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CLIMATE CHANGE, LIVESTOCK PRODUCTION AND INCOME VULNERABILITY- BANGLADESH PERSPECTIVE

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ABSTRACT: *Climate change has a direct effect on overall livestock sector and as a result has an indirect effect on livestock rearing farmers. However, the study was conducted considering specific objectives: i) to determine the socioeconomic profile of the respondent farmers; ii) to depict the present livestock scenarios; iii) to study the climate change scenario in areas and iv) to delineate the effects of climate change on income vulnerability status of the respondents. Four districts namely Barguna, Bhola, Lalmanirhat and Kurigram of Bangladesh were selected on the basis of frequency of climate change events. Taltoli and Charfashion Upazilas were more prone to natural catastrophic of cyclone and tidal surge; and Lalmanirhat and Bhurungamari Upazilas were severely vulnerable of flood and draught. Simple random sampling method was used to collect primary data with a structured questionnaire. Total sample size was 300. Both tabular and statistical techniques were used to analyse the data. Descriptive statistics such as frequency, average, percentage, ratios were also estimated and STATA software was used to analyse the vulnerability status. The study found that 77% farmers were in age group 50 to 65 followed by 20%, 66 to 80 and 3% above 80 years old. 77% farmers had agriculture as their primary occupation followed by 15% business and 8% service. Average family size was found 5.56 which were higher than the national average 4.9 (HIES 2014) and farm size indicates small farm category which was 1.1 hectare. On average, farmers had 41 years of farming experience. Among the sampled farmers, 81% of the respondents opined that major livestock species were reducing over the last three decades. Livestock population was reducing over the years and 56% respondents stated this scenario. On the other hand, livestock rearing cost was increasing alarmingly and it was found 4.45 times compared to three decades ago. The study found a scenario of major livestock population which indicated that livestock population per household was declining over the decades. Among the studied farm household 93% and 84% were found vulnerable at present and 30 years ago, respectively. At present and 30 years ago, average vulnerability was estimated 0.93 and 0.85, respectively. Heat stroke, repeat breeding and less conception rate fall livestock production into jeopardized condition. In conclusion, we can say that to give more attention to our native genetic resource potentialities and it would be wise to adopt new technologies and to adapt with predictable and unpredictable climate change for sustainable and profitable livestock enterprise in future.*

KEYWORDS: Climate Change, Income Vulnerability, Livestock Population, Livestock Production, Diseases, Livestock Rearing Farmers

INTRODUCTION

Intergovernmental Panel on Climate Change (IPCC, 2007) identifies Bangladesh as one of the smallest countries in the world that has been experiencing severe vulnerability to the issues related to climate change. Changes in climate and extreme weather events have received increased attention in the recent years. Changing temperature and weather pattern have great influence on increasing magnitude of climate change impacts (Kimaro and Chibinga, 2013). The climate change would affect particularly the economics of the rural areas where people are more dependent on livestock, fisheries and agriculture related activities for their livelihoods (IFAD, 2009). Livestock play a vital role in the agriculture sector in developing nations, and about 12% agricultural GDP comes from the livestock sector and 10 million people are directly involved to this livestock sector for their livelihood (Karim *et al*., 2010). Global demand for foods of animal origin is growing and it is apparent that the livestock sector will need to expand (FAO, 2009). They are adversely affected by the detrimental effects of extreme weather condition. Climatic extremes and seasonal fluctuations in herbage quantity and quality will affect the well-being of livestock, and will lead to declines in production and reproduction efficiency (Sejian, 2013). It is a major threat to the sustainability of livestock systems globally. Consequently, adaptation to, and mitigation of the detrimental effects of extreme climates has played a major role in combating the climatic impact on livestock (Sejian *et al*., 2015a). Global warming is affecting agribusiness in its economic aspects. It has complex impacts on domestic animal production system affecting feed supply, challenging thermoregulatory mechanism resulting thermal stress, emerging new diseases due to change in epidemiology of diseases and causing many other indirect impacts. Animals exposed to heat stress reduce feed intake and increase water intake, and there are changes in the endocrine status which in turn increase the maintenance requirements leading to reduced performance (Gaughan and Cawsell-Smith, 2015). Environmental stressors reduce body weight, average daily gain and body condition of livestock. Declines in the milk yield are pronounced and milk quality is affected. It also negatively influences on growth, reproduction performance, milk production, wool production, animal health and welfare (Walter *et al.,* 2010). There are many rapidly emerging diseases that continue to spread over large areas. Outbreaks of diseases such as foot and mouth disease or avian influenza affect very large numbers of animals and contribute to further degradation of the environment and surrounding communities' health and livelihood. Climate change has a direct effect on overall livestock sector and as a result has an indirect effect on livestock rearing farmers. Ultimately climate change is affecting negatively the livelihood of farmers who rear various species of livestock. But research in this arena is very limited. So, the proposed study was given attention to determine the socioeconomic profile, farmers' perception towards climatic effect on livestock production and income vulnerability which have vast negative effects on livestock production and provide some policy recommendations for the betterment of sustainable livestock production. It was also given emphasis to find out the present livestock population scenario of the climate change affected livestock farmers.

Objectives of the Study:

i. To assess the farmers' socioeconomic profile in the study areas;
ii. To delineate the livestock population scenario at household level;
iii. To study the climatic change scenario in the study areas; and
iv. To assess the effects of climate change on vulnerability status of the respondents.

METHODOLOGY

Study areas were selected purposively on the basis of frequent climate change events from four districts namely Taltali under Barguna, Charfashion under Bhola, Patgram under Lalmanirhat and Bhurungamari under Kurigram district of Bangladesh. Simple random sampling technique was followed for selecting the respondent farmers. Samples were consisted of 75 livestock farmers from each Upazila and total sample size was 300. Field survey method was followed to collect primary data from November/2016 to February/2017. Data were collected from respondents by using structured interview schedule and conducting FGD (Focus Group Discussion) for group information. The structured interview schedules were developed and field-tested for necessary modifications before starting data collection. Data were collected through direct interviews making personal visits to the house of selected farmers. Secondary data and information were also collected and discuss for this research from different handouts, reports, publications, notifications, etc. Combinations of descriptive, statistical and mathematical techniques were applied to achieve the objectives.

Measurement of Vulnerability

The vulnerability to poverty was measured that was proposed by Chaudhuri (2003), Chaudhuri *et al.* (2002) and Suryahadi and Sumarto (2003), developed particularly for cross-section data. Vulnerability, in this context, is define as expected poverty, or in other words as the probability that a household's consumption will lie below the predetermined poverty line in the near future. Following Chaudhuri (2003), for a given household *h*, the vulnerability was defined as the probability of its consumption being below poverty line at time *t*+1:

$V_{ht} = \Pr (ln\ c_{h,t+1} < ln\underline{c})$

Where V_{ht} is vulnerability of household *h* at time *t*, $c_{h,t+1}$denotes the consumption of household *h* at time *t+1* and $\underline{c}$ stands for the poverty line of household consumption.

Assuming that for household *h*, the data generation process for consumption was captured by the following equation:

$$ln c_h = X_h \beta + \varepsilon_h \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where c_h stands for per capita consumption expenditure for household, X_h represents a vector of observable household characteristics (containing both idiosyncratic and community elements), β is a vector of parameters, and ε_h is a mean-zere disturbance term that captures household's idiosyncratic factors (shocks) contributing to differential level of per capita consumption for households that share the same characteristics.

Consumption expenditures, c_h was assumed log-normally distributed and as such the disturbance term, ε_h was distributed normally. The vulnerability to poverty of household, *h* with characteristics X_h can be calculated using the coefficient estimates of the equation (1) in the following manner:

$$\hat{v_h} = \hat{p}r\ (\ln c_h < \ln\underline{c} \mid X_h) = \Phi\ (\frac{\ln \underline{c} - Xh\hat{\beta}}{\hat{\sigma}}) \quad \ldots\ldots\ldots\ldots (2)$$

Where $\hat{V}_h$ denote vulnerability to poverty, that is the probability that the per capita consumption level (c_h) was lower than the poverty line ($\underline{c}$) conditional on household

characteristics X_h. Meanwhile, Φ(.) denotes the cumulative density of the standard normal distribution and is the standard error of the equation (1).

Households future consumption is further assumed to be dependent upon uncertainty about some idiosyncratic and community characteristics. To get consistent estimate of parameters, it is necessary to allow heteroskadastisity, that is, variances of the disturbance term to vary. This can take the following functional form:

σ_e^2,h= Zhθ= $\sum_i\sum_{j\geq i} X_h^i X_h^j \theta_{ij} + \eta_h$…….....(3)

A three step Feasible Generalized Least Squares (FGLS) procedure was used to estimate the parameter θ. Equation (1) was estimated first using an ordinary least squares (OLS) produce. Then the estimated residuals from the equation (1) was used to estimate the following equation, again by OLS:

$\hat{e}^2_{OLS,h}$ = Zhθ + η_h = $\sum_i\sum_{j\geq i} X_h^i X_h^j \theta_{ij}$ + η_h..... (4)

The estimate from above is then used to transform the equation (4) into the following:

$\frac{\hat{e}^2_{OLS,h}}{Zh\theta OLS}$ = $(\frac{\text{Zh}}{Zh\theta OLS})\,\theta + \frac{\eta h}{Zh\theta OLS}$.....(5)

This transformed equation has estimated using OLS to obtain an asymptotically efficient FGLS estimate $\hat{\theta}$FGLS. Zh$\hat{\theta}$FGLS is a consistent estimate of σ_e^2,h which is the variance of the idiosyncratic component of household consumption. This is then used to transform the equation (1) into:

$\frac{lnch}{\sqrt{\text{Zh}\hat{\theta}\ FGLS}} = (\frac{Xh}{\sqrt{\text{Zh}\hat{\theta}\ FGLS}})\,\beta + \frac{eh}{\sqrt{\text{Zh}\hat{\theta}\ FGLS}}$ ..... (6)

OLS estimation of the equation (6) yields a consistent and asymptotically efficient estimate of β. The standard error of the estimated coefficient, $\hat{\beta}$ FGLS can be obtained by dividing the reported standard error by the standard error of the regression. Finally, the estimates of β and θ obtained through this FGLS method can be used to estimate the vulnerability to poverty of household *h* through the following generalization of the equation (2):

$\hat{V_h}$ = Φ $(\frac{ln\underline{c} - \text{Xh}\beta}{\sqrt{\sum i\sum j\geq i X_h^i X_h^j \theta ij}})$..... (7)

Clearly, estimation of vulnerability to poverty depends on the following elements: the distributional assumption of normality of log consumption, the choice of poverty line $\underline{c}$, the expected level of log consumption and the expected variability of log consumption. The higher the level of expected consumption and expected consumption variability the lower the vulnerability is.

RESULTS

Farmers' Socioeconomic Profile

Study found that 77% farmers were in age group 50 to 65 followed by 20%, 66 to 80 and 3% above 80 years old indicating that farmer were well aware of the socioeconomic, climatic and sociopolitical scenario of the respective regions. 77% farmers had agriculture as their primary occupation followed by 15% business and 8% service meaning that household prime income source was agriculture. In case of education, 38% farmers had primary education followed by 35% SSC, 17% illiterate, 6% HSC and 4% above degree. Average family size was found 5.56 which were higher than the national average 4.9 (HIES 2014) and farm size indicates small farm category which was 1.1 hectare. Duration of living in same village was calculated 50% above 50 years followed by 44% from 31 to 50 years and only 6% up to 30 years. On average, farmers had 41 years of farming experience (Table 1).

Table 1. Farmers' socioeconomic profile

Particulars	Lalmonirhat	Kurigram	Bhola	Borguna	Average
From 50 to 65 (Age)	65 (87)	57 (76)	58 (77)	51 (68)	57.75 (77)
From 66 to 80 (Age)	6 (8)	16 (21)	15 (20)	22 (29)	14.75 (20)
Above 80 (Age)	4 (5)	2 (3)	2 (3)	2 (3)	2.5 (3)
Occupation (%)					
Agriculture	63 (84)	55 (73)	56 (75)	58 (77)	58 (77)
Business	10 (13)	16 (21)	9 (12)	11 (15)	11.5 (15)
Service	2 (4)	4 (5)	10 (13)	6 (8)	5.5 (7)
Education (%)					
Illiterate	31 (41)	20 (27)	0	0	12.75 (17)
Primary	22 (29)	37 (49)	32 (43)	26 (35)	29.25 (38)
SSC	17 (23)	23 (31)	30 (40)	39 (52)	27.25 (35)
HSC	2 (3)	3 (4)	7 (9)	6 (8)	4.5 (6)
Degree & above	3 (4)	1 (1)	4 (5)	4 (5)	3 (4)
Family size (No/HH)	6.04	5.44	5.8	4.96	5.56
Dependent member (No/HH)	1.53	.95	3.13	0.36	1.49
Working member (No/HH)	4.51	4.49	2.67	1.6	4.06
Dependency Ratio	0.34	0.21	1.17	0.08	0.37
Living (Year)					
Up to 30	3 (4)	3 (4)	8 (11)	4 (5)	4.5 (6)
31 to 50	27 (36)	19 (25)	37 (49)	50 (67)	33.25 (44)
Above 50	45 (60)	53 (71)	21 (28)	30 (40)	37.25 (50)
Experience (Year)	39.47	43.37	37.4	43.21	40.86
Farm size (Hectare)	0.84	0.81	1.02	1.72	1.10

Source: Field survey, 2017. (Figure in the parentheses indicated percentage).

Loan for livestock production

In the study areas, farmers had managed finance from various source alongside by own for producing livestock. Only 5% had taken loan for purchasing and managing the livestock. Loan had taken from various financial institutions by the farmer. Among the loan taker, 72% and 28% respectively, had taken loan from NGOs and Government Banks (Table 2).

Table 2. Loan taken for livestock rearing

Yes	No	Govt. Bank	NGOs
14 (5%)	286 (95%)	4 (28%)	10 (72%)

Source: Field survey, 2017. (NGOs: BRAC, ASA, RDS, Poverty Reduction Projects etc.)

Service taken from Upazila Veterinary Hospital

Farmers had taken services from the Upazila Veterinary Hospital for treatment of their livestock. The frequency of the service taken was shown in the Table 3. Among the surveyed farmers, 22 per cent had taken service 1 time followed by 18 per cent 2 times, 12 per cent 3 times 11 per cent 4 times per year. Ten per cent farmers never had gone to Upazila Veterinary Hospital for taking service (Table 3).

Table 3. Service taken frequency from Upazila Veterinary Hospital

Times	No. of farmers	Percentage (%)
0	31	10
1	67	22
2	55	18
3	37	12
4	34	11
5	20	7
6	28	9
7	15	5
8	11	4
9	2	1

Source: Field survey, 2017.

Livestock Species Reducing and the Trend

Among the sampled farmers, 81% opined that major livestock species were reducing over the last three decades at household level indicating that small farmers are very much reluctant for rearing livestock because of lack of free grazing land and for increasing rearing cost in all sphere of input cost. Though one or two livestock species were added to the farming enterprise such turkey, a newly added livestock specie to our farming activities. Livestock population was reducing over the years and 56% respondents stated that the reducing trend was moderately reduced.

Livestock Rearing Cost Compare to Past

As the grazing land are reducing day after day due to need for cereal and non-cereal crop production & urbanization and price of all the cattle feed ingredients are also increasing. Frequent outbreak of various bacterial and viral diseases to livestock and treatment cost added an incremental pressure on livestock rearing cost. Livestock rearing cost was increasing alarmingly and it was found 4.45 times compared to three decades ago (Table 4).

Table 4. Livestock rearing cost increased and its magnitude

Areas	Times
Lalmonirhut	4.11
Kurigram	3.96
Bhola	5.12
Borguna	4.59
Average	4.45

Major livestock population scenario at present and 30 years ago at HH

If we go back to one decade and a half, we could see that livestock was the driving force for ploughing lands in the rural traditional agriculture. As the modernization touches the farming system with mechanical power, the dependency on livestock has reduced. That's why cattle population per household decreased in the rural areas. But commercialization in the livestock production has made balance for livestock population. In the country, a good number of cattle and poultry farms have been producing various species of livestock for meeting the increasing demand for animal protein. The study found a scenario of major livestock population which indicated that livestock population per household was declining over the decades (Table 5).

Table 5. Major livestock population scenario at present and 30 years ago per HH

Areas	Time	Cattle	Buffalo	Goat	Sheep	Chicken	Duck	Pigeon
Lalmonirhut	Present	4	-	2.75	0.69	9.00	2.83	2.71
	30 yrs ago	9.25	0.28	5.87	1.63	16.58	5.87	4.97
Kurigram	Present	3	-	0.95	0.17	10.00	3.44	1.20
	30 yrs ago	8.37	0.21	3.96	1.11	14.68	7.28	4.28
Bhola	Present	4.44	0.75	1.49	0.60	14.00	7.25	3.92
	30 yrs ago	9.65	10.56	3.4	0.07	23.00	18.48	3.77
Borghuna	Present	6	0.81	2.69	0.03	11.00	5.29	5.57
	30 yrs ago	15.93	4.72	6.63	1.16	26.00	17.00	14.00
Average	Present	4.45	0.39	1.97	0.37	11.00	4.70	3.35
	30 yrs ago	10.81	3.94	4.96	0.99	23.79	12.18	6.63

Source: Field survey, 2017.

Major livestock availability in the study areas

From the findings, it was clear that to individual farm level livestock production in respect to all species gone down over the year than the previous. But the total livestock production was increasing because many small and medium livestock enterprises were established throughout the country and those enterprises produced a big amount of livestock and play a vital role into total amount (Table 6).

Table 6. Major livestock availability now and then (30 years ago) in the areas

Species	At present				30 years ago			
	Sufficient	Normal	Low	No idea	Sufficient	Normal	Low	No idea
Cattle	59 (20%)	149 (50%)	92 (31%)	-	231 (77%)	63 (21%)	6 (2%)	-
Buffalo	-	61 (20%)	139 (46%)	100 (33%)	119 (40%)	71 (24%)	86 (29%)	24 (8%)
Goat	11 (4%)	145 (48%)	144 (48%)	-	138 (46%)	109 (36%)	53 (18%)	-
Sheep	5 (2%)	63 (21%)	216 (72%)	16 (5%)	29 (10%)	146 (49%)	110 (37%)	15 (5%)
Chicken	126 (42%)	140 (47%)	34 (11%)	-	132 (44%)	158 (53%)	10 (3%)	-
Duck	104 (35%)	139 (46%)	57 (19%)	-	97 (32%)	178 (59%)	25 (8%)	-
Pigeon	12 (4%)	82 (27%)	174 (58%)	32 (11%)	38 (13%)	108 (36%)	149 (50%)	5 (2%)

Source: Field survey, 2017.

Natural Disasters Occurrences

The study identified some factors which had devastating effects on livestock growth and development such as extreme temperature, high humidity, less average rainfall, prolonged drought length duration, flash flood, cyclone, tornado, tidal surge and salinity in the costal belt and very recent added thunder storm with heavy lightening. It was clear from the Table 7 that Lalmonirhut and Kurigram regions are very much prone to cyclone, flood and drought, on the other hand, Bhola and Borguna are frequently affected by tidal surge.

Table 7. Natural Disasters Occurrences

Areas	Natural disaster	Occurrence (Frequency)/year
Lalmonirhut	Flood	1.37
	Drought	1.26
	Cyclone	1.98
	Tidal surge	-
Kurigram	Flood	1.69
	Drought	1.01
	Cyclone	2.00
	Tidal surge	-
Bhola	Flood	1.65
	Drought	1.15
	Cyclone	2.03
	Tidal surge	2.47
Borguna	Flood	1.68
	Drought	1.45
	Cyclone	2.27
	Tidal surge	1.37
Average	Flood	1.60
	Drought	1.22
	Cyclone	2.07
	Tidal surge	1.92

Source: Field survey, 2017.

Duration of Flood and Drought

Duration of flood and drought were different in respect to regions. As the regions are more tress prone areas of flood, drought, cyclone and tidal surge, the devastating effects of those natural calamities were presented in the table stating over months. Average flood duration was estimated 1.0 months and the drought duration was estimated 1.63 months (Table 8).

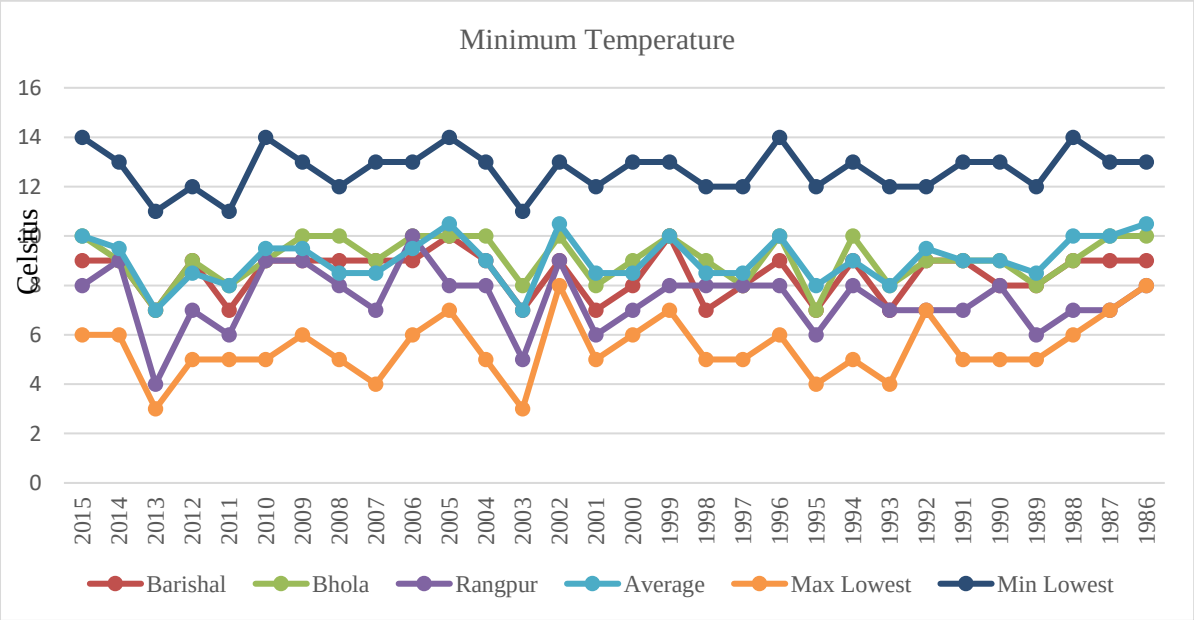
Table 8. Duration of Flood and Drought in the Areas

Areas	(Months)	
	Flood	Drought
Lalmonirhut	1.46	2.50
Kurigram	1.89	3.17
Bhola	0.50	0.25
Borguna	0.43	0.61
Average	1.07	1.63

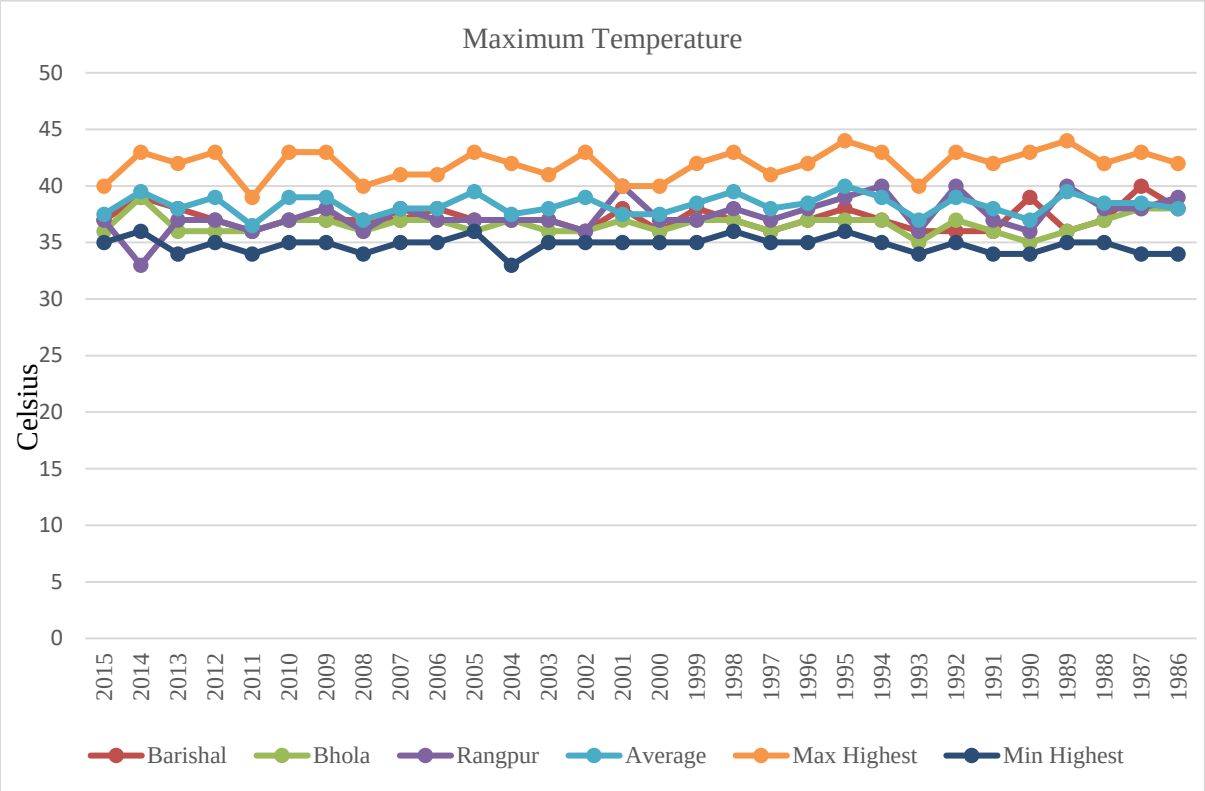
Source: Field survey, 2017.

Temperature and Rainfall

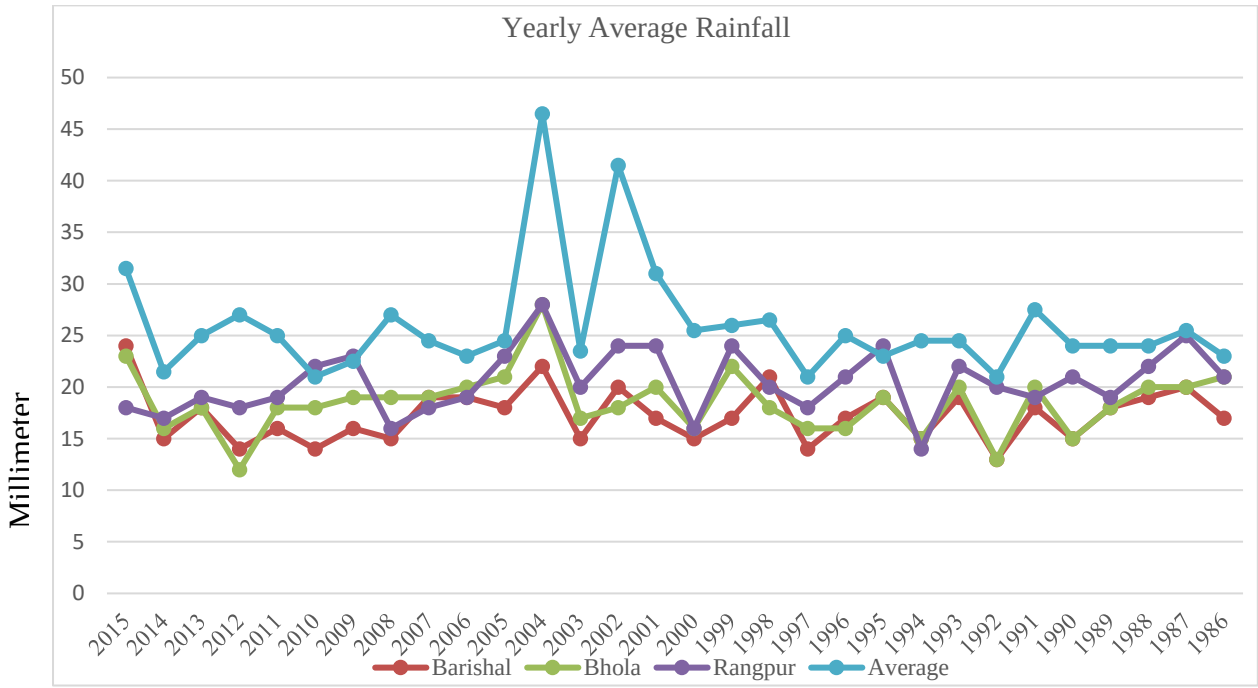
Temperature and rainfall are the most important parameters for evaluating and addressing the climate change issue. The study identified some factors which had devastating effects on livestock growth and development such as extreme temperature, high humidity, less average rainfall, prolonged drought length duration, flash flood, cyclone, tornado, tidal surge and salinity in the costal belt and very recent added thunder storm with heavy lightening. In study areas, 30 years temperature and rainfall data from Bangladesh Meteorological Department, analyzed and the pattern of temperature and rainfall were shown in the line graphs. Temperature and rainfall fluctuation were observed more in the recent year than the remote past (Graph 1, 2 & 3).



Graph 1.



Graph 2.



Graph 3.

Estimation of Income Vulnerability

Study considered household income flow of the farmers from agriculture, business and service sectors. All agricultural components are strongly influenced by climatic factors for its production behaviour, therefore, income variability occurred. Among the studied farm household 93% and 84 % were found vulnerable at present and 30 years ago, respectively. At present and 30 years ago, average vulnerability was estimated 0.93 and 0.85, respectively (Table 9).

Table 9. Estimation of income vulnerability status of the studied household farm

Areas	Score	Present	30 years ago
Lalmonirhut	1	70	67
	0	5	8
Kurigram	1	71	57
	0	4	18
Bhola	1	66	61
	0	9	14
Borghuna	1	72	68
	0	3	7
Average	1	279	253
	0	21	47
Average vulnerability		0.93	0.85

Source: Field survey, 2017.

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CONCLUSION

Although livestock production is gradually increasing by means of commercial farming but in HH level, it is declining trend. For this, reasons income vulnerability is occurring in the HH livestock production. In the light research findings and to attain the SDGs of the UN, the following recommendations should take under consideration for sustainable livestock development in the changing climatic situation-

- To give more attention to our native genetic resource potentialities, in cattle- such as RCC, Pubna Breed, Munshigonj Cattle.
- Cross breeding should not be encouraged beyond 50 % blood level.
- Encourage fodder production and provide training on scientific fodder preservation
- To develop sound marketing system for livestock product and by products so that farmers get better price.
- It would be wise to adopt new technologies and adapt with predictable and unpredictable climate change.

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