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Adaptation strategies followed by the livestock rearers of Coastal Odisha and West Bengal to cope up with climate change

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ABSTRACT

Adaptation to climate change and variability has recently become a subject of increasing importance in climate change research with an objective to reduce the vulnerability of climate sensitive people. The present study was designed to identify and assess the adaptation strategies followed by the climate sensitive livestock rearers of coastal Odisha and West Bengal. Livestock rearers (480) were selected from 4 coastal districts of Odisha and West Bengal. The study revealed that 17 adaptation strategies were followed by the livestock rearer. To trace the relative importance among the adaptation strategies, an exclusively climate change adaptation index was developed. It was observed that change in micro-climate in cattle shed/grazing area/stall was the most preferred adaptation strategy followed by providing the frequent clean and fresh drinking water and additional washing/sprinkling of cattle and buffaloes. Livestocks are very much susceptible to heat stress. Therefore, most of the livestock rearers followed heat alleviating adaptation strategies.

Key words: Adaptation, Climate change, Livestock-rearers, Coastal areas

The impact of climate change on India, one amongst 27 countries most vulnerable to the impacts of global warming related to accelerated sea level rise (UNEP 1991), has great significance because of its extensive low-lying densely populated coastal zone. Observations suggested that the sea level has risen @ 2.5 mm/year along the Indian coastline since 1950s. A mean sea level rise of between 15 and 38 cm is projected by the mid 21st century along India's coast, and estimate is that 1 m rise in sea-level could displace nearly 7 million people from their homes in India (IPCC 2001). Added to this, a 15% projected increase in intensity of tropical cyclones would significantly enhance the vulnerability of populations living in cyclone prone coastal regions of India. Patnaik and Narayanan (2005) reported that eastern coast is more vulnerable than the west coast with respect to the frequency of occurrence of extreme climatic events. There are two fragile ecosystems existing in eastern coast, i.e. the Sunderban and the Chilka lagoons which are rich in agro and livestock bio-diversity. East coast of India is the house of several livestock breeds like Chilka buffalo; Ganjam, Dalua, Garole breed of sheep; Ganjam, Black Bengal, Dalua breed of goat, etc. Therefore, the coastal region is as rich in livestock as in crop production and fisheries. The phenomenon of global climate change occurring due to GHG emissions has also been directly affecting the livestock production system world over. Milk yield of cows (crossbred, Hariana, Sahiwal) and buffaloes were found to be negatively correlated with temperature humidity index (Kaur and Arora 1982, Lal *et al.* 1987, Shinde *et al.* 1990, Kulkarni *et al.* 1998, Mandal *et al.* 2002, Tailor and Nagda 2005). The direct heat stress on lactating cows and buffaloes causes a production loss of more than 1.8 million tonnes of milk. The increase in thermal stress days due to temperature rise has been estimated to cause an additional loss in milk production of 1.6 million tonnes in 2020 accounting about ₹2,365.8 crores INR at current price rate (Upadhyay *et al.* 2009).

Adaptation to climate change and variability is now considered as an important response option worthy of research and assessment, not simply to guide the selection of the best mitigation policies, but rather to reduce the vulnerability of groups of people to the impacts of climate change, and hence minimize the costs associated with the inevitable (Kane and Shogren 2000, Pielke 1998, Smit and

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Pilifosova 2001). This has, in part, stemmed from a realization that a certain amount of climate change will occur, and that society can take concrete steps to minimize the net losses (including taking advantage of opportunities for gains) (Schroter *et al.* 2005). It is often heard about different adaptation strategies especially micro-environment modification like shelter modifications; water cooling or sprinkler system; strategic nutrient supplementation etc while forgetting the ground reality that out of 529.7 million livestock, 440 million livestock are reared by 100 million household with/without any housing system and by crop residues. Mostly, livestock rearers modify micro climate in changing climatic scenario for sustainable productivity of their livestock. Therefore, farmers led adaptation strategies are required to be documented to cope up with climate change. Keeping in view of all these, a comprehensive study was conceptualized on the adaptation strategies followed by the livestock rearers of coastal Odisha and West Bengal for skilful implementation that helps to reduce vulnerability to prosper their socio-economic status and overall quality of life.

MATERIALS AND METHODS

Length of coastline of India including the coastlines of Andaman and Nicobar Islands in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea is 7,517 km. Length of coastline of Indian mainland is 6,100 km and divided into east coast and west coast. Among West Bengal, Odisha, Andhra Pradesh and Tamil Nadu, the 4 states in eastern coastal region of India, Odisha and West Bengal were selected randomly. Balasore, Bhadrak, Kendrapara, Jagatsighpur, Puri and Ganjam districts are in coastal Odisha and South 24 Parganas, North 24 Parganas and Purba Medinipur districts are in coastal West Bengal. Among these districts, Ganjam, Bhadrak, Purba Medinipur and South 24 Parganas were selected randomly for the present study. Three blocks in each selected district namely Rangeilunda, Ganjam, and Chhtrapur from Ganjam; Basudevpur, Tihidi, and Chandbali from Bhadrak; Deshapran (Contai-II), Ramnagar-I and Ramnagar-II from Purba Medinipur; Gosaba, Basanti and Namkhana from South 24 Parganas were selected randomly, thus, the present study was confined to 12 blocks. A block-wise list of villages, where few numbers of livestock depended households were existing, were prepared in consultation with the block level veterinary officers. Subsequently, total 24 villages were selected randomly by selecting 2 villages from each selected block. A livestock-rearer who has more than 30 years of experience in livestock rearing of at least one species among cattle, buffalo, goat, sheep and pig; and having main income from livestock was considered as respondents for the present study. Village-wise lists of livestock depended households were prepared with the help of livestock enumerator of that respective villages. Household head was considered as respondents for the present study. Subsequently, 20 respondents from each village were selected randomly. Thus, a total sample size of the present study was 480.

Climate change in Intergovernmental Panel on Climate Change (IPCC) usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any changes in climate over time, whether due to natural variability or as a result of human activity. Awareness is the state or ability to perceive, to feel, or to be conscious of events, objects or sensory patterns. Awareness regarding climate change was operationalized as the conscious feeling of livestock rearers regarding the changing climatic scenario. At first, the respondents were directly asked whether they feel any change in climate over the past 30 years on the binary response YES or NO. Livestock rearers who recognized the changing climatic scenario during last 30 years were again directly asked whether they adopt any measure to cope up with the negative impact of climate change on the binary response YES or NO. Those who responded YES, again they were requested to put their response on a three point continuum, viz. continued the adoption, discontinued the adoption and never followed/adopted with the score of 2, 1, and 0 on a prelisted adaptation strategies for both the region.

Adaptation refers to adjustment in ecological, social or economic systems in response to actual or expected climate stimuli and effects or impacts. Adaptation strategies was operationalized as the measures adopted and/or followed by the livestock rearers of coastal region to cope up with the adverse impact of climate change on livestock rearing and/or their livelihood for sustainable livestock productivity and/or sustainable livelihood security.

A list of adaptation strategies were prelisted during a pilot survey in the study area using the snowball technique. Therefore, in order to quantify the adaptation strategies, an exclusive climate change adaptation index (CCAI) was developed by using the following formula:

$$\text{Climatge change adaptation index (CCAI)} = \frac{\text{Obtained score}}{\text{Maximum obtainable score}}$$

Adaptation strategies with higher index value indicate that these adaptation strategies has comparatively more cope up capacity than the adaptation strategies with lower index value. Ranking of these adaptation strategies were done according to their higher index value.

RESULTS AND DISCUSSION

Climate change adaptation among the livestock rearers of coastal region: The results (Table 1) revealed that 85, 99.17, 83.33 and 100% of the livestock rearers of Ganjam, Bhadrak, Purba Medinipur and South 24 Parganas district, respectively, had awareness regarding the changing climatic scenario. They were subsequently asked if they had responded through adaptation to reduce negative impacts of climate change and 79.41, 97.48, 90.00 and 59.17% of them, respectively, stated that they have adopted at least

Table 1. Climate change adaptation among the livestock rearers of coastal region who had awareness regarding climate change

Study area	Climate change awareness	Adaptation among those who were aware	
		Adopted	Not adopted
Ganjam (n = 120)	102 (85.00)	81(79.41)	21 (20.59)
Bhadrak (n = 120)	119 (99.17)	116 (97.48)	3 (2.52)
Purba Medinipur (n = 120)	100 (83.33)	90 (90.00)	10 (10.00)
South 24 Parganas (n = 120)	120 (100)	71 (59.17)	49 (40.83)
Coastal region overall (n = 480)	441 (91.88)	358 (81.18)	83 (18.82)

values in parenthesis indicate percentage.

one adaptation strategies to cope up with climate change. Remaining respondents did not follow any adaptation strategies to cope up with climate change.

Adaptation strategies and their state of adoption by the livestock rearers of the coastal region: Total 17 adaptation strategies were documented from the coastal districts of Odisha and West Bengal. Detail including rationale of each adaptation strategy (1–17) of is discussed as follows with their state adoption in the Table 2 and 3.

Additional concentrate to livestock: Almost all the livestock rearers of coastal region perceived that during the period of heat stress in summer, feed intake as well as production of their livestock was decreased. Therefore, they used to offer more green grasses and/or fodder, concentrate etc. to their animal for maintaining productivity and body weight of the animal during the heat stress. Many researchers (Upadhyay *et al.* 2009, Prasad 2010, Sirohi and Sirohi 2010) reported that the composition of the diet is believed to be important in alleviating heat stress.

Majority (67.90, 85.35, 66.67 and 74.65% of Ganjam, Bhadrak, Purba Medinipur and South 24 Parganas district, respectively) of livestock rearers of coastal Odisha and West Bengal were providing additional concentrate to their animal to maintain proper productivity and producing during hot summer.

Providing mineral supplementation and feed additives: Livestock rearers believed that animal is also sweating like man in hot and humid environment. This is the cause of excessive loss of water, thereby, reduce mineral level like sodium and potassium. They also believed that it is one of the major causes of reduced milk production. Therefore, livestock rearers of coastal region used to offer common salt and mineral mixture available in the market to maintain the proper mineral profile. Studies indicated that in the lactating cows feeding of complete mixed diets supplemented with K (Mallonee *et al.* 1985) as well as K and Na (Schneider *et al.* 1985) above current recommendations (NRC 1978) during heat stress resulted in 3 to 11% increase in milk yield during lactation. Livestock rearers of coastal region also offered some feed additives like vitamin-A and E, selenium, zinc etc. to reduce the negative impact of heat stress, improve milk quality and to improve health condition of their animal. Gbetibouo and Ringler (2009) also reported that farmers of

Table 2. Adaptation strategies followed by the livestock-rearers of the coastal districts of Odisha

ADS	Ganjam (n = 81)								Bhadrak (n = 116)							
	Followed		Continued		Discontinued		Never Followed		Followed		Continued		Discontinued		Never Followed	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
1	55	67.90	46	56.79	9	11.11	26	32.10	99	85.35	72	62.07	27	23.28	17	14.65
2	28	34.57	21	25.93	7	8.64	53	65.43	54	46.55	45	38.79	9	7.76	62	53.45
3	72	88.89	72	88.89	0	0.00	9	11.11	82	70.69	82	70.69	0	0.00	34	29.31
4	49	60.49	46	56.79	3	3.70	32	39.51	76	65.52	67	57.76	9	7.76	40	34.48
5	41	50.62	37	45.68	4	4.94	40	49.38	11	9.48	9	7.76	2	1.72	105	90.52
6	64	79.01	64	79.01	0	0.00	17	20.99	112	96.55	112	96.55	0	0.00	4	3.45
7	49	60.49	43	53.09	6	7.40	32	39.51	111	95.69	86	74.14	25	21.55	5	4.31
8	28	34.57	22	27.16	6	7.41	53	65.43	39	33.62	32	27.59	7	6.03	77	66.38
9	77	95.06	77	95.06	0	0.00	4	4.94	113	97.41	113	97.41	0	0.00	3	2.59
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	25	30.86	16	19.75	9	11.11	56	69.14	10	8.62	10	8.62	0	0.00	106	91.38
12	62	76.54	57	70.37	5	6.17	19	23.46	91	78.44	87	75.00	4	3.44	25	21.56
13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	37	45.68	34	41.98	3	3.70	44	54.32	54	46.55	41	35.35	13	11.20	62	53.45
15	20	24.69	16	19.75	4	4.94	61	75.31	39	33.62	36	31.03	3	2.59	77	66.38
16	50	61.73	41	50.63	9	11.10	31	38.27	17	14.66	14	12.07	3	2.59	99	85.34
17	52	64.20	47	58.03	5	6.17	29	35.80	69	59.48	57	49.14	12	10.34	47	40.52

ADS, Adaptation strategies; F, frequencies; P, percentage; NA, not applicable.

Table 3. Adaptation strategies followed by the livestock-rearers of the coastal districts of West Bengal

ADS	Purba Medinipur (n = 90)								South 24 Parganas (n = 71)							
	Followed		Continued		Discontinued		Never followed		Followed		Continued		Discontinued		Never followed	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
1	60	66.67	56	62.22	4	4.45	30	33.33	53	74.65	45	63.38	8	11.27	18	25.35
2	27	30.00	26	28.89	1	1.11	63	70.00	27	38.03	26	36.62	1	1.41	44	61.97
3	42	46.67	42	46.67	0	0.00	48	53.33	37	52.11	37	52.11	0	0.00	34	47.89
4	65	72.22	58	64.44	7	7.78	25	27.78	51	71.83	50	70.42	1	1.41	20	28.17
5	19	21.11	18	20.00	1	1.11	71	78.89	7	9.86	6	8.45	1	1.41	64	90.14
6	89	98.89	89	98.89	0	0.00	1	1.11	60	84.51	60	84.51	0	0.00	11	15.49
7	87	96.67	76	84.44	11	12.23	3	3.33	60	84.51	53	74.65	7	9.86	11	15.49
8	18	20.00	15	16.67	3	3.33	72	80.00	19	26.76	19	26.76	0	0.00	52	73.24
9	83	92.22	83	92.22	0	0.00	7	7.78	64	90.14	64	90.14	0	0.00	7	9.86
10	NA	NA	NA	NA	NA	NA	NA	NA	38	53.52	38	53.52	0	0.00	33	46.48
11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12	72	80.00	72	80.00	0	0.00	18	20.00	51	71.83	51	71.83	0	0.00	20	28.17
13	NA	NA	NA	NA	NA	NA	NA	NA	71	100.00	0	0.00	71	100.00		0.00
14	30	33.33	18	20.00	12	13.33	60	66.67	18	25.35	10	14.08	8	11.27	53	74.65
15	12	13.33	11	12.22	1	1.11	78	86.67	15	21.13	15	21.13	0	0.00	56	78.87
16	4	4.44	4	4.44	0	0.00	86	95.56	1	1.41	1	1.41	0	0.00	70	98.59
17	27	30.00	24	26.67	3	3.33	63	70.00	31	43.66	25	35.21	6	8.45	40	56.34

ADS, Adaptation strategies; F, frequencies; P, percentage; NA, not applicable.

Limpopo basin of South Africa adopted feed supplementation as an adaptation strategy to maintain proper livestock productivity.

Due to the high cost of the mineral supplementation and feed additives, most of the livestock rearers of coastal region of Odisha and West Bengal never provided mineral supplementation and feed additives to their animal.

Use of additional crop residue and hay: The feed intake as well as production in livestock is decreased during hot summer. Therefore, to maintain the production and productivity of their animal, livestock rearers of coastal region used to offer more crop residue and hay.

Results (Tables 2 and 3) revealed that 88.89, 70.69, 46.67 and 52.11% livestock rearers of Ganjam, Bhadrak, South 24 Parganas and Purba Medinipur district, respectively, adopted this practice. The data also revealed that those who adopted were continuing this practice to maintain the gap of mineral supplementation and feed additives as it was a low cost adaptation strategy.

Change in feeding schedule: Livestock rearers felt that day time feeding during hot summer is the cause of restlessness, uneasiness and discomfort in their animal. Upadhyay *et al.* (2009) also reported that heat production in animals fed in the morning will peak during the middle of the day when environmental temperature are also high. Therefore, livestock rearers of coastal region used to feed their animal in the late afternoon and in the early morning. Sirohi and Sirohi (2010) suggested that during hot summer, at least 70% of the daily ration should be given fresh at night. Whereas, other researchers (Reinhardt and Brandt 1994, Brosh *et al.* 1998) reported that feeding of animals later in the day or cooler parts prevents the coincidal occurrence of peak metabolic and environmental heat load.

Few livestock rearers also reported that they fed their animal frequently and in small quantity throughout the day. Upadhyay *et al.* (2009) and Sirohi and Sirohi (2010) reported that the frequency of feeding should be increased and small quantities of the ration should be given during the day to improve the dry matter intake and to reduce heat stress during summer. They also further reported that feeding fresh feed improves dry matter intake and more frequent feeding keeps feed fresh and encourages the animals to eat more.

Majority (60.49, 65.52, 72.22 and 71.83% of Ganjam, Bhadrak, Purba and South 24 Parganas district, respectively) of the livestock rearers of coastal Odisha and West Bengal changed feeding schedule of their animal by considering the heat stress during hot summer.

Change in grazing time: Livestock rearers of coastal region who depend on the grazing fields changed the grazing time to protect their animals from the heat stress during hot summer. During the summer, they grazed their animals in the early morning and late afternoon. Generally they avoid grazing between 11.00 AM to 3.00 PM. More than half (50.62%) of the livestock rearers of Ganjam district changed timing of grazing of their livestock. But, 90.52, 78.89 and 90.14% of the livestock rearers of Bhadrak, Purba Medinipur and South 24 Parganas district, respectively, did not change the timing of grazing. Actually, few of the livestock rearers of the coastal Bhadrak and West Bengal depended on the grazing. Therefore, adoption of this practice was too low.

Providing frequent clean and fresh drinking water: During the hot and humid summer, livestock rearers of

coastal region provided fresh and clean drinking water in adequate quantity to reduce heat stress as well as body temperature. They also reported that they used to provide 1.5 to 2 times of water during hot summer than they normally provide. Sometimes they provide 70–80 litre water/day to the lactating animal to maintain proper productivity. Upadhyay *et al.* (2009) and Sirohi and Sirohi (2010) reported that adequate supply of cool, fresh and clean water is essential to minimize the effects of heat stress in lactating cows and buffaloes.

All most all the livestock rearers of Bhadrak and Purba Medinipur district were providing frequent clean and fresh drinking water to their animal to reduce heat stress during summer. In Ganjam and South 24 Parganas district, majority (79.01% and 84.51%, respectively) of the livestock rearers also offer frequent clean and fresh drinking water to their animal. It was also found that all those who adopted this practice were continuing as this practice was the least costly adaptation strategy.

Additional washing/sprinkling of cattle and buffaloes: To reduce the heat stress, livestock rearers of the coastal region used to wash/sprinkle water during the hot summer. Generally, at 10 AM and 5 PM, they washed/sprinkled water on their animal. Few buffalo owners of coastal Odisha also used wallowing tank for their buffalo. Like previous adaptation strategy, the same trend was observed in adoption of additional washing/sprinkling of cattle and buffaloes. This practice was also least costly, therefore, higher level of adoption was observed.

Reduction in herd size: Coastal zones are more sensitive to erosion, flooding, submergence and deterioration of coastal grazing fields due to inundation and salinization. Therefore, shortage of feed and fodder is the common scenario in coastal region as an aftershock of an extreme climatic event. Therefore, livestock rearers of coastal region were forced to reduce their herd size. As far as reduction in herd size was concerned, lower level of adoption was observed in the coastal districts of both Odisha and West Bengal.

Change in micro-climate in cattle shed/grazing area/stall: Livestock rearers of coastal region adopted several ways to change the micro climate in the cattle shed/grazing area/stall. They used electric fan and heat insulating roof material in their cattle sheds to protect their animal from heat stress. They also used locally available resources like coconut leaves, straw on the roof of their cattle shed or stall to reduce inside temperature. Few commercial livestock rearers of coastal region also used mist cooling system in their cattle shed during hot summer. Community people also planted several saplings under social forestry programmes in the grazing grounds to get shade for their animal during hot summer. Knapp and Grummer (1991) stated that either an increase in convection with fans or to decrease air temperature by evaporative cooling or to directly cool the cow through use of sprinklers and soakers are some of the strategies that may be followed to reduce heat stress.

Data (Tables 2, 3) clearly depicted that all most all (95.06, 97.41, 92.22 and 90.14% of Ganjam, Bhadrak, Purba Medinipur and South 24 Parganas district, respectively) the livestock rearers of coastal district Odisha and West Bengal changed the micro climate of their cattle shed/grazing ground/stall during the hot summer. Considering its importance, livestock rearers of the both states who adopted this strategy were continuing.

Shifting to small ruminants from large ruminant: Livestock rearers of the coastal South 24 Parganas district of West Bengal reported that they shifted to small ruminants like sheep (Garole breed) and goat (Black Bengal breed) from the large ruminant cattle. They also revealed that this trend was observed during last 3 years after devastating effect of the *Aila* (cyclone) (the *Aila* hits coastal Bengal on 25 May 2009). They also stated that due to the *Aila,* grazing and fodder fields were covered with saline water that led to shortage of feed and fodders. A large numbers of livestock also died during this devastating extreme climatic event. Therefore, to minimize the risk of huge monetary loss and to get relief from fodder scarcity, they adopted small ruminant rearing like sheep and goat. Hassan and Namehcha (2009) also reported that livestock rearers of Africa shift to different species in changing climatic scenario.

In coastal Odisha and Purba Medinipur district, there is no evidence of shifting to small ruminant from large ruminant. But, in South 24 Parganas district, more than half (53.52%) of the livestock rearers shifted to small ruminant like sheep and goat from large ruminant like cattle to minimize risk of loss during extreme climatic events.

Keeping/promoting/interested in local breed: Mean temperature of eastern coastal region of India during summer is always near to 40°C and sometimes maximum temperature crossed 45°C. Along with the high temperature, humidity of the region even crossed 80–90%. Therefore, this environmental scenario is not all suitable for crossbred animal like Holstein Frisen, Gersy cross etc. Livestock rearers of coastal region also perceived that their crossbred animals were always restless, having drastically reduced productivity and more prone to disease during summer leading to heavy economic loss in dairy farms. Therefore, now a days, these livestock rearers were more interested in maintaining locally available or non-descriptive breed upgraded with proven indigenous breeds having higher productivity poetntial like Red Sindhi, Sahiwal, Gir, Haryana. Livestock rearers near to the Chilka lake of Ganjam district of Odisha were more interested in rearing native Chilka breed of buffalo and in other parts of district, they like to rear Ganjam and Dalua sheep; and Ganjam breed of goat. In case of West Bengal, it was Garole sheep and Black Bengal goat.

Evidence of keeping/promoting/interested in local breed than the crossbred were recorded in coastal Odisha. Though a little number (30.86% and 8.62% of Ganjam and Bhadrak, respectively) of livestock rearers adopted this strategy, but, this is one of the innovative adaptation strategies followed by the livestock rearers of coastal Odisha. In coastal West

Bengal, livestock rearers keep local breed like Garole sheep and Black Bengal goat, but, there is no evidence of keeping/ promoting in local breed than crossbred in coastal West Bengal.

Providing more health care practices to the livestock: Scientists have already established the relationship of climate parameters and disease outbreak in livestock. Livestock rearers of coastal region reported that incidences of diarrhoea, protozoan diseases like trypanosomiasis and babesiosis, vector-borne diseases were increased and incidence of heat stroke is common in the region. To get relief from this negative impact of climate change, livestock rearers of coastal region adopted curative healthcare practices and preventive healthcare services like vaccination in consultation with the veterinary doctors. Upadhyay *et al.* (2009) stated that incidences of protozoan diseases e.g. trypanosomiasis and babesiosis may increase in sensitive and non-adapted high producing crossbred and pure exotic cattle breeds.

Majority of the livestock rearers of coastal Odisha and West Bengal opined that they are providing additional preventive as well as curative healthcare facility to their animal to protect from climate change induced diseases.

Using mosquito net to protect from mosquito: Livestock rearers of coastal South 24 Parganas reported that the increase in rainfall in the district during last 10–15 years have several folds increased the mosquito population. Scientists have already established that increase in mosquito population has a strong relationship with the changing climatic scenario. Therefore, livestock rearers of the South 24 Parganas district used several mosquito repellent in their cattle shed and after few days they observed that these repellents were not working and also caused irritation in their animals. Therefore, finally they covered their cattle shed and animal with the mosquito net to protect their animal from mosquito problem.

Livestock rearers of coastal Odisha and Purba Medinipur district reported that mosquito was not a big problem in their locality and therefore, no evidence of using mosquito net in cattle shed in these districts. But, in South 24 Parganas district, all the livestock rearers used mosquito net to protect their animal from increased population of mosquito.

Selling of few animals from their herd: Yirga (2007) reported that livestock in addition to serving as a source of power for farming and manure for fertilizing soil, also serve as asset and insurance against shocks. Here in the locale of the study, livestock rearers used to sell their livestock to meet the emergency expenses after extreme climatic events. Deressa *et al.* (2011) reported that selling livestock is a common adaptation strategy among the African farmers.

Majority of the livestock rearers of coastal Odisha as well as West Bengal did not sell their animal even in distress condition during extreme climatic events or natural calamities (Tables 2, 3).

Livestock insurance: Death of livestock during extreme climatic events like cyclone, flood and drought was widely reported. Therefore, commercial livestock rearers of coastal region insured their livestock with insurance company to get some monetary benefits from accidental death of their livestock. The present study revealed that most of the livestock rearers did not have awareness regarding livestock insurance. Therefore, majority of them from both the states did not insure their animal. Dhaka *et al.* (2010) also reported that farmers of Bundi district of Rajasthan adopted insurance as an adaptation strategy.

Social migration: Family members of the livestock rearers of the coastal region migrate to the different cities of India like Kolkata, Mumbai, Delhi, Bangalore, Visakhapattnam, Hyderabad etc. for employment purpose after the extreme climatic events to maintain their livelihood. They were mainly engaged as unskilled labourers in masonry works, factory, etc.

In case of social migration as an adaptation strategy, 61.73% of the respondents from Ganjam district reported that at least one of their family members has migrated to other place for employment purpose. But, majority (85.35%) of Bhadrak district and all most all the livestock rearers of coastal West Bengal reported that none of their family members has migrated for employment purposes.

Search of alternate sources of income: Livestock rearers those who did not migrate to the cities were engaged in different works to earn livelihood for their family members. Livestock rearers were mainly engaged in the Mahatma Gandhi National Rural Employment Guarantee Programme (MNAREGA) popularly known as 100 days works programme, collection of fingerlings of fish, helper of fisherman, vegetable cultivation, agricultural labourers etc.

In case of search of alternate source of income, majority of the livestock rearers of coastal Odisha reported that they were searching alternate sources of income to maintain their livelihood in a sustainable manner. But, opposite result was found in West Bengal i.e. majority of the livestock rearers of coastal West Bengal did not search any alternate source of income.

Ranking of adaptation strategies followed by the livestock rearers of coastal region

The index score of each adaptation strategies at district as well as state level and finally at coastal region level is given in Table 4. Change in micro-climate in cattle shed/ grazing area/stall was the most preferred adaptation strategy among the livestock rearers of coastal Odisha as well as in coastal region overall. This practice was second most preferred adaptation strategy across the coastal districts of West Bengal. Livestock rearers of coastal region were very much concerned regarding the heat stress than the other extreme climatic events. Therefore, they adopted this adaptation strategy to alleviate heat stress during hot summer.

Livestock rearers of coastal region overall, Bhadrak district and coastal Odisha overall perceived that providing clean and fresh drinking water was the second most preferred adaptation strategy. Whereas, livestock rearers of coastal Purba Medinipur district and coastal West Bengal

Table 4. Index score and ranking of adaptation strategies followed by the livestock rearers of coastal region

ADS	Odisha			West Bengal			
	Ganjam (n=81)	Bhadrak (n=116)	Odisha Overall (n=197)	Purba Medinipur (n=90)	South 24 Parganas (n=71)	West Bengal Overall (n=161)	Coastal region (n=358)
1	0.62 (V)	0.74 (V)	0.69 (VI)	0.64 (VI)	0.69 (VII)	0.66 (VI)	0.68 (V)
2	0.30 (XIII)	0.43 (IX)	0.38 (X)	0.29 (VIII)	0.37 (XI)	0.33 (IX)	0.35 (VIII)
3	0.89 (II)	0.72 (VI)	0.79 (III)	0.47 (VII)	0.52 (IX)	0.49 (VII)	0.65 (VI)
4	0.59 (VII)	0.63 (VII)	0.61 (VII)	0.68 (V)	0.71 (VI)	0.70 (V)	0.65 (VI)
5	0.48 (X)	0.09 (XIV)	0.25 (XIII)	0.21 (XI)	0.09 (XV)	0.16 (XII)	0.21 (XII)
6	0.79 (III)	0.97 (II)	0.90 (II)	0.99 (I)	0.85 (III)	0.93 (I)	0.91 (II)
7	0.57 (VIII)	0.86 (III)	0.74 (V)	0.91 (III)	0.80 (IV)	0.86 (III)	0.79 (III)
8	0.31 (XII)	0.31 (XII)	0.31 (XI)	0.18 (XII)	0.27 (XII)	0.22 (XI)	0.27 (X)
9	0.95 (I)	0.98 (I)	0.97 (I)	0.92 (II)	0.90 (II)	0.91 (II)	0.94 (I)
10	NA	NA	NA	NA	0.54 (VIII)	0.24 (X)	0.11 (XV)
11	0.25 (XIV)	0.09 (XIV)	0.15 (XIV)	NA	NA	NA	0.09 (XVI)
12	0.73 (IV)	0.78 (IV)	0.76 (IV)	0.80 (IV)	0.72 (V)	0.76 (IV)	0.76 (IV)
13	NA	NA	NA	NA	1.00 (I)	0.44 (VIII)	0.20 (XIII)
14	0.44 (XI)	0.42 (X)	0.43 (IX)	0.27 (X)	0.20 (XIV)	0.24 (X)	0.34 (IX)
15	0.22 (XV)	0.32 (XI)	0.28 (XII)	0.13 (XIII)	0.21 (XIII)	0.16 (XII)	0.23 (XI)
16	0.56 (IX)	0.13 (XIII)	0.31 (XI)	0.04 (XIV)	0.01 (XVI)	0.03 (XIII)	0.18 (XIV)
17	0.61 (VI)	0.54 (VIII)	0.57 (VIII)	0.28 (IX)	0.39 (X)	0.33 (IX)	0.46 (VII)

Values in parenthesis indicate rank column wise; ADS, adaptation strategies; NA, not applicable

overall perceived this practice as most important. But, livestock rearers of Ganjam district and South 24 Parganas districts perceived this practice as third important practice. Additional washing/sprinkling of cattle and buffaloes was adjudged as the third important adaptation strategy among the livestock rearers of coastal region overall. The same rank was also found among the livestock rearers of coastal Purba Medinipur district, Bhadrak district and coastal West Bengal overall.

Providing additional healthcare practice to the livestock was ranked fourth by the livestock rearers of all the studied coastal districts, states and overall coastal region except South 24 Parganas district. Livestock rearers of South 24 Parganas perceived that population of mosquito increased due to the variation in rainfall in the district. Therefore, use of mosquito net to protect from mosquito was the most preferred adaptation strategy among them.

Additional concentrate to livestock was adjudged as the fifth important adaptation strategy by the livestock rearers of overall coastal region. Use of additional amount of feed residue and hay, and change in feeding schedule got the equal importance and ranked sixth by the livestock rearers of coastal region overall followed by the search of alternate sources of income, providing minerals supplementation and feed additives, selling of animals from stock, reduction in herd size, livestock insurance and change in grazing time.

Adaptation strategies like, using of mosquito net to protect from mosquito, shifting to small ruminant to large ruminant and keeping/promoting/interested in local breed got the least preference among the overall coastal region. These practices were location specific adaptation strategies. Therefore, these strategies got higher rank in their respective places/district but got least preference in overall.

Livestock rearers of coastal Odisha and West Bengal perceived changing climatic scenario and followed several coping mechanism to cope up with its negative impact of climate change. Among the coping mechanisms change in micro-climate in cattle shed/grazing area/stall and providing frequent clean and fresh drinking water were found to be most preferred adaptation strategies. Livestock rearers generally followed adaptation strategies against the heat stress as it had a direct effect on the livestock productivity of coastal region due to higher level of temperature and humidity during summer. Livestock rearers used to follow the cost effective adaption strategies. It was also found that all the adaptation strategies has a scientific basis. Reinvention of these adaptation strategies were also observed according to the local situation.

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