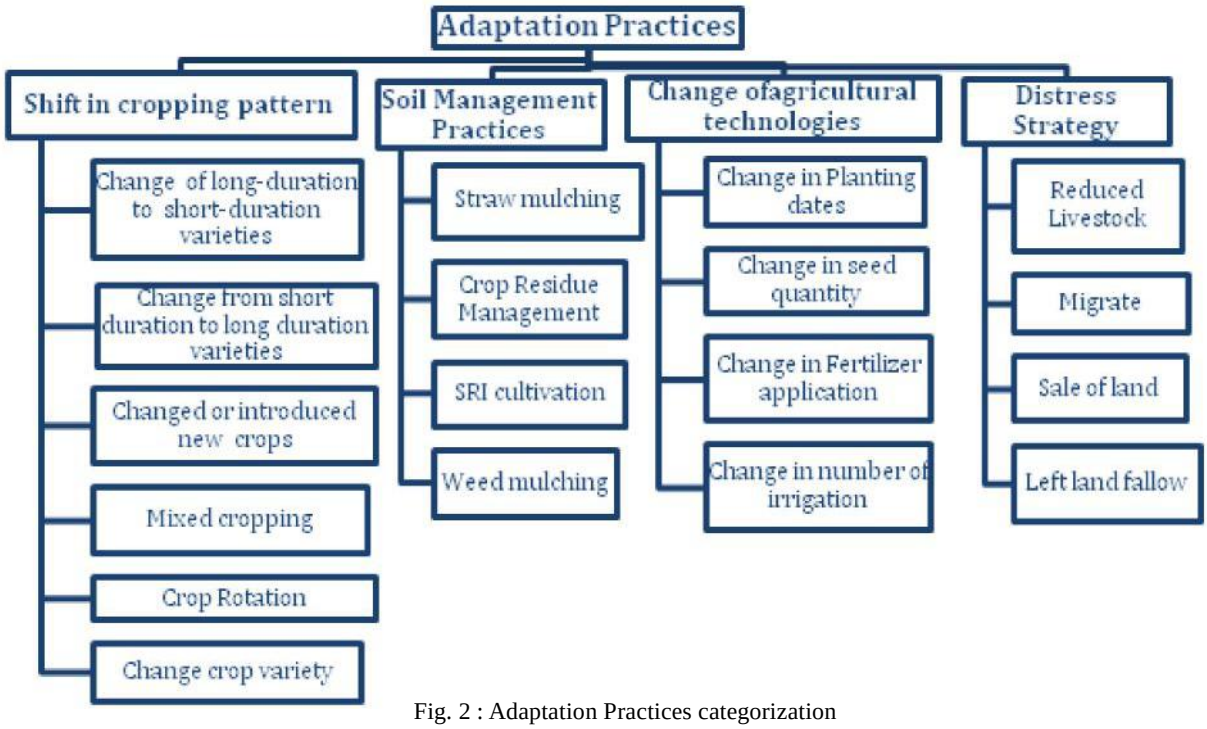

Fig. 2 : Adaptation Practices categorization

together in adaptation literature (Ghimire *et al.*, 2017 and Ofori *et al.*, 2015). Specifically, practices like mixed cropping and crop rotation are promoted to increasethe soil nutrients.

Results and Discussion

Shift in cropping pattern as an adaptation mechanism to climate change

Table I depicts a range of shifts in cropping patterns across districts in different vulnerability zones. Among various practices adopted by farmers in terms of the shift in cropping patterns, across districts shifts to crop variety and to other crops are the more popular practices. This is seen by farmers across the landholding sizes and districts as well. The shift in crop variety is often done after a recommendation from other farmers or to the varieties which are promoted in agricultural markets by the government or private contractors. In Saharanpur district, a number of farmers have shifted out of sugarcane cultivation and have instead opted for rice-wheat cropping due to a sharp fall in sugarcane prices and industrial incompetence.

A shift towards long duration varieties from short duration ones is not popular among farmers in almost all districts, though the highest percentage of farmers shifting to long-term varieties was reported in Gorakhpur district. The shift is more specific in case of the rice crop in the region. A particular variety of rice was reported to have a higher yield in two villages in Gorakhpur district, which was considered one of the reasons for opting a long duration variety. Farmers in Banda district reported that long duration varieties of rice are not suited for the region, due to higher water requirement among these varieties. Additionally, farmers in Khujaopur village in Kanpur reported using a frost resistant variety of wheat instead of the other popular varieties in the region.

In both Kanpur and Gorakhpur districts farmers have opted for a specific short duration variety of wheat (Halna). This variety is marketed as a 60-day variety of wheat. A number of farmers reported sowing Halna variety in early January. Farmers would often sow vegetable crops of potato, onion, garlic, carrots, and cabbage in between the kharif and rabi crop. Though it was mentioned that the variety often takes almost 80 days and has lesser produce than the long duration varieties, it provides an extra income from the sale of vegetables for the farmers. While in Saharanpur district, specific short duration basmati rice variety gained popularity among farmers which required lesser number of irrigation and was sold at a

TABLE I

Percentage farmers opting for various shifts in cropping patterns across districts

District			Shift in cropping pattern					
			Shift to other crops	Shift in crop variety	Shift from short term to long term variety	Shift from long term to short term variety	Crop Rotation	Mixed Cropping
Banda	% within farmer type	Marginal	21.3	2.1	4.3	8.5	4.3	19.1
		Small	17.1	2.9	0.0	5.7	5.7	28.6
		Small - Medium	21.7	13.0	8.7	13.0	0.0	47.8
		Medium	36.4	18.2	9.1	9.1	9.1	63.6
		Large	30.0	30.0	0.0	30.0	0.0	30.0
	Total % of farmers with in districts		22.2	7.9	4.0	10.3	4.0	31.7
Gorakhpur	% within farmer type	Marginal	34.5	46.4	19.0	29.8	6.0	22.6
		Small	41.2	58.8	35.3	41.2	5.9	47.1
		Small - Medium	35.3	52.9	11.8	35.3	17.6	41.2
		Medium	28.6	42.9	0.0	14.3	14.3	14.3
		Large	33.3	100.0	33.3	33.3	66.7	33.3
	Total % of farmers with in districts		35.2	50.0	19.5	31.3	9.4	28.1
Kanpur	% within farmer type	Marginal	39.0	37.3	8.5	45.8	3.8	3.4
		Small	51.6	54.8	9.7	48.4	12.5	12.9
		Small - Medium	45.0	45.0	15.0	35.0	25.5	10.0
		Medium	33.3	33.3	33.3	0.0	38.3	0.0
		Large	33.3	66.7	0.0	100.0	23.7	33.3
	Total % of farmers with in districts		43.1	44.0	10.3	44.8	25.0	7.8
Saharanpur	% within farmer type	Marginal	20.0	20.0	10.0	25.0	3.0	15.0
		Small	23.1	7.7	15.4	15.4	5.5	30.8
		Small - Medium	43.8	50.0	9.4	18.8	10.5	37.5
		Medium	37.1	34.3	11.4	22.9	23.4	31.4
		Large	53.6	53.6	10.7	28.6	33.2	46.4
	Total % of farmers with in districts		38.3	37.5	10.9	22.7	16.12	33.6
Total % within each landholding size type	farmer type	Marginal	31.4	31.4	11.9	29.0	4.8	15.7
		Small	33.3	30.2	11.5	27.1	5.4	17.1
		Small - Medium	37.0	40.2	10.9	23.9	6.5	34.8
		Medium	35.7	32.1	10.7	17.9	10.0	33.9
		Large	45.5	52.3	9.1	34.1	14.6	48.9
	Total % of farmers with in districts		34.5	34.7	11.2	26.9	12.4	25.7
	Kendall tau, p value		0.12, NS	0.25, NS	-0.82, NS	0.11, NS	0.48, 0.05	0.12, NS

NS = Non-significant

higher price in the markets. In Saharanpur district, farmers across land holding size have access to the short duration basmati rice variety, while in Banda district, bigger farmers had access to the same. The seed price of the short-duration basmati variety was higher than the other varieties that farmers were sowing in the area and therefore was a deterrent among small and marginal farmers.

Farmers in all the four districts have started opting out of certain processes like crop rotation over the last 3-4 years. An increase in the number of Nilgai and cows in the village were often stated as a reason to do so. Banda district, additionally, had a specific cultural practice called 'Annapratha', where cows in the summer months (end of April to June) are left stray to graze in open lands. This practice ensured fodder for animals during the parched summer months. Over the years the common pasture lands have reduced and are being used for agricultural purposes, resulting in cows entering farmlands.

Farmers who are able to fence their farms are still able to continue crop rotation. Across districts, it was seen that small and marginal farmers, who cannot invest in the infrastructure required to cope with stray animal menace have opted out of crop rotation which explains the positive correlation that was seen between land holding size and crop rotation.

Mixed cropping is practised more commonly in Banda and Saharanpur districts, while Kanpur district has a very low number of farmers opting for this practice. In Kanpur district, farmers plot small monoculture crops on the smaller farm rather than practising mixed cropping. In Saharanpur district, larger farms, in general, are lined with Poplar and Eucalyptus trees. Presence of sugar and paper mills aids in the diversification of crops on the farm. A number of farmers also own mango orchards besides growing poplar and sugarcane. Farmers practice mix cropping between mustard and wheat during rabi season. It was mentioned by a farmer that mix cropping is possible with wheat, but with rice it is usually not so profitable, as the tree shade often reduces productivity in rice, while the wheat crop is sown within sparsely populated poplar farms.

Soil management practices as an adaptation mechanism to climate change

Table II depicts the distribution of various soil management practices in various districts. Government policies on adaptation to climate change often promote soil management practices, which helps not only in increasing soil fertility but also reduces carbon emissions from the field (Bijay-Singh *et al.*, 2008; Fangueiro *et al.*, 2017 and Ghimire *et al.*, 2017). Most of the soil management practices are not traditionally practised by farmers, therefore knowledge dissemination regarding benefits of the practice is often done by the Agriculture Department and non-governmental organization working in the field of agriculture.

Crop residue management due to higher water requirement is practised by farmers who have easy access to irrigation. Marginal and small farmers with no access to irrigation rarely opted for crop residue management. Farmers in Banda district also reported using crop residue and weed as fodder for animals instead of mulching the residue. As indicated in Table III, Banda district has the lowest propensity of farmers opting for crop residue management while Saharanpur district has the highest. Farmers in Saharanpur district reported decreased use of fertilisers as a result of crop residue management over the years.

Straw mulching is one of the soil management practices which has been part of the traditional agricultural system. In Banda district, a number of farmers reported practising straw mulching more than 15 years back but this has been discontinued in the last 10-15 years. The two main reasons stated for the same was delayed rains and destruction of the crop by 'Anna' cows, while in Kanpur district the farmers suggested discontinuation of the practice due to non-availability of straw seeds. Earlier, farmers would receive free straw seeds from the Agricultural University in the area, but discontinuation of subsidy from government institutions has lead farmers to discontinue straw mulching. Some of the large farmers in sampled villages like Bhisi Jargaon and Pachor (Kanpur) still continue straw mulching. The soil quality in Pachor village has deteriorated considerably

TABLE II

Percentage farmers opting for soil management practices across districts

District			Soil Conservation practices			
			Crop residue managment	Straw mulching	SRI cultivation	Weed mulching
Banda	% within	Marginal	0.0	0.0	4.3	21.3
	Farmer type	Small	2.9	2.9	0.0	31.4
		Small-medium	17.4	26.1	4.3	39.1
		Medium	9.1	9.1	9.1	54.5
		Large	50.0	30.0	0.0	60.0
	Total % of farmers		8.7	8.7	3.2	33.3
Gorakhpur	% within	Marginal	15.5	8.3	1.2	16.7
	Farmer type	Small	11.8	5.9	0.0	17.6
		Small-medium	17.6	23.5	11.8	29.4
		Medium	0.0	0.0	0.0	0.0
		Large	33.3	0.0	0.0	33.3
	Total % of farmers within district		14.8	9.4	2.3	18.0
Kanpur	% within	Marginal	15.3	13.6	3.4	13.6
	Farmer type	Small	19.4	22.6	12.9	16.1
		Small-medium	20.0	20.0	25.0	25.0
		Medium	33.3	66.7	66.7	66.7
		Large	33.3	33.3	0.0	0.0
	Total % of farmers within district		18.1	19.0	11.2	17.2
Saharanpur	% within	Marginal	15.0	25.0	5.0	5.0
	Farmer type	Small	30.8	46.2	0.0	0.0
		Small-medium	31.3	31.3	9.4	18.8
		Medium	28.6	34.3	8.6	17.1
		Large	42.9	50.0	3.6	14.3
	Total % of farmers within district		30.5	36.7	6.3	13.3
Total % within each landholding size type	Farmer type	Marginal	11.9	9.5	2.9	15.7
		Small	13.5	15.6	4.2	19.8
		Small-medium	22.8	26.1	12.0	27.2
		Medium	21.4	26.8	10.7	25.0
		Large	43.2	40.9	2.3	25.0
	Total	18.1	18.5	5.6	20.5	
	Kendall tau, p value		0.51, 0.01	0.26, NS	-0.012, NS	0.30, NS

NS = Non-significant

over the years and farmers are trying to restore the quality. Farmers with access to submersible pumps and tractors reported being more prone to adopting straw mulching and crop residue management.

In Saharanpur and Kanpur districts, a number of farmers adopt parts of the Systemic Rice Intensification (SRI) technique to crop rice as compared to other two districts. Farmers reported higher productivity with SRI cultivation, but also reported that the cost of cultivation increases due to its labour intensive and time-consuming nature, resulting in many farmers not adopting the practice. In general, the districts of Banda and Gorakhpur showed a lesser propensity towards adopting soil management practices like Systemic Rice Intensification (SRI) cultivation and straw mulching as compared to other two districts. A negative, non-significant correlation was seen among farmer type and adoption of SRI cultivation, indicating that size of landholding did not impact this. One of the reasons was that it is labour intensive in nature and while smaller farmers could practise SRI cultivation using family labour and practising SRI cultivation on larger tracts of land could often be economically unviable.

Change in agricultural technologies as an adaptation mechanism to climate change

Changes in agricultural technologies are often considered as coping mechanisms as opposed to adaptation practices. It has also been argued that coping mechanisms like a change in planting dates can result in a complete shift in a farming season over a period of time (Crane *et al.*, 2011). Table III represents the distribution of these shifts in farming practice among farmers across districts.

Change in seed quantity as a coping mechanism is popular among farmers across districts. A non-significant correlation was observed across the landholding sizes as mentioned in Table III. While farmers in Banda district reported increasing the seed quantity over the years, specifically when using same crop variety in the consecutive years, farmers in Saharanpur district decreased the seed quantity. The trend for decreasing seed quantity was seen among farmers who shifted to basmati rice variety. The short duration variety seeds were more viable and hence the decrease. Similarly, in Kanpur district, it was seen that farmers cropping late variety of wheat often also used lesser seeds as compared to traditional long-duration wheat varieties.

Change in an average number of irrigations given per crop was not opted by most of the farmers in Gorakhpur district. Farmers reported using diesel-based pumps in case of failure of rainfall. Farmers in all the four districts reported that irrigation is an important component of grain productivity, specifically for rice which is a water-intensive crop. While for wheat, in general, water requirement was not as much and one or two showers of rain from the winter rainfall was enough, apart from the pre-sowing irrigation. Interestingly, in Saharanpur district the use of short duration variety was seen as a preferred option as the number of irrigations could be reduced for rice crop.

Additionally, Saharanpur district presents a unique case in terms of change in agricultural technologies. Farmers reported decreasing the quantity of fertiliser over the years. The average fertiliser used in the district is comparatively substantially lesser as compared to other three districts. Farmers reported that in the last five years, use of Urea and Di-Ammonium Phosphate has also considerably reduced. Even in terms of pesticides, farmers here use one or two sprays of pesticides as opposed to 3-5 sprays per crop in the other three districts. Kanpur district gave a different picture in different villages, villages which were closer to the Agricultural University were more likely to use a lesser amount of fertilisers and pesticide as compared to villages further away.

Banda district has the highest number of farmers dependent upon rainfall, therefore planting dates are often shifted, especially for the kharif (rice) crop, while the change in planting dates is not seen as so prevalent for the rabi crop in Banda district. In Kanpur and Gorakhpur districts, farmers cropping Halna variety of wheat often take late sowing of wheat. In Banda district, farmers do not opt for this variety due to the shedding of matured grains if not harvested on time. Change in planting dates is more often reported by farmers' solely dependent on rainwater for irrigation across various districts.

TABLE III

Percentage farmers opting for a change in agricultural technologies across districts

			Change in Agricultural Technologies			
			Change in seed quantity	Change in number of irrigation	Decrease fertilizer quantity	Change in planting dates
Banda	% within	Marginal	38.3	6.4	8.5	31.9
	Farmer type	Small	48.6	11.4	20.0	62.9
		Small-medium	52.2	17.4	21.7	60.9
		Medium	27.3	54.5	18.2	72.7
		Large	40.0	10.0	10.0	50.0
	Total % of farmers within district		42.9	14.3	15.1	50.8
Gorakhpur	% within	Marginal	36.9	3.2	5.6	35.7
	Farmer type	Small	41.2	4.3	2.3	52.9
		Small-medium	47.1	7.4	1.4	47.1
		Medium	14.3	0.0	6.8	57.1
		Large	0.0	0.0	9.6	33.3
	Total % of farmers within district		36.7	3.7	4.0	40.6
Kanpur	% within	Marginal	57.6	21.7	7.8	47.5
	Farmer type	Small	48.4	13.2	3.4	38.7
		Small-medium	55.0	3.0	15.1	35.0
		Medium	66.7	0.0	32.3	33.3
		Large	66.7	0.0	0.0	0.0
	Total % of farmers within district		55.2	11.7	11.72	41.4
Saharanpur	% within	Marginal	50.0	15.0	30.0	40.0
	Farmer type	Small	46.2	7.7	38.5	53.8
		Small-medium	40.6	6.3	31.3	37.5
		Medium	62.9	11.4	22.9	31.4
		Large	46.4	7.1	21.4	46.4
	Total % of farmers within district		50.0	7.8	27.3	39.8
Total % within each landholding size type	Farmer type	Marginal	44.3	22.4	4.8	38.6
		Small	46.9	16.3	12.5	52.1
		Small-medium	47.8	6.5	16.3	44.6
		Medium	50.0	7.9	17.9	42.9
		Large	43.2	6.8	15.9	43.2
	Total		46.0	6.0	10.8	43.2
	Kendall tau, p value		-0.017, NS	-0.012, NS	0.001, NS	-0.098, NS

NS = Non-significant

While, soil management practices and shift in cropping patterns may vary highly significantly among farmers in accordance with their socio-economic status in the village, with more large farmers opting for them, change is agricultural technologies has a non-significant correlation to land holding sizes. Change in the agricultural technologies is strongly related to irrigation type, with farmers dependent on rains for agriculture being more prone to changing planting dates than farmers using irrigation from tube-wells and submersible pumps.

Distress adaptation practicesas an adaptation mechanism to climate change

Farmers in more vulnerable districts resort to a number of distress adaptation strategies which include opting for alternative livelihood options, migrating out of agriculture and sale of land and livestock. Table IV shows the distribution of these distress strategies opted by farmers in various districts.

Banda district ranks highest in terms of farmers opting for distress adaptation, Gorakhpur district also has a high number of farmers migrating to different cities and states where most of them opt for circular migration, where they come to the city during sowing and harvesting season, while the rest of the time the crop is maintained by women and elderly in the family. Difference between migration in Banda and Gorakhpur districts, depends upon nature of the job that individuals take up in the cities they migrate to. While migrants from Gorakhpur got training as skilled labour and therefore could send in money for maintenance of the farms in the home city, Migrants of Banda district mostly took up jobs as unskilled labour resulting in leaving the farms fallow or selling the land.

In Kanpur district, different blocks gave a different picture. In the Sarsaul block, which is on down stream of river channels in which factory effluents from leather industry are dumped, farmers leave land fallow during the *kharif* in case of delayed rains. In terms of migration, farmers in Bidnu block reported that individuals have back-migrated to the village while in Sarsaul block young farmers are still migrating out. Diverse forms of irrigation play an important role in the distress situation of farmers in Kanpur district as well.

Banda district is an important site for understanding farmers in distress situations. A number of social factors play an important role in the formulation of the crisis that is occurring in Banda district. Apart from the distress option mentioned in Fig. 2. Banda district also has a high number of farmer suicides in the region. Of the villages surveyed, two of the respondents mentioned that their family members have committed suicide. High amounts of crop indebtedness and crop failure in the region has resulted in farmers either migrating out of agriculture or taking extreme measures like suicides.

The inherent nature of farming requires constantly work with natural phenomena like temperature and rainfall, therefore it is suggested that the human environment synergy can be best understood by conceptually reflecting upon responses from the local level. Some of the practices like opting for short duration varieties have benefited farmers in multiple ways in terms of reducing seed quantity, fertiliser use and irrigation, while strategies like SRI cultivation which is labour intensive do not seem to be popular among farmers. The climate adaptation strategies which are more economically viable and less resource intensive are more likely to be undertaken by farmers. In this regard, government intervention at a local level becomes paramount importance as seen in the case of Kanpur district, where farmers practised straw mulching when the subsidy for straw seeds was available. Additionally, within a district often the large farmer is more likely to opt for soil management practices while marginal and small farmers are more prone to distress adaptation strategies, specifically in districts like Banda and Gorakhpur. Such disparity that exists

TABLE IV

Percentage farmers opting for distress adaptation practices across districts

			Distress Adaptation Strategies			
			Increase fallow land	Reduce livestock	Migrate	Sold land
Banda	% within	Marginal	34.0	8.5	33.4	23.4
	Farmer type	Small	40.0	22.9	22.9	34.3
		Small-medium	56.5	13.0	13.0	8.7
		Medium	63.6	36.4	4.5	18.2
		Large	60.0	10.0	2.3	10.0
	Total % of farmers within district		44.4	15.9	16.0	22.2
Gorakhpur	% within	Marginal	11.9	17.9	37.9	8.3
	Farmer type	Small	17.6	0.0	27.8	5.9
		Small-medium	29.4	29.4	23.5	5.9
		Medium	0.0	14.3	3.7	0.0
		Large	66.7	0.0	0.0	0.0
	Total % of farmers within district		15.6	16.4	18.6	7.0
Kanpur	% within	Marginal	32.2	3.4	13.6	6.8
	Farmer type	Small	35.5	3.2	9.7	6.5
		Small-medium	25.0	5.0	5.0	0.0
		Medium	66.7	0.0	0.0	0.0
		Large	0.0	0.0	0.0	0.0
	Total % of farmers within districts		31.9	3.4	10.3	5.2
Saharnpur	% within	Marginal	10.0	0.0	0.0	5.0
	Farmer type	Small	0.0	0.0	2.9	7.7
		Small-medium	12.5	0.0	0.0	3.1
		Medium	2.9	5.7	0.0	8.6
		Large	10.7	3.6	0.0	7.1
	Total % of farmers within districts		7.8	2.3	0.8	6.3
Total % within each landholding size type	Farmer type	Marginal	22.4	10.0	16.2	11.0
		Small	29.2	9.4	20.8	16.7
		Small-medium	29.3	9.8	16.3	4.3
		Medium	17.9	12.5	12.5	8.9
		Large	25.0	4.5	6.8	6.8
		Total	24.7	9.6	15.9	10.2
	Kendall tau, p value		0.104, NS	-0.018, NS	-0.553, 0.01	-0.230, NS

NS = Non-significant

among farmers based on the vulnerability zone that they are in and their own land holding size becomes a determinant for opting for adaption practices.

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