Original Research Article

Impact of climate change on milk production and perceptions of Farmers in the West Bengal

ABSTRACT

The cause and effect relationship of climatic variables on milk production of indigenous cattle and buffalo had been carried in West Bengal state (mention the month and year or research). Regression analysis indicated the indigenous cow milk production was directly responsive to annual minimum temperature, while crossbred cow milk production was indirectly responsive to annual maximum temperature and relative humidity. The buffalo milk production was inversely related to annual maximum temperature and relative humidity. More than half of surveyed farmers had a medium level of experience in farming. Majority of farmers were perceived climate variability in general like increase in temperature during the summer season, late onset of monsoon and early withdrawal of monsoon season. For crop farming, crop diversification was the most preferred adaptation strategy among the farmers followed by changing crop variety. For dairy farming, provide proper shed and shelter was most preferred adaptation strategy followed by provide additional fresh drinking water in summer.

Keywords : Cause and effect relationship,(regression analysis) climate change, farmers perceptions, adaptive strategies

1.INTRODUCTION

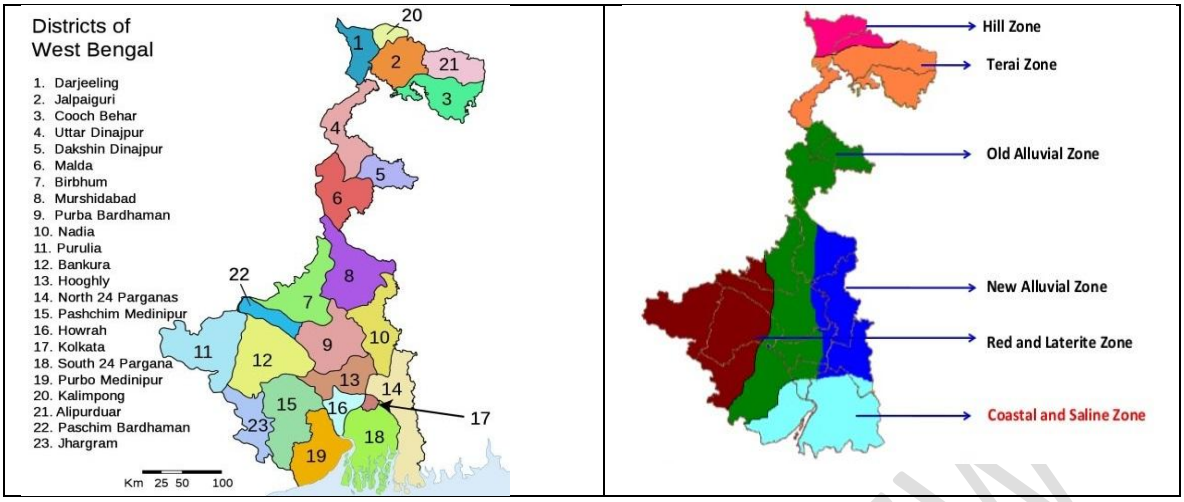
Agricultural production has expressed significant effects for a slight change in climatic factors [1]. Particularly developing country like India is bounded to be affected more as country is highly depended on the agriculture [2]. Climate change has a significant impact on livestock performance also, in addition to having a negative influence on crop production [3]. Climate has a significant effect on livestock growth, production, reproduction, and health by influencing animal physiology, disease incidence, and other factors[4]. The combination of a high ambient temperature and a high relative humidity Lactating cows' milk yield is lowered [5]. Climate change impacts number of associated variables with animal production, reproduction, and health. Higher temperatures cause changes in the animal's body physiology, such as increased respiration rates (> 70-80/minute), blood flow, and body temperature (>102.5 ^{0}F) [6]. Erratic fluctuations in weather directly affect animal production of 58 percent and reproduction of 63.3 percent [7]. Heat waves can reduce milk yield in cattle and buffaloes by 10-30% in the first lactation and 5-20% in the second and third lactation periods. They can also affect the growth, puberty, and maturity of crossbreed cows and buffaloes [8].

The diverse animal resources contribute to the West Bengal food security and nutritional needs by producing protein-rich foods like meat, milk, and eggs. Animal resources also augment the prospects for income generation and diversification in rural areas, particularly for landless workers, small and marginal farmers, and women[9]. Due to the steady contraction of agricultural lands due to urbanization and the restricted scope of absorption of rural jobless young into the industrial and service sectors, an increasing number of individuals are opting for animal husbandry. Farmer perceptions are considered a key determinant of adaptation and a necessary precondition for it [10]. A variety of factors influence perception, including culture, knowledge, and information access. Farmers utilize climate variability perception to understand climate variability phenomena better and assist them in adjusting to their situations.

2. MATERIAL AND METHODS

For primary data collection, three districts were randomly selected across the state. West Bengal is partitioned in two major parts viz, North Bengal and South Bengal to collect the diverse respondents. As North Bengal consisted of 8 districts, and South Bengal contained of 15 districts. One district was selected randomly from North Bengal, whereas two districts were selected from larger South Bengal area. The selection of the block and villages was based on simple random sampling. In selecting respondents, 25 farmers from each village covering a total sample of 150 respondents were taken up through a simple random technique. The secondary data on the monthly rainfall and temperature of 23 districts of West Bengal during the period from 1991 to 2020 had been utilized.

Image 1. Study area



The impact of climate variability on milk production was analysed by using multiple regression models. The following regression model was utilized:

$\ln Y_{it} = a + d_i + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + U_{it}$

Where, Y = Milk Production

x_1 = Fodder area

x_2 = Mean maximum temperature

x_3= Mean minimum temperature

x_4 = Mean relative humidity

x_5= Mean wind speed

b_i = Coefficients for x_i

d_i = Dummy variables and

U_{it} = Error term.

3.RESULTS AND DISCUSSION

3.1 RAINFALL VARIABILITY

The trend of in districts rainfall was represented by radar chart (Figure 1). Kharif rainfall varied between 898.98 mm in the Bankura district and 2233.47 mm in the Jalpaiguri district of West Bengal. The standard deviation varied between 153.70 mm (Purulia) and 311.07 mm (Darjeeling). Kharif rainfall indicated rainfall had a decreasing trend in the Dakshin Dinajpur, Nadia and Murshidabad districts. None of the district had shown a significant increasing trend, while Darjeeling, Jalpaiguri, Bankura, and Purulia districts had showed an insignificant increasing trend. Sen's slope estimator indicated a maximum increasing trend in the district Darjeeling (+5.92) and the maximum decreasing trend was in the Coochbehar (-12.80) district. Rabi rainfall varied between 49.88 mm in the Uttar Dinajpur district and 112.65 mm in the Darjeeling district of the state. Rabi rainfall indicated decline trend in the districts Darjeeling, Coochbehar, Uttar Dinajpur, Malda, Birbhum and Bankura, Murshidabad and Purulia Dakshin Dinajpur had expressed. None of the district had shown any increasing trend. Sen's slope estimator pointed out a maximum decreasing trend had been found in the district South 24 Parganas (-1.90), and a minimum decreasing trend had seen in the Jalpaiguri (-0.66) district. Annual rainfall varied between 1250.61 mm in the Purulia district and 3495.64 mm in the Jalpaiguri district of West Bengal. Annual rainfall trend indicates a decreasing trend in the districts Dakshin Dinajpur, Murshidabad, and Nadia at 5% level of significance, while the districts Hooghly and Howrah had shown at 10% level of significance. No district has shown a significant increasing trend, while Darjeeling, Bankura, and Purulia districts have shown an insignificant increasing trend. Sen's slope estimator indicates a maximum increasing trend in the district Purulia (+4.18) and the maximum decreasing trend in the district Dakshin Dinajpur (-14.54).

3.2 VARIABILITY IN TEMPERATURE

Radar chart represented the variation for temperature among district's of the state. Maximum Kharif temperature varied between 27.82 ^{0}C in the Darjeeling to 32.80 ^{0}C in the Nadia district (Figure 2). Maximum Kharif temperature trend indicated maximum temperature had shown an increasing trend in

the Darjeeling, Jalpaiguri, Coochbehar, Uttar Dinajpur, and Dakshin Dinajpur districts at 5% level of significance while the districts Malda and Purulia has shown at 10% level of significance. None of the district had showed a significant decreasing trend, while Purba Medinipur and North 24 Parganasd districts have exhibited an insignificant decreasing trend. Minimum Kharif temperature varied from 21.36 ^{0}C in the Darjeeling district to 26.07 ^{0}C in the North 24 Parganas district. The standard deviation varied between 0.40 ^{0}C and 0.48 ^{0}C. Inter-year variation in minimum temperature has been found highest in the district Darjeeling (2.08%), while it has found the lowest in Malda and South 24 Parganas (1.59%) district. Minimum Kharif temperature indicated an increasing trend in the districts Coochbehar, Uttar Dinajpur, and Purulia at 10% level of significance while the district Jalpaiguri had shown at 5% level of significance whereas the district Darjeeling had shown at 1% level of significance. None of the district had shown any decreasing trend. Maximum Rabi temperature varied between 21.99 ^{0}C in the Darjeeling district and 28.44 ^{0}C in the Kolkata district. The standard deviation varied between 0.82 ^{0}C and 0.93 ^{0}C. Inter-year variation in maximum temperature has been found highest in the district Darjeeling (4.06%), while it has found the lowest in Kolkata (2.93%) district. Maximum Rabi temperature trend observed that no district had showed a significant increasing trend and any decreasing trend. All the districts have shown an insignificant increasing trend. Minimum Rabi temperature varied between 11.07 ^{0}C in the Darjeeling district and 16.40 ^{0}C in the North 24 Parganas district. The standard deviation varied between 0.55 ^{0}C and 0.64 ^{0}C. Inter-year variation in minimum temperature has been found highest in the district Darjeeling (5.30%), while it has found the lowest in the North 24 Parganas (3.70%) district. Minimum Rabi temperature trend indicates minimum temperature has shown a decreasing trend in the districts Murshidabad, Nadia, Burdwan, Howrah, and Kolkata at 10% level of significance, while the district Purba Medinipur, Hooghly, North and South 24 Parganas has shown at 5% level of significance. No district has shown a significant increasing trend, while Darjeeling and Jalpaiguri's districts have shown an insignificant increasing trend.

3.3 EFFECT OF CLIMATE CHANGE ON CATTLE MILK PRODUCTION

The effect of climate variables on the cattle milk production was represented by Table 1. The regression analysis indicated that minimum temperature had shown a positively significant relationship with indigenous cow milk production at 10% level of significance, whereas; maximum temperature and relative humidity had expressed a positively non-significant relationship [11]. The 1^{0}C increase in annual minimum temperature increased the indigenous cow milk production by 3.3% for the present study.

The maximum temperature and relative humidity had shown a negatively significant relationship at 1% level of significance for the milk production of crossbred cow. Minimum temperature had exhibited a non-significant relationship in direct manner [12]. For 1^{0}C increase in annual maximum temperature annual crossbred milk production decreased by 17.7% whereas for 1% increase in relative humidity the annual production decreased by 7.6% in study.

3.4 EFFECT OF CLIMATE VARIABLES ON BUFFALO MILK PRODUCTION

The effect of climate variables on milk production of buffalo was depicted by Table 1. The regression analysis indicated that maximum temperature and relative humidity had expressed a significant relationship with annual buffalo milk production at 10% level of significance with a negative direction [13]. For 1^{0}C increase in maximum temperature decreased the annual milk production by 12.1% while for the 1% increase in relative humidity the annual milk production decreased by 4.3%.

3.5 FARMER'S PERCEPTION TOWARDS CLIMATE CHANGE

Table 2 indicated that majority (78%) of the farmers (50.67% SA and 27.33% A) perceived that there was an increase in temperature during the summer season while 16% and 2.67% of farmers were disagreed and strongly disagreed, respectively [14]. Nearly 38.67% of the farmers were agreed that there was a decrease in temperature in the winter season and was strongly agreed by 23.33%, whereas 21.33% and 6.67% of farmers were disagreed and strongly disagreed, respectively. Majority (76%) of farmers (43.33% A and 32.67% SA) were felt that late onset of monsoon. However, 9.33% and 8.00% of farmers were disagreed and strongly disagreed, respectively. Majority (77.33%) of farmers (41.33% A and 36.00% SA) were experienced the early withdrawal of monsoon season, whereas 9.33% of farmers had no idea and disagreed. An equal portion (30.00%) of farmers were agreed and disagreed that uneven distribution of rainfall was observed, while 14.67% and 12.00% of farmers were strongly disagreed and strongly agreed, respectively. 36.67% of farmers were disagreed that there was unseasonal rainfall, and it was agreed by 29.33% of farmers, while 21.33% and 6.67% of farmers were strongly disagreed and strongly agreed, respectively. 33.33% of farmers were agreed that there was frequently natural hazard like cyclone occurred while 30.00% and 23.33% of farmers

were disagreed and strongly disagreed, respectively. 32.67% of farmers were agreed that there was frequently flood occurred and was disagreed by 28.67% of farmers, whereas 19.33% and 14.00% of farmers were strongly disagreed and had no idea, respectively. Majority (68.66%) of farmers (49.33% A and 19.33% SA) were felt that the duration of winter had decreased, while 16.67% of farmers were disagreed. 40.67% of farmers were agreed that there was an increase in foggy days during the winter season and was disagreed by 26.67% of farmers. However, 20.67% and 10.00% of farmers had no idea and strongly agreed, respectively[15].

3.6 RANKING OF FARMERS ADAPTATION STRATEGIES

Table 3 denoted the scoring of each adaptation strategies of farmers in dairy farming across districts by sampled region (West Bengal). 'Provide proper shed and shelter' was the most preferred adaptation strategies by the farmers of Coochbehar district, Nadia district, Purba Medinipur district, and also for the overall region. Farmers have highly perceived the negative impact of heat-stress on their dairy; therefore, almost all of them were adopting this practice in order to reduce heat stress on the animals [16]. The second most preferred strategies by the farmers of the districts and overall region was 'provide additional fresh drinking water in summer season'.

'Feeding crop-residue to animals' was preferred third most important adaptation strategy by the farmers of Purba Medinipur and the overall region, whereas it was preferred as fourth and fifth most important adaptation strategy in Nadia and Coochbehar district, respectively. 'Change in feeding schedule' was ranked fourth by the farmers of Purba Medinipur and overall region, while it was preferred as third and fifth most important adaptation strategy in Coochbehar and Nadia district, respectively. 'Feeding of mustard cake to animals' was ranked fifth by the farmers of the overall region, while it was the third, fourth and sixth important adaptation strategies by the farmer of Nadia, Coochbehar and Purba Medinipur district, respectively. 'Provide additional health care practices' was considered as sixth most important adaptation strategies by the farmers of Coochbehar district as well by the overall region. It was considered fifth important adaptation strategy by the farmers of Nadia and Purba Medinipur district. 'Provide feed additives' was the least preferred adaptation strategies by the farmers of the districts as well by the overall region.

CONCLUSION

The indigenous cow milk production was responsive to annual minimum temperature, while crossbred cow milk production was responsive to annual maximum temperature and relative humidity. The buffalo milk production was only responsive to annual maximum temperature and relative humidity. More than half of farmers had a medium level of experience in farming. Majority of farmers were perceived climate variability in general like increase in temperature during the summer season, late onset of monsoon and early withdrawal of monsoon season. For crop farming, crop diversification was the most preferred adaptation strategy among the farmers followed by changing crop variety. For dairy farming, provide proper shed and shelter was most preferred adaptation strategy followed by 'provide additional fresh drinking water in summer.

REFERENCES

1. Lu S, Bai X, Li W, Wang N. Impacts of climate change on water resources and grain production. Technological Forecasting and Social Change. 2019;143: 76-84.
2. Birthal P S, Khan T, Negi D S, Agarwal S. Impact of climate change on yields of major food crops in India: Implications for food security. Agricultural Economics Research Review. 2014;27(2): 145-155.
3. Srinivasarao Ch, Prasad RS, Mohapatra T. Climate Change and Indian Agriculture: Impacts, Coping Strategies, Programmes and Policy. Technical Bulletin/Policy Document 2019. Indian Council of Agricultural Research, Ministry of Agriculture and Farmers' Welfare and Ministry of Environment, Forestry and Climate Change, Government of India, New Delhi. 2019;p25.
4. Abbas Q, Han J, Adeel A, Ullah R. Dairy Production under Climatic Risks: Perception, Perceived Impacts and Adaptations in Punjab, Pakistan. International journal of Environmental Research and Public Health. 2019;16(20): 4036.
5. Kichamu E A, Ziro J S, Palaniappan G, Ross H. Climate change perceptions and adaptations of smallholder farmers in Eastern Kenya. Environment, Development and sustainability. 2018; 20(6): 2663-2680.

6. Ayanlade A, Radeny M, Morton J F. Comparing smallholder farmers' perception of climate change with meteorological data: A case study from south western Nigeria. Weather and Climate Extremes. 2017;15: 24-33.
7. Mandal D K, Mandal A, Bhakat C, Chatterjee A, Karunakaran M. Effect of Climatic Stress on Milk Production in Jersey Crossbred Cows Herd. Journal of Agricultural Engineering and Food Technology. 2016 ; 3(3): 230-232.
8. Kumar S, Raju B M K, Ramarao C A, Ramilan T. Sensitivity of livestock production to climatic variability under Indian drylands and future perspective. Current Agriculture Research Journal. 2015;3(02):142-149.
9. Siva G S, Gupta D S. Comprehensive Socioeconomic and Demographic Profile of Farm Households in West Bengal, India. Current Journal of Applied Science and Technology. 2019;1-11.
10. Kundu S K, Mondal T K. Analysis of long-term rainfall trends and change point in West Bengal, India. Theoretical and Applied Climatology. 2019;138(3-4): 1647-1666.
11. Promket D, Kenchaiwong W, Ruangwittayanusorn K. Effects of climate change on milk yield and milk composition in Thai crossbred holstein cows. International Journal. 2020; 18(67): 108-113.
12. Mauger G, Bauman Y, Nennich T, Salathé E. Impacts of climate change on milk production in the United States. The Professional Geographer. 2015; 67(1): 121-131.
13. Rawat S, Nain A. Impact of weather variables on Milk Production of Buffaloes. Journal of Agrometeorology. 2014;16 (I): 90-94Belachew O, Zuberi M I. Perception of climate change and livelihood of a farming community of Maruf Kebele, Central Oromia, Ethiopia. American Journal of Climate Change. 2015;4(03): 269.
14. Dhanya P, Ramachandran A. Farmers' perceptions of climate change and the proposed agriculture adaptation strategies in a semi arid region of south India. Journal of Integrative Environmental Sciences. 2016;13(1): 1-18.
15. Mkonda, M. Y., He, X., & Festin, E. S. Comparing smallholder farmers' perception of climate change with meteorological data: experience from seven agroecological zones of Tanzania. Weather, Climate, and Society. 2018; 10(3): 435-452.
16. West J W, Mullinix B G, Bernard J K. Effects of Hot, Humid Weather on Milk Temperature, Dry Matter Intake, and Milk Yield of Lactating Dairy Cows. Journal of Dairy Science. 2003;86: 232–242.

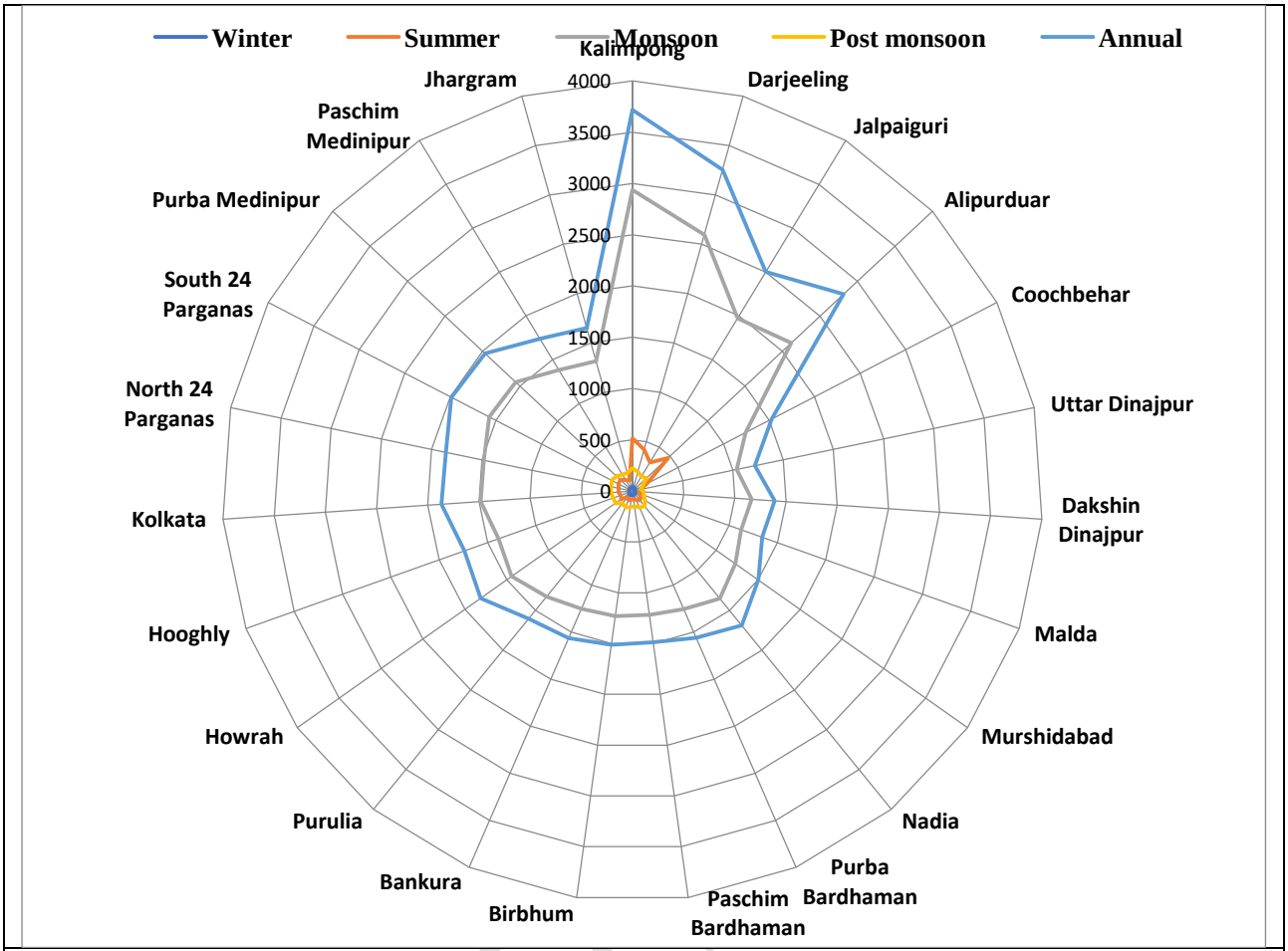


Fig. 1. Radar chart to depict the variation in rainfall pattern among districts

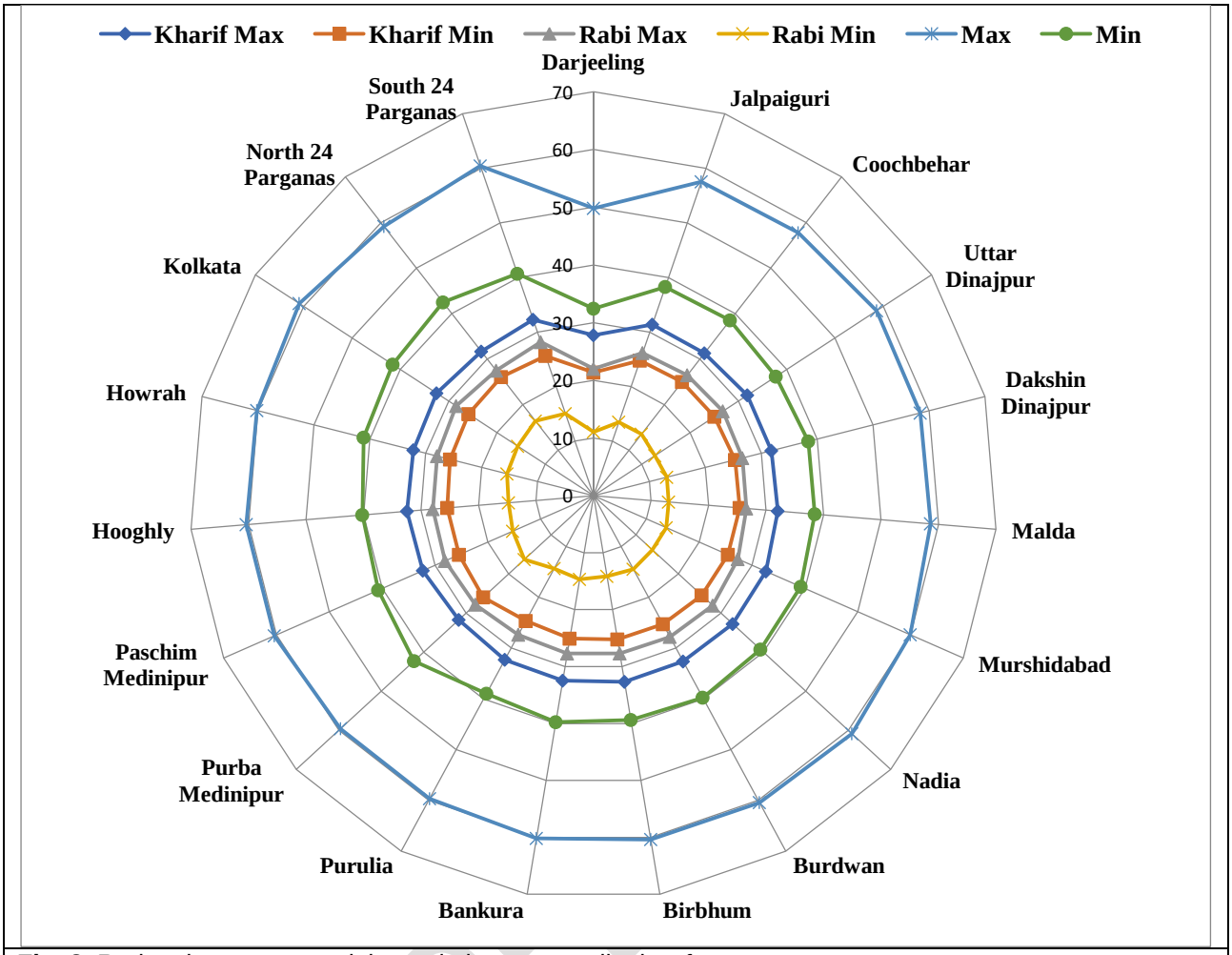


Fig. 2. Radar chart expressed the variation among districts for temperature

Table 1. Effect of climate variables on milk production

Sl. No.	Climate Variables	Indigenous Cow		Crossbred Cow		Buffalo	
		Coefficient	P value	Coefficient	P value	Coefficient	P value
1	Intercept	0.836	0.134	5.582***	0.000	5.322***	0.000
2	Fodder Area	0.022	0.348	-0.113***	0.000	0.049***	0.000
3	Maximum Temperature	0.011	0.449	-0.177***	0.000	-0.121***	0.006
4	Minimum Temperature	0.033*	0.093	0.036	0.663	0.015	0.715
5	Relative Humidity	0.029	0.593	-0.076***	0.000	-0.043***	0.000
	F statistics	48.716***	0.000	34.907***	0.000	42.324***	0.000
	R^2	0.513		0.407		0.531	
	No of Observation	238		238		216	

(Note: *, **, & *** indicates significance at 10%, 5%, & 1% level.)

Table 2. Distribution of respondents as per their perception towards climate variability

Sl. No.	Statement	Strongly Agreed		Agreed		No Idea		Disagreed		Strongly Disagreed	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
1	Increase in temperature during summer	76	50.67	41	27.33	5	3.33	24	16.00	4	2.67
2	Decrease in temperature during winter	35	23.33	58	38.67	15	10.00	32	21.33	10	6.67
3	Late onset of monsoon	49	32.67	65	43.33	10	6.67	14	9.33	12	8.00
4	Early withdrawal of monsoon	54	36.00	62	41.33	14	9.33	14	9.33	6	4.00
5	Uneven distribution of rainfall	18	12.00	45	30.00	20	13.33	45	30.00	22	14.67
6	Unseasonal rainfall	10	6.67	44	29.33	9	6.00	55	36.67	32	21.33
7	Frequent occurrence of natural hazard like cyclone	16	10.66	50	33.33	19	12.66	35	23.33	30	20.00
8	Frequent occurrence of flood	8	5.33	49	32.67	21	14.00	43	28.67	29	19.33
9	Duration of winter has decreased	29	19.33	74	49.33	14	9.33	25	16.67	8	5.33
10	Increase of foggy days in winter	15	10.00	61	40.67	31	20.67	40	26.67	3	2.00

Table 3. Index score and ranking of adaptation strategies in dairy farming

Sl. No.	Adaptation Strategies	Coochbehar (n=38)	Nadia (n=32)	Purba Medinipur (n=41)	Overall (n=111)
1	Change in feeding schedule	0.50(III)	0.39(V)	0.50(IV)	0.46(IV)
2	Provide proper shed and shelter	0.89(I)	0.96(I)	0.92(I)	0.92(I)
3	Feeding of mustard cake to animals	0.47(IV)	0.58(III)	0.36(VI)	0.45(V)
4	Provide appropriate health care practices	0.39(VI)	0.38(V)	0.39(V)	0.39(V)
5	Provide feed additives	0.30(VII)	0.29(VII)	0.31(VII)	0.30(VII)
6	Provide additional fresh drinking water in summer	0.86(II)	0.93(II)	0.90(II)	0.89(II)
7	Feeding of crop-residue	0.42(V)	0.48(IV)	0.56(III)	0.48(III)

(Column wise rank indicated in parenthesis)