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Adaptive capacity to climate change among the *Chilika* buffalo rearers of Odisha

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ABSTRACT

Climate change combined with human activities poses significant risks to people's livelihood especially in developing countries. Adaptation at the community level is crucial in enabling them to respond to the direct and indirect effects of changes in climate. The present study was designed to assess the adaptive capacity of the *Chilika* buffalo rearers. So, the study was purposively conducted at the *Chilika* lake region of Odisha as it is the breeding tract of *Chilika* buffalo. A total 150 *Chilika* buffalo rearers were selected randomly from the cluster villages of the adjacent districts of *Chilika* lake. Sustainable Livelihood Approach (SLA) was used to develop *Adaptive Capacity Assessment Index* to measure the adaptive capacity of the *Chilika* buffalo rearers. They were having better physical capital (0.55) possession followed by social capital (0.48), financial capital (0.47), human capital (0.45) and natural capital (0.35). The average adaptive capacity of the *Chilika* buffalo rearers was found to be 0.46, which was quite unsatisfactory and majority of them (62.67%) were having a medium level of adaptive capacity to cope up with changing climatic scenario. Adaptive capacity of the *Chilika* buffalo rearers were having a strong and significant relationship with its every component. Therefore, to strengthen the adaptive capacity of the *Chilka* buffalo rearers, status of each and every capital has to be improved significantly.

Keywords: Adaptive capacity, *Chilika* buffalo rearers, Climate change, Odisha

Livestock farming contributes about 26% to the agricultural GDP and provides employment to about 20 million people, mostly in rural India. There is a substantial scientific literature examining the relationship between climatic parameters and animal productivity across the globe (NRC 1981). However, climate change is likely to be gradually a more difficult challenge to the growth of the livestock sector in India. The anticipated rise in temperature between 2.3°C and 4.8°C over the entire country together with increased precipitation (resulting from climate change) is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance (Sirohi and Michaelowa 2007).

Among the 17 registered buffalo breed in India, the *Chilika* buffalo breed has an exceptional capability of converting the saline biomass of the lake into the most precious milk and dung. These buffaloes transform the saline water vegetation into wholesome milk that provides income to the poor living in the rural area of Odisha without any investment. Although *Chilika* buffalo is low yielder of milk (2–6 litre/day) and taste is slightly salty than other breeds due to high salt content in animal's diet. In recent past, warming trend of mean maximum and minimum temperature (Fig. 1) especially in the hottest month was observed in *Chilika* lagoons region. Increased rate of tropical cyclone, flood, extremely heavy rainfall (Fig. 2), etc. was also observed in this region.

Therefore, extended periods of high air temperature coupled with high relative humidity compromise the ability of buffalo to dissipate excess body heat which affects feed intake, milk production, and reproductive efficiency and ultimately reducing profitability for of its rearers. Hence, climate change combined with human activities poses significant risks to people's livelihood and adaptation at the community level is of crucial importance in enabling them to respond to the direct and indirect effects of changes in climate. Therefore, the present study was formulated with an objective to appraise adaptive capacity of the *Chilika* buffalo rearers before developing customized adaptation planning for *Chilika* buffalo and its rearers to cope up with the climate change.

MATERIALS AND METHODS

The study was carried out in the purposively selected adjacent region of *Chilika* lagoon of Ganjam, Khurda and Puri district of Odisha as the *Chilika* buffalo is found in the nearby villages of *Chilika* lagoon. Therefore, from each district, two blocks which are adjacent to *Chilik*a lake were selected purposively. Thus, Khalikote and Rambha blocks were selected from Ganjam district; accordingly, Balugaon

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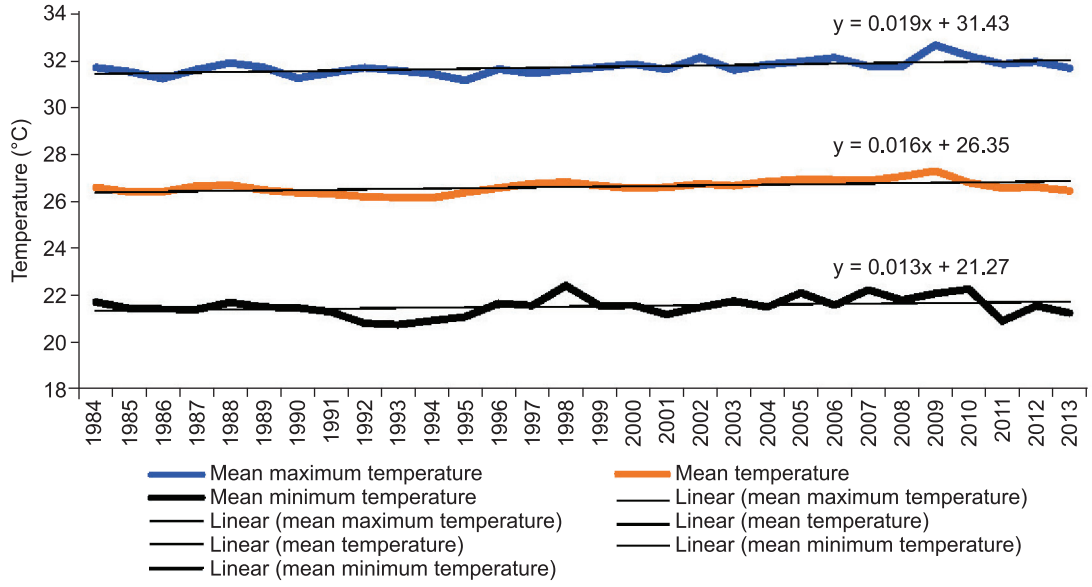

Fig. 1. Changing temperature at *Chilika* lagoon region of Odisha (*Source:* http://imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html).

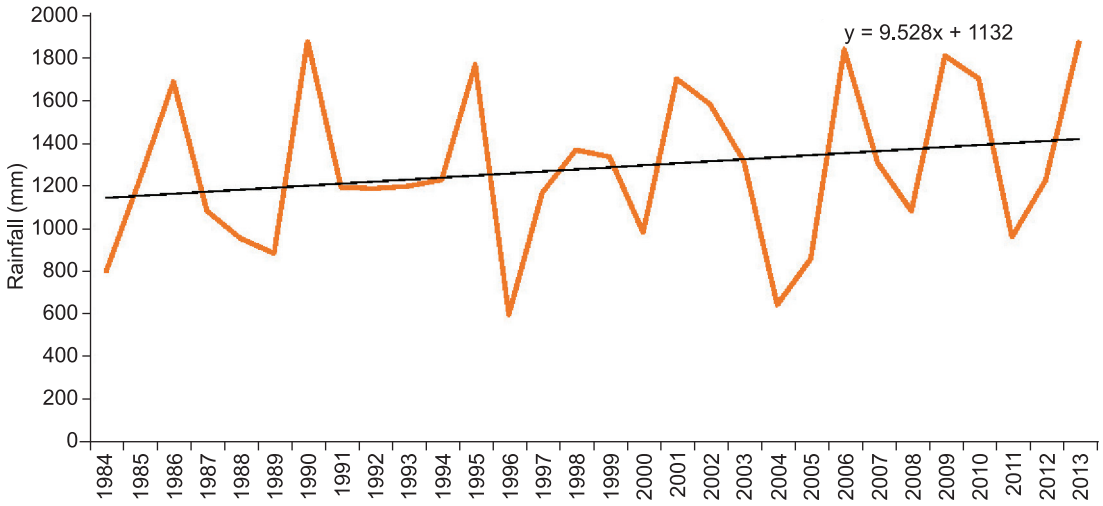

Fig. 2. Rainfall pattern at *Chilika* lagoon region of Odisha (*Source:* http://imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html).

and Tangi from Khurda district; Krushnuprasad and Brahmagiri from Puri district were selected. Hence, a total six blocks from three districts were covered under the present study. Further, a cluster of villages were selected from each block based on the availability of *Chilika* buffalo rearers. Thus, from each block, 3–4 villages, which are located near to *Chilika* lake and having good population of *Chilika* buffaloes were selected. A *Chilika* buffalo-rearer who had more than 30 years of experience of rearing this breed and having at least one *Chilika* buffalo was considered as respondent. Household head was considered as respondents for the present study. Subsequently, 25 respondents from each of the cluster of villages were selected, randomly. Thus, total sample size for the present study was 150.

Measurement of adaptive capacity: The concept of adaptive capacity is highly used in relation to the vulnerability of socioecological systems. The concept of 'adaptive capacity' and 'coping capacity' are respectively used to denote long-term and short-term adjustments (Smit and Wandel 2006). Intergovernmental Panel on Climate Change (IPCC) defined adaptive capacity in their most recent, i.e. 5th Assessment Report as the 'the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (IPCC 2014). An exclusively Adaptive Capacity Assessment Index (ACAI) was developed to assess the adaptive capacity of *Chilika* buffalo rearers to cope with the changing climatic scenario by using the following steps:

Selection of indicators: Sustainable Livelihood Approach (SLA) was used to execute the adaptive capacity of the

Chilika buffalo rearers. The sustainable livelihoods approach views livelihood outcomes as a function of the ownership or access to livelihood assets. This principle is based on Nobel Laureate Amartya Sen's entitlements approach, where households with sufficient range of entitlements, capabilities or assets have more choices of adopting strategies suitable to cope up during the periods of adversities or minimize the associated risks (Jakobsen 2011, Ludi and Slate 2008). McCarthy *et al.* (2001) further concluded that the adaptive capacity of a system is determined by an array of factors which are neither independent nor mutually exclusive but a result of a combination of these factors. Hence, in the present study, adaptive capacity was operationalized as the combined effect of five types of livelihood capital, viz. physical, human, natural, financial and social. A total 21 variables/ indicators were collected from the different published literatures and consultation with the subject matter specialists for calculating adaptive capacity of a household. These variables/indicators covered the livelihood capital, viz. Human capital (Age of the household head, Educational status of the household head, Family education status), Social capital (Social participation, Community participation, Community cohesiveness, Extension contact, Number of relative in the village or community, Assistance from external agency, Farmer to farmer extension), Physical capital (Herd size, Modern farm equipment used, Fodder source and availability, Land holding), Natural capital (Sources of climatic information, Distance to purchase critical inputs, Distance to sell farm output) and Financial capital (Annual income, Ratio of output from livestock to total income, Proportion of household expenditure to livestock, Availability of credit).

In the next step, suitability of the identified indicators need to be checked. Therefore, Principal Component Analysis (PCA) was applied to identify significant and non-significant indicators. Before running of PCA, all the indicators were normalized. PCA was applied on the normalized data for extraction and varimax method for rotation of factors by using SPSS 23 analytical software. For this study the cut-off of communality value was customized at 0.45 to test the suitability of the identified indicators. Since, all the communality values of the data set were above 0.45, then, not a single indicator was dropped from factor analysis model for further analysis. Hence, all the identified indicators were found to be suitable to appraise adaptive capacity of the *Chilika* buffalo rearers to cope up with the climate change. The data set were used for further calculation to assign weight to each indicators.

Assignment of weight to the indicators: Again PCA was run to obtain factor loading and eigen values. Components were identified, those were having eigen values greater than 1. According to the number of eigen values greater than 1, the same number of components were extracted by using varimax rotational method for each indicator. Then, method followed by Feroze and Chouhan (2010) adopted for this study to assign the weights to the indicators.

Calculation of Adaptive capacity index: Finally, Adaptive Capacity Assessment Index (ACAI) was calculated by using the following formula.

$$ACAI = \Sigma HAI + \Sigma SAI + \Sigma P\&NAI + \Sigma FAI \quad \text{... (i)}$$

where, HAI, Human Asset Index; SAI, Social Asset Index; P&NA, Physical and Natural Asset Index; FAI, Financial Asset Index.

Final index value was calculated as 0 to 1 by using the following formula to understand the relative position of the sampled households:

$$ACAI_I = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad \text{... (ii)}$$

where, $ACAI_I$, Normalized Adaptive Capacity Assessment Index value of the i^{th} household; X_i, Adaptive Capacity Assessment Index value of the i^{th} household; X_{min}, Minimum Adaptive Capacity Assessment Index value among the sampled of household; X_{max}, Maximum Adaptive Capacity Assessment Index value among the sampled of household.

RESULTS AND DISCUSSION

Age is concerned to highlight respondents' maturity with regard to his/her experience in livestock rearing as well as changing climatic scenario. Table 1 clearly indicates that average age of the *Chilika* buffalo rearers was 54.25 years. A *Chilika* buffalo rearer having at least 30 years of experience in livestock rearing was considered as the respondent for the study. Therefore, average age of the *Chilika* buffalo rearers was high in the present study. On an average, family member of the *Chilika* buffalo rearers were having formal education up to sixth standard (Table 1).

Family education status is an important component in decision making on any aspect of family including farming as well as livestock rearing. But, poor family educational status among the *Chilika* buffalo rearers may be cause of poor adaptation towards changing climatic scenario. The same table also depicts that the average score for the social participation of the *Chilika* buffalo rearers was 2.17 with a standard deviation of 1.20. They were having the membership of the farmers' club, and self-help groups. The maximum possible score for the social participation was 7. Therefore, it may be concluded that the *Chilika* buffalo rearers were having a lower level of social participation. Table 1 also depicts the average score for the community participation of the respondents was 2.15 of a maximum possible score of 3. Hence, it may be concluded that respondents were having good community participation. The same table also depicts the existence of strong community cohesiveness among the *Chilika* buffalo rearers which further contributed to their adaptive capacity. Extension contact was referred to both acquaintance and frequency of respondent's contact with expert, stockman, VLW, ADO, BDO, bank officials etc. Table 1 also depicts the average score for extension contact for the respondents

Table 1. A glimpse of socio-economic profile of the *Chilika* buffalo rearers (n=150)

Variable	Mean	SD
Age of the respondents (Years)	54.25	6.75
Family educational status	6.00	1.08
Social participation (0–7)	2.17	1.20
Community participation (0–3)	2.15	0.70
Community cohesiveness (0–7)	5.70	0.95
Extension contact (0–30)	5.70	2.08
Herd size (*Chillika* buffalo)	22.91	13.65
Land holding (ha)	1.30	0.91
Annual family income (lakhs)	1.88	0.74
Ratio of income from livestock to family income	0.61	0.21
Milk production (kg) per day per animal	1.87	0.12

Values in parenthesis indicate possible range of score.

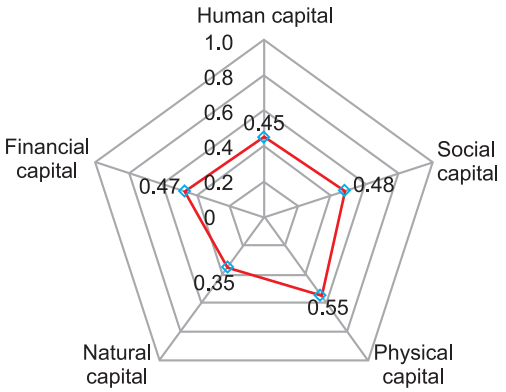

Fig. 3. Average index score of the components of adaptive capacity of the Chilika buffalo rearers of Odisha.

was 5.70 which represented a poor extension contact. *Chilika* buffalo rearers were having a large herd size of 23 *Chilika* buffaloes, but, they were having very small size of operational land holding of 1.3 hectare. The *Chilika* buffalo were marginal and small farmers. Therefore, they concentrated on livestock rearing for their livelihood. The average family income of the respondent was ₹1,87,600 with standard deviation of ₹74461.65. As most of the farmers' sole occupation was rearing of *Chilika* buffalo and *Chilika* buffaloes were having lower production potentiality. Only 61% of their family income used to come from the rearing of *Chilika* buffalo. Therefore, *Chilika* buffalo rearers depended on the other source of income for their livelihood.

Index score of the components of adaptive capacity of the Chilika buffalo rearers of Odisha: Sustainable Livelihood Approach (SLA), conceptualized by Ellis (2000) and DFID (1999) was used to execute the adaptive capacity of the *Chilika* buffalo rearers. The sustainable livelihoods approaches view livelihood outcomes as a function of the ownership or access to livelihood capitals. Hence, in the present study, adaptive capacity was operationalized as the combined effect 5 types of livelihood capital, viz. physical, human, natural, financial and social. The index value of each capital category as well as overall adaptive capacity was calculated and presented in Fig. 3. Index values ranged between 0 to 1. Values towards 1 indicated higher level of possession of that particular capital and vice-versa. Among these asset categories, *Chilika* buffalo rearers were having better physical capital possession followed by social capital, financial capital, human capital and natural capital. *Chilika* buffalo rearers were having an average herd size of 23 buffaloes and fodder were available abundantly for these herd from the *Chilika* lagoons. Therefore, possession of physical capital was comparatively higher than the other capitals. Maiti *et al.* (2014) studied the adaptive capacity of the livestock rearers of Ganjam and Bhadrak district of Odisha and reported that social asset was comparatively better performing asset of sustainable livelihood security followed by physical and natural asset, human asset and financial asset. The average adaptive capacity of the *Chilika* buffalo rearers was calculated as 0.46±0.01 which indicated lower to middle level of adaptive capacity.

Duncun's Multiple Range Test (DMRT) was applied for a comparative evaluation among the five capitals to identify the statistically significant best contributing capital towards adaptive capacity of the *Chilika* buffalo rearers. It is evident that possession of the physical capital (0.55±0.02) among the *Chilika* buffalo rearers was significantly ($p<0.05$) higher in comparison to the other capitals. But, possession of human capital, social capital and financial capital did not differ significantly ($p<0.05$) with each other. At the same time, possession of the natural capital (0.35±0.01) among the *Chilika* buffalo rearers were significantly ($p<0.05$) lower in comparison to the other capitals. Maiti *et al.* (2014) studied adaptive capacity of the livestock rearers of Ganjam and Bhadrak district of Odisha and found significant differentiation in each capital among the livestock rearers of Ganjam and Bhadrak district.

Relationship among the adaptive capacity and its components: Pearson correlation coefficients were calculated among the adaptive capacity and its components to understand their existing relationship with each other. Table 2 clearly depicts that adaptive capacity of the *Chilika* buffalo rearers were having a strong and significant ($p<0.01$) relationship with its every component. Therefore, it may be concluded that to strengthen the adaptive capacity of the *Chilika* buffalo rearers, status of each and every capitals has to be improved significantly. If any one of the capital category gets lesser importance during improvement process, then, it will directly reduce the adaptive capacity of the *Chilika* buffalo rearers. The study also revealed that highest correlation was observed between adaptive capacity and human capital followed by financial capital, natural capital, social capital and physical capital. Garai *et al.* (2019) studied the dairy-based sustainable livelihood security in West Bengal and reposted that economic parameters of the dairy production scenario were highly correlated with the sustainable livelihood security followed by social and infrastructural parameters. Whereas, Chand *et al.* (2011) concluded that sustainability of livestock-based livelihood can be improved by strengthening economic efficiency.

Differential level of adaptive capacity among the Chilika

Table 2. Correlation coefficient among adaptive capacity and its components (n= 150)

Component of adaptive capacity	Human capital	Social capital	Physical capital	Natural capital	Financial capital	Adaptive capacity
Human capital	1.00					
Social capital	0.16	1.00				
Physical capital	–0.07	–0.22**	1.00			
Natural capital	0.53**	0.23**	-0.29**	1.00		
Financial capital	0.19*	0.01	0.32**	0.07	1.00	
Adaptive capacity	0.67**	0.40**	0.37**	0.54**	0.63**	1.00

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

buffalo rearers: Chilika buffalo rearers were having differential level of adaptive capacity. Therefore, all the *Chilika* buffalo rearers were classified into five categories based on the equal intervals across the components as well as overall adaptive capacity. It was found that most of the respondents were in the medium category (index score ranged between 0.41 to 0.60) of human, social, physical and financial capital. But, 38.67% of the *Chilika* buffalo rearers were in the lower category of the natural capital. Majority of the respondents (62.67%) had medium level of adaptive capacity followed by 28.67% and 8.67% of them were having low and high level of adaptive capacity, respectively. None of the *Chilika* buffalo rearers had very low and very high level of adaptive capacity and the trend of the distribution of the respondents were towards medium to lower categories than the medium to very high categories. Hence, it may be concluded that possession of different capital as well as overall adaptive capacity of the *Chilika* buffalo rearers were medium to low. Hence, to cope with the changing climatic scenario, necessary efforts may be initiated at the earliest to improve their adaptive capacity.

Identification of the influential indicators of adaptive capacity: A total of 21 indicators were considered to calculate the adaptive capacity of the *Chilika* buffalo rearers and every indicator were having differential weightage towards adaptive capacity. Extracted communalities of each indicator are presented in Table 3 and it is found from the same table that communality value of each indicator was above the cut-off, i.e. 0.45. Hence, all the indicators were suitable to calculate adaptive capacity of the respondents. Importance of the suitable indicators was fixed according to their weightage score and indicator with higher weightage was the comparatively more influential indicator than the indicator with lower weightage.

Table 3 clearly depicts that annual family income (4.31) had the highest influence to overall adaptive capacity followed by ratio of income from livestock to family income (3.36), land holding (3.35) and distance of market to purchase inputs (3.33). It was also found from the same table that indicators of financial capital and natural capital were having comparatively higher weightage. Hence, it may be concluded that parameters of financial and natural capital were the influential indicators to improve adaptive capacity of the *Chilika* buffalo rearers to cope up with the changing climatic scenario.

The average adaptive capacity of the *Chilika* buffalo rearers was found to be 0.46, which is quite unsatisfactory and majority of the them (62.67%) were having a medium level of adaptive capacity to cope up with changing climatic scenario. Adaptive capacity of the *Chilika* buffalo rearers were having a strong and significant ($p<0.01$) relationship with its every components. To strengthen the adaptive capacity of the *Chilika* buffalo rearers, status of the each

Table 3. Influential indicators of adaptive capacity (n= 150)

Variable	1st Run of factor analysis		Weightage
	Communalities		
	Initials	Extraction	
Human capital			
Age of the respondents	1.00	0.75	3.00
Education of the respondents	1.00	0.66	3.15
Education of the family	1.00	0.69	2.02
Social capital			
Social participation	1.00	0.68	3.14
Community participation	1.00	0.54	2.65
Community cohesiveness	1.00	0.60	2.26
Relatives in village	1.00	0.51	2.34
Extension contact	1.00	0.46	2.83
Farmer to farmer contact	1.00	0.73	2.34
Assistance from external organisation	1.00	0.75	1.43
Physical capital			
Herd size	1.00	0.90	2.78
Farm equipment	1.00	0.62	1.94
Fodder resources	1.00	0.63	2.90
Natural capital			
Land holding	1.00	0.56	3.35
Availability of climate related information	1.00	0.47	2.48
Distance of market to purchase inputs	1.00	0.74	3.33
Distance of markets to sell outputs	1.00	0.74	3.24
Financial capital			
Annual family income	1.00	0.86	4.31
Ratio of income from livestock to family income	1.00	0.80	3.36
Credit availability	1.00	0.48	2.42
Expenditure on livestock	1.00	0.71	3.22

and every capital has to be improved significantly. It was also found that indicators of financial capital and natural capital were having comparatively higher weightage. Hence, it may be concluded that parameters of financial and natural capital were the influential indicators to improve adaptive capacity of the *Chilika* buffalo rearers to cope up with the changing climatic scenario.

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