



## Factors influencing adaptation strategies by livestock owners to combat climate variability in Karnataka state: Application of ordered logistic regression model

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Received: 12 December 2015; Accepted: 24 February 2016

### ABSTRACT

Climate variability refers to the way climate fluctuates yearly above or below a long-term average value. It is considered as one of the most serious long-term challenges faced by livestock rearers, in this context it is important to know about the adaptation strategies followed by the livestock rearers in combating the climate variability vagaries. The present study was conducted in purposively selected northern dry zone of Karnataka with 120 livestock rearers, the major findings of the study were: Majority of the respondents were following adaptation strategies like keeping, promoting and interested in local breeds (60.83%), about 42.50% of livestock rearers made changes in micro-climate in cattle shed/stall, and 47.50% of respondents were providing extra concentrate, minerals supplementation and feed additives to their livestock, etc. An ordered logit model is estimated to investigate the factors influencing adoption of various strategies to combat climate variability. Among the adaptation strategies, the proportional odds assumption was satisfied only for keeping, promoting and interest in local breeds; change in micro-climate in cattle shed /stall and shifting from large ruminants to small ruminants were found significant with the herd size; land holding and education level of the respondents and for other variables the ordinal regression was not performed. It was also found that livestock rearers followed the cost effective adaption strategies, and all the adaptation techniques were region-specific, requiring no external help and were inherently scientific.

**Key words:** Adaptation, Climate variability, Livestock, Logistic regression

The climate variability is increasingly becoming an important consideration of our lives. Climate variability refers to the way climate fluctuates yearly above or below a long-term average value. The IPCC (2007) predicted that by the year 2100, increase in global average surface temperature may be between 1.8 and 4.0°C, with global average temperature increasing by 1.5–2.5°C. Approximately, 20–30 % of plant and animal species are expected to be at risk of extinction (FAO 2007).

Livestock sector has the potential to act as an instrument to bring about socio-economic transformation. Small and marginal farmers and landless laborers derive substantial part of their livelihood from sale of milk and own about 70% of cattle in rural areas (Upadhyay *et al.* 2009). Increasing climatic variability in recent times poses significant potential risk to the livestock sector, which attracts serious attention towards efforts at mitigation of adverse effect of climate changes. In recent times, climate

variability is considered as one of the most serious long-term challenges faced by the livestock rearers (Maiti *et al.* 2014).

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 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). Different adaptation strategies were talked about 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 households with/without any housing system and based upon 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

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up with climate change. In view of the above context, the present study was conceptualized with the objective of ascertaining the adaptation strategies followed by the livestock rearers to combat climate variability in northern dry zone of Karnataka. It is expected that these findings would help in skillful implementation of documented strategies, which would ultimately help to reduce vulnerability of the rural poor and enhance their socio-economic status and overall quality of life.

#### MATERIALS AND METHODS

The study was conducted in northern dry zone area, which was purposively selected because this zone is most frequently exposed to climate variability (MoEF 2005). Nearly 70% of the area in this region falls under dry land farming. Raichur and Bellary districts coming under this dry zone were selected purposively for the study, as these districts hold the largest livestock population in the region. From each district, 2 taluks were selected randomly. In the next step, 2 villages were selected from each taluk, randomly. From each selected village, 15 livestock rearers were selected randomly. Thus, total 120 livestock rearers spread over in 8 villages of Manvi, Raichur, Huvinahadagli and Bellary taluks constituted the ultimate sample for the study.

Adaptation refers to initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects (IPCC 2007). Adaptation strategies were operationalized as the measures adopted and/or followed by the livestock rearers to cope up with the adverse impact of climate change on livestock rearing and/or their livelihood for sustainable livestock productivity and/or sustainability. The respondents were 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 3 point continuum, viz. continued the adoption, discontinued the adoption and never adopted with the score of 2, 1 and 0 on a prelisted adaptation strategies.

Based on review of literature and consultation with experts, 10 socio-economic variables were considered for the study, viz. age, education, family size, family income, herd size, land holding, experience dairying, organizational participation, mass media exposure and training undergone. Among these socio-economic variables except education and training undergone, all were categorized based on mean  $\pm$  standard deviation (SD).

*Ordered logistic regression:* The ordinal logistic model considers a set of dichotomies, one for each possible cut of the response categories into 2 sets, of high and low responses, this is meaningful only if the categories of Y do have an ordering. In our example, these cut-offs are strongly disagree vs. (disagree, agree, or strongly agree), i.e. SD vs. (D, A, or SA) but whereas multinomial logistic regression having n number of observations and possible cut of the response categories is more than two sets. In the present

study, ordinal logistic model were employed because the cut-off of are adoption continued vs. adoption discontinued or never adopted.

An ordered logit model is estimated to investigate the factors influencing adoption of various strategies to combat climate variability. In this model, adoption was measured on a 3-point continuum, viz. continued adoption (score of 2), adopted but discontinued (score of 1) and non-adoption (score of 0) to generate the dependent variable. Since adoption is an ordinal variable, the ordered logit model was used to identify the factors (independent variables) like age, landholding, education, family size, annual income, experience in dairy farming, herd size, knowledge of farmers about climate variability and the perception of farmers of towards climate variability. Separate ordered logit models were developed for each adaption strategy. At the beginning, the linearity assumption was tested using the Ad-Hoc method of testing curvilinearity (Osborne 2015). In this method, the squared and cubed terms of independent variables are added to the logistic model and tested to see if there are any curvilinear relationships. If squared variable is significant, it indicates quadratic distribution, while significant cubed term shows a cubic distribution. All the analyses were made using statistical software SPSS (Version 17 for Windows).

#### RESULTS AND DISCUSSION

*Socio-economic profile of dairy farmers:* A large number of livestock rearers (Table 1) in the study area were middle aged (52.50%). Highest proportion of the respondents had no formal education (36% illiterate, 1.67% functionally literate). Most of the respondents were having low level of social participation. Most of the respondents (42%) were marginal landholders followed by small holders (28%). Forty five per cent of the herd sizes were medium (5–7 heads of dairy animals) while 22% of the households owned large herd sizes (more than 7 heads of cattle and buffaloes). For majority of the households, annual family income was between INR 50,000 to 1 lakh, whereas 25% of dairy farmers had low income (less than INR 50,000). Majority of dairy farmers in the study area had high level of mass media exposure (43%) but low degree of social participation (47%). Vast proportion (69%) of the respondents had 10–20 years of experience in dairying. The findings of Nataraju (2012) supported the present results. Whereas, the findings of Gour (2002) and Arora *et al.* (2006) were contradictory.

The respondents reported a diversity of coping strategies that included both modern and traditional methods. Majority of the respondents (Table 2) followed adaptation strategies like keeping and interested in local breeds (60.83%), which were well adapted to native climatic conditions. Farmers perceived that local breeds require less water, are resistant to many diseases and survive well in adverse climatic condition; about 42.50% of dairy farmers made changes in micro-climate in cattle shed/stall in such a way that animals can live without stress, for example planting a tree in the mid of shed for providing shade and proper ventilation in a

cattle shed. About 32% of the respondents had adopted strategies like 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 is also high. Therefore, livestock rearers of coastal region used to feed their animal in the late afternoon and in the early morning. Extra concentrate minerals supplementation and feed additives to livestock was adopted by 47.5 % of the

Table 1. Socio-economic profile of dairy farmers

Characteristics	Frequency	Per cent
<i>Age (years)</i>		
Young (< 35 years)	26	21.67
Middle (36 to 50 years)	63	52.50
Old (> 50 years)	31	25.83
<i>Education</i>		
Illiterate	43	35.83
Functionally literate	22	18.33
Primary school	12	10.00
Middle school	8	6.67
Secondary school	16	13.33
Higher secondary (PUC)	17	14.17
Graduation and above	2	1.67
<i>Family size(Nos)</i>		
Small (<4 members)	14	11.67
Medium (5 to 8 members)	80	66.67
Large (> 8 members)	26	21.66
<i>Family income (₹)</i>		
Low (<1 50,000)	30	25.00
Medium (1 50,001– 100,000)	72	60.00
High (>1 100,000)	18	15.00
<i>Herd size (Nos)</i>		
Small (< 4)	40	33.33
Medium (5–7)	54	45.00
Large (> 7)	26	21.67
<i>Land holding</i>		
Landless (0 acres)	10	8.33
Marginal (< 2.5 acres)	50	41.67
Small (2.5 to 5 acres)	34	28.33
Medium (5 to 10 acres)	20	16.67
Large (> 10 acres)	6	5.00
<i>Experience in dairying</i>		
Less (< 10 years)	20	16.67
Moderate (10 to 20 years)	83	69.17
More (> 20 years)	17	14.17
<i>Mass media exposure</i>		
Low (< 9.52)	35	29.16
Medium (9.52–12.67)	33	27.50
High (> 12.67)	52	43.34
<i>Social participation</i>		
Low (< 2.04)	56	46.66
Medium (2.04–4.40)	36	30.00
High (4.40)	28	23.34
<i>Training undergone</i>		
Attended	24	20.00
Not attended	96	80.00

Table 2. Distribution of respondents (120) based on their adaptation practices followed in dairying

Adaptation strategies	AC	AD	NA
Keeping and interested in local breeds	72(60.83)	22(26.4)	6(7.20)
Providing extra concentrate, minerals supplementation and feed additives to livestock	48(47.50)	29(34.8)	23(27.60)
Change in feeding schedule to farm animals	37(30.83)	25(30.00)	38(45.6)
Change in micro-climate in cattle shed/stall	51(42.50)	30(36.00)	19(22.8)
Shifting from large ruminants to small ruminants	53(44.17)	26(31.20)	21(25.2)
Reduction in herd size	46(38.33)	21(25.20)	33(39.6)
Plantation of fodder trees around animal shed/ house to reduce effects of cold and heat waves	26(21.67)	26(31.20)	48(57.6)
Seasonal migration along with livestock	17(14.17)	26(31.20)	57(68.4)
Providing bedding material for livestock during extreme winter/ cold conditions	95(79.17)	5(6.00)	0(0.00)

AC, adoption continued; AD, adoption discontinued; NA, never adopted.

households. Nearly 45% of the farmers reported that they had shifted from large ruminants to small ruminants. The reason being that loss of large animals (cattle/buffalo) made farmers more vulnerable on account of their much higher value and loss of such animals from adverse climatic event entailed a bigger shock to their livelihood. This risk of huge monetary loss was minimized if they reared small ruminants. Therefore, to minimize the risk of huge monetary loss they shifted to small ruminants besides this gave them relief from fodder scarcity.

Majority of respondents (79.17%) told that they provide bedding for livestock during extreme winter/cold to prevent them from cold stress. For bedding material they used paddy straw, cob husk and other field wastes, which cost nothing but prevents cold stress. Only 22% of the respondents reported that they have adopted plantation of fodder tree lines around animal shed/house to reduce effects of cold/heat waves as an important coping strategy. Migration along with livestock was one of the coping strategies for only 14% of the farmers. During adverse climatic conditions, the farmers migrate towards the southern Karnataka region in search of fodder sources and again after peak summer they turn back to their original places. Dairy farmers those who did not migrate to the cities were engaged in different works to earn livelihood for their family members.

#### Ordered logistic regression

While running the ordinal regression, the proportional

odds assumption was tested using parallel lines test. The assumption is that the effects of any independent/explanatory variables are consistent (proportional) across the different thresholds i.e. the splits between each pair of categories of ordinal outcome variable. If the test is statistically not significant, we can proceed with ordinal regression. Among the adaptation strategies, only the proportional odds assumption was satisfied only for keeping and interested in local breeds ( $\chi^2= 15.38$ ;  $P=0.015$ ); change in micro-climate in cattle shed /stall ( $\chi^2= 18.73$ ;  $P=0.058$ ); and shifting from small ruminants to large ruminants ( $\chi^2= 14.35$ ;  $P=0.158$ ) for other variables, the ordinal regression was not performed.

*Keeping and interest in local breeds:* The ordered logit produced a likelihood ratio chi-square of 15.98 with a  $P<0.01$ , indicating significant fit of the ordinal model (Table 3).

Table 3. Estimated coefficients for keeping and interested in local breeds

Variable	Estimate	Std. error	Wald	Sig.	95% confidence interval	
					Lower bound	Upper bound
Age	-.002	.014	.167	.683	-.022	.034
Land holding	.024	.045	1.600	.206	-1.159	.78
Family size	-.022	.048	.258	.611	-.069	.118
Income	.000	.0058	.238	.625	-7.673E-6	1.276E-5
Experience	.012	.015	.016	.898	-.027	.031
Herd size (Both large and small ruminants)	.030	.100	3.459	.009**	-.321	.069
Perception	-.941	.028	.206	.650	-.069	.043
Education	.016	.104	4.073	.050*	-1.339	.570
Training	.503	.417	.929	.335	-.415	1.219

Significant at \*\*1% and \*5% levels of significance.

Among all variables, only education ( $P<0.05$ ) and herd size had significant effect ( $P=0.098$ ) on the farmers' interest towards local breeds. It implies that the farmers' likelihood of adopting this strategy increases with increase in education level and herd size. The reason may be that an educated farmer is aware of the vulnerability of crossbreed animals to diseases and to the changing climate, hence they are rearing indigenous breeds to withstand against vagaries of climate variability. Besides rearing of crossbreeds involves huge expenditure from purchasing of animals to feeding and health management. Hence, farmers with good herd size are rearing indigenous breeds.

*Change in micro-climate in cattle shed/stall:* The regression analysis indicated that the likelihood ratio chi-square of 18.73 with a P-value ( $< 0.05$ ) indicated that the ordinal model fits significantly better than an empty model (i.e. a model with no predictors). The estimated coefficients are displayed in Table 4.

Table 4. Estimated coefficients for change in micro-climate in cattle shed/stall

Variable	Estimate	Std. error	Wald	Sig.	95% confidence interval	
					Lower bound	Upper bound
Age	-.002	.014	.024	.877	-.030	.026
Land holding	-.024	.036	5.541	.007**	-.046	.095
Family size	.022	.049	.197	.657	-.117	.074
Income	.000	.000	.213	.644	.000	.000
Experience	.012	.015	.576	.448	-.018	.041
Herd size (Both large and small ruminants)	.030	.097	3.729	.051*	-.160	.220
Perception	.941	.028	.024	.050	-.77	.150
Education	-.016	.103	4.956	.018*	-.186	.217
Training	.503	.416	1.466	.226	-.311	1.318

Significant at \*\* 1%, and \*5% level of significance.

Among all variables, only land holding size ( $P<0.01$ ), herd size ( $P<0.05$ ) and education ( $P<0.05$ ) had significant effects on the farmers' effort towards change in micro climate in cattle shed/ stall. The signs of regression coefficients indicated positive influence of the variable herd size while the variables landholding and education level exerted negative influence, indicating a reverse effect on adopting change in micro-climate strategy. Educated and land holder respondents are having alternative source for their livelihood. But farmers with less land and poorly educated are adopting change in micro-climate strategy under adverse climate. Since livestock forms a significant part of their livelihood, their care under adverse condition is justifiable.

Table 5. Estimated coefficients for shifting from large ruminants to small ruminants

Variable	Estimate	Std. error	Wald	Sig.	95% confidence interval	
					Lower bound	Upper bound
Age	-.032	.011	.024	.877	-.030	.024
Land holding	.021	.032	.453	.498	-.046	.095
Family size	-.022	.049	.193	.657	-.117	.074
Income	.000	.000	.213	.644	.000	.000
Experience	.013	.025	.476	.458	-.018	.041
Herd size (Both large and small ruminants)	.030	.097	4.450	.006**	-.160	.220
Perception	-.941	.028	.024	.053	-.770	.150
Education	.015	.103	4.953	.015**	-.186	.217
Training	.502	.415	1.364	.326	-.311	1.278

Significant at \*\*1% and \*5% level of significance.

*Shifting from large ruminants to small ruminants:* Among all variables, only herd size ( $P < 0.01$ ) and education ( $P < 0.05$ ) had significant effects in shifting from large ruminants to small ruminants (Table 5). Both the variables had positive coefficients indicating that farmers with larger herd size and higher degree of education are more inclined to shift from large ruminants to small ruminants to cope against adverse climate. The reason being that educated respondents know or are aware of the loss of crossbreed animals or in general large ruminants in adverse climatic condition. So they are shifting from large ruminants to small ruminants. Household with large herd size were facing shortage of feed and fodder, and they also stated that large ruminants are more prone to diseases and climate vagaries. Therefore, to minimize the risk of huge monetary losses and to get relief from fodder scarcity, they adopted rearing of small ruminant like sheep and goat.

Livestock rearers of Karnataka perceived changing climatic scenario and followed several adaptation mechanisms to cope up with its negative impact of climate variability. Through ordered logistic regression model adaptation strategies like keeping promoting and interested in local breeds, change in micro-climate in cattle shed / stall and shifting from large ruminants to small ruminants were found significant with land holding education and herd size, etc. Livestock rearers used to follow the cost effective adaptation strategies. It was also found that all the adaptation techniques are local specific, require no external help and are inherently scientific. Documentation and validation of such practices and techniques should be done and it can be used for further capacity building programmes.

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