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# Impact of Climate Change and Vulnerability Status of Dairy Farming System in Dang, Nepal

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**Abstract:** The study was conducted in Dang district to analyse the farmer's perception, impact and vulnerability of dairy farming system in the context of changing climatic condition. Total 120 livestock farmers were selected from two VDCs using purposive simple random sampling. Primary data were collected through household survey and Focus Group Discussion using structured and pretested interview schedule. Descriptive statistics, integrated vulnerability approach based on principle component analysis and indexing were used to analyse the collected data. Agriculture was major source of household income for majority of respondent households (67.5%) following foreign employment (17.5%) and off farm activities (15%). The average livestock holding was nearly 16.81 livestock standard unit that contribute 31 percent to annual household income. A large majority of respondents (89.0%) observed the weather variation. Farmers perceived incidence of livestock disease (95%), decrease in milk yield (75.0%) and unavailability of feed and grasses (66.7%) as the major impact of climate change on livestock production. Most of respondents felt that extreme hot, drought spells, and floods were most prioritized climatic hazards in study area. Integrated vulnerability approach based on principle component analysis was used to analyze the livelihood vulnerability of livestock farmers. The vulnerability index of Dang district was found to be 4.4 which signified high risk of climate change in the district. The study concluded that farming practices and livelihood options of large portion of livestock farmers were affected negatively. Based on results, awareness raising program, effective adaptation strategy like livestock insurance, institutional enrollment and extension service with new technologies are recommended to enhance the adaptive capacity of vulnerable livestock communities in changing climatic scenario.
**Keywords:** Vulnerability, dairy farming system, climate change, Principal component analysis, Dang

## INTRODUCTION

Livestock being integral part of Nepalese farming system has substantial role in the national economy. Climate change as evidenced by increased climatic variability and temperature, is affecting the livelihoods of rural poor and marginal farmers in Nepal [1]. Therefore, climate change has been a real threat to livelihood of Nepalese farmers due to the problematic impact on their crop and livestock production system. The climate change would likely result in considerable adverse impacts on breeding pattern, fertility, repeated breeding, productivity, disease incidence, and reduced feed conversion efficiency in warmer regions like terai part in general and western dry arid terai in particular of Nepal. Changing climatic condition clearly plays a key role in poor livestock performance [2]. However, there are considerable gaps in research findings to know how climate change affects livestock production system and the livelihoods of farmers in the context of large microclimatic variation in Nepal.

National target for achieving growth rate in livestock sector during twenty years periodic plan is 6.1% in 2015 from 2.9% at base year period (APP, 1995). But the livestock sector being highly vulnerable to climate change and due to other technical and institutional obstacles related to it the target rate could not be achieved. Studies on climate variability at local level are very sporadic in spite of the accepted fact that the micro-level community vulnerability and adaptation assessment is more relevant than the mega-scale. Therefore, assessing vulnerability provides a starting point for the determination of effective means of promoting remedial action to limit impacts by supporting coping strategies and facilitating adaptation [3]. Identification of impact of climate change helps to formulate appropriate coping strategies and further recommends for policy makers to give due attention to this phenomenon so as to make farmers sustain in this farming sectors. This study will help to identify previous research gaps and impact of climate change on livestock production and its effect on livelihood in specific location along with types of impact associated. The findings from this proposed study will be useful to support timely improvement of these policies and formulation of new policies after identifying the level of vulnerability in livestock sector.

## MATERIALS AND METHODS

This research was conducted in two VDCs, namely Lalmatiya and Urahari of Dang district of Nepal. Two VDCs were selected purposively in consultation with DLSO based on vulnerability to climate change impact and commercialization of livestock farmers. From these two VDCs, each two wards were selected randomly using simple random sampling techniques. Sampling frame was prepared taking the name list of livestock farmers of selected two ward of each VDC and simple random sampling technique was used to select the respondents in the size 120 from two different VDCs under study. Various sources and technique were used for collection of necessary information. In this study, both the primary and secondary data were collected. The methodologies consisted of household survey, review of previous studies, and interviews with key informants, and also direct observation by the researchers. Livestock farmers were the primary source of information. The pre-tested interview schedule was administered to the respondents to collect primary information. All randomly selected participants were visited and interviewed. Primary data were also collected through Focus Group Discussion (FGD) and Key Informant Survey (KIS) using interview guide. Meteorological data like temperature, precipitation and relative humidity (RH) of the proposed study area from 1981 to 2013 was taken from Department of Hydrology and Meteorology, Kathmandu. Other secondary information related to livestock production performance, livelihood and other socio economic information of country and study area were collected from various published materials and reports of different National and International organization. District agriculture information was collected from District Agriculture Development Office and District Livestock Service Office. After collection of necessary information it was coded and entered to SPSS software for analysis. Data analysis was done by using statistical packages for social sciences (SPSS V.20) and STATA 12. Mean, standard deviations, frequency, percentage were used to derive inference needed.

For obtaining the information on the livestock based livelihood vulnerability in the study area, integrated vulnerability assessment approach was used. Vulnerability Assessments are the crucial component to study the livelihood condition of the people. According to Deressa, Hassan, & Ringler, et al. [4], the integrated vulnerability approach is considered to be superior over other approaches and is particularly useful for policy decision. Accordingly, socio-economic and biophysical indicators of vulnerability were employed and classified into adaptive capacity, exposure and sensitivity.

For the analysis of vulnerability through integrated approach, both primary and secondary sources of data were used. The chosen indicators of adaptive capacity, exposure and sensitivity were separately employed for PCA. The loading from the first component of PCA were used as the weights for the indicators. The weights assigned for each indicator varies between -1 to +1, sign of the indicators denoting the direction of relationship with other indicators used to construct the respective index. The magnitude of the weights describe the contribution of each indicator to the value of the index.

Thus, vulnerability was calculated as defined by IPCC (2001),

Vulnerability = Adaptive capacity-Sensitivity-Exposure

Equation above can be operationalized as follows:

$$V = \sum_{i=1}^{n} W_i .X_i - (\sum_{i=1}^{n} W_i.Y_i + \sum_{i=1}^{n} W_i.Z_i)$$

Where

i= 1,2,3,4,…….n households

V= Vulnerabilty index

$W_i$= Weight obtained from first principal component scores of $i^{th}$ variable.

$X_i$= Adaptive capacity of $i^{th}$ variable

$Y_i$= Sensitivity of $i^{th}$ varibles

$Z_i$= Exposure of $i^{th}$ varibles

The relationship between Vulnerability Index and Vulnerability is negative. The higher value of vulnerability index indicates lesser vulnerability and vice versa condition [5]. But, negative value of the index doesn't imply that the household is not vulnerable at all. The index value gives the comparative ranking of sampled households/ study area rather absolute measurement of vulnerability.

The suitable variables used for calculation of vulnerability index need to be normalized so as to bring the values of variables within the comparable range [6, 7]. Normalization is done by subtracting the mean from the observed value and dividing by the standard deviation for each variable.

$$\text{Normalized value} = \frac{\text{Observed value} - \text{mean}}{\text{Standard deviation}}$$

Climatic hazards and extremities in the study areas were identified with the use of index. . The formula given below was used to find index for severity of climatic hazards.

$$I_{prob} = \Sigma \, SiFi/N$$

Where,

$I_{prob}$ = Index value for intensity of problem

Si = Scale value of ith intensity

Fi = Frequency of ith response

N = Total number of respondents

## RESULTS

### Description of the study area

The Dang is one as Inner Terai district of Mid-Western Development Region. Geographically, Dang district has been expanded from $27^0$ 36' to $28^0$ 29' North latitude and between $80^0$ 02' to $82^0$ 54' East longitude. It is bordered with Kapilbhastu and Argakhanchi district in the east, Salyan, Rolpa and Piuthan in the North, Uttar Pradesh of India in the South and Surkhet, Banke and Salyan in the West. It extends 90 km east west and 71 km north south and the area of 2955 square kilometer which occupies 2.03% area of Nepal. The elevation varies between 213m. And 2058 m. above mean sea level [8]. There are 116415 households with total population 552583 (CBS, 2011).

**Table-1: Land use pattern of the district**

| Particulars | Area in (Ha) |
|---|---|
| Total area | 2,95,500 |
| Forest | 2,01,900 |
| Cultivable land | 69,950 |
| Cultivated land | 65,580 |
| Low land | 38,600 |
| Upland | 26,980 |
| Pastureland | 12,950 |
| Others | 10,700 |

Source: DADO, Dang, 2013/2014

### Socio-economic and demographic characteristics

The socio-economic characteristics of respondents include age distribution, population and sex distribution, economically active population, education, land utilization pattern, involvement of farmers in local institution, group, access to credit etc. These characteristics are described below.

The average age of the respondent is 44.22 years ranging from 16 to 88 years. Whereas the average age of the household head was 49.01 years and ranges from 24 years to 83 years. The total population of the sampled household was 702, of which average family size of the survey district area was 5.86 which is higher than the national average 4.46 (CBS, 2011). The household were found as patriarchal, out of the 120 household that were sampled in area 65.0 % was male headed family remaining 35.0 % was only the female headed family. The study revealed that the majority of the population were Chettri (57.5%) followed by the Brahmin (24.2%) and Ethnic/indigenous (13.3%) and other occupational caste as 5.0%.

### Occupational and educational status and economically active population

The economically active population, educational and occupational status were studied. The major occupation was categorized as the agriculture, off farm income and foreign employment. From the study the majority of the studied household (67.5%) have the agriculture as their major occupation followed by the foreign employment (17.5%). Only 15 percent household sustain their livelihood mainly from off farm income. The study revealed that the majority of respondents have secondary level education. Relatively fewer respondents (10.8%) have attained higher level education.

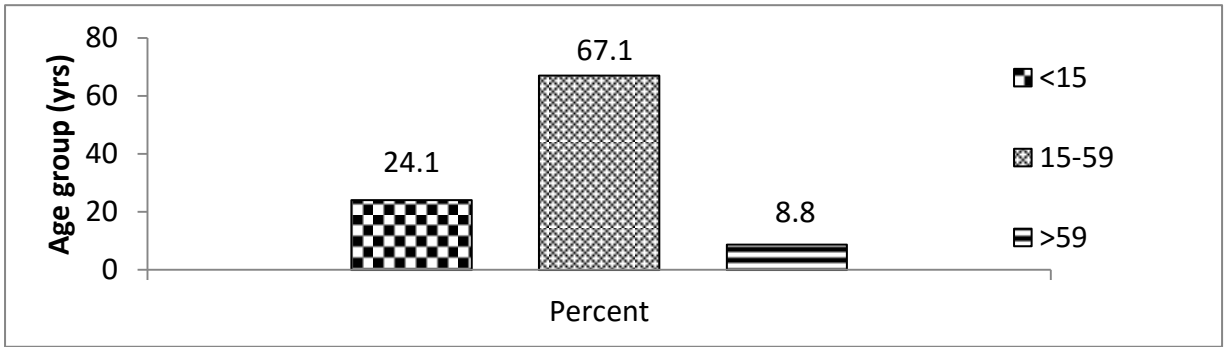


**Fig-1: Economically active population**

The number of economically active population was categorized into three group; less than 15 years, 15-59 year and more than 59 year. The study revealed that more than two third of population (67.1%) were economically active.

**Livestock Standard Unit**

The average livestock holding size was 16.81 LSU. The minimum holding was found 2.60 LSU while maximum was recorded in 503.80 LSU. The maximum LSU (503.8) in study area may be due to large number of poultry production in commercial scale.

**Table-2: Livestock holding (LSU)**

| Livestock holding (LSU) | VDC | | Total |
|---|---|---|---|
| | Lalmatiya | Urahari | |
| Mean | 22.80 | 10.81 | 16.81 |
| S.D | 81.41 | 10.34 | 58.09 |
| Minimum | 2.60 | 2.60 | 2.60 |
| Maximum | 503.80 | 82.00 | 503.80 |

Source: Field Survey, 2015

**Perception of respondents towards climate change**

About 89 percent had observed the change in the climate and 11 percent did not observed any changes in climate.

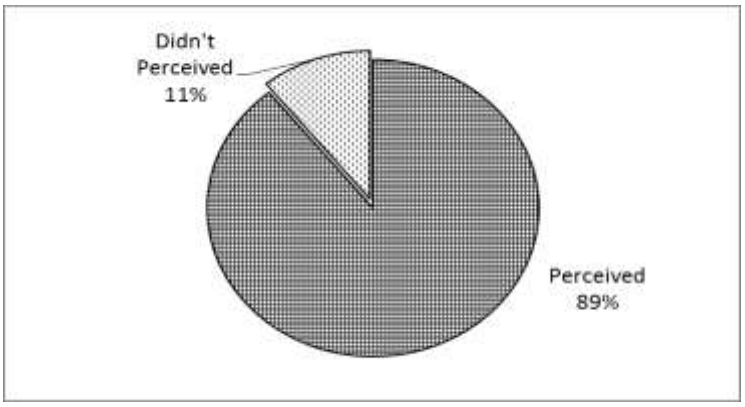


**Fig-1: Perception of respondents towards the climate change**

**Climatic and biological hazards prioritized by famers**

Flood, drought, extreme hot and hailstorm were four major climatic problems in the study area of Dang district. Similarly crop disease, livestock internal/external parasite, loss in grass land and loss in forage biodiversity were four major biological hazards. The result showed that extreme hot (0.67) was major climatic hazard in study area followed by drought (0.580) and least climatic hazard was hailstorm (0.30). Likewise, crop disease pest outbreak, livestock internal and external parasite, loss in grass land and loss in forage biodiversity were major biological hazard.

**Table-3: Perception of respondent towards major climatic hazards and prioritization**

| Climatic Hazards | Index value | Ranking | Biological Hazards | Index value | Ranking |
|---|---|---|---|---|---|
| Floods/Riverbank Erosion | 0.462 | III | Crop disease pest outbreak | 0.731 | I |
| Drought/Dry Spell | 0.580 | II | Livestock internal/external parasite | 0.698 | II |
| Extreme Hot | 0.673 | I | Loss in grass land | 0.623 | III |
| Hailstorm | 0.304 | IV | Lose in forage biodiversity | 0.387 | IV |

Source: Field Survey, 2015

**Perception on changing temperature and rainfall**

There is a gradual increase in temperature in different ecological zones of the western development region of Nepal [9]. Most of the respondents (92.5%) felt the increase in general temperature level. 95.0% of the respondents felt that the number of hot summer days has increased and 92.5% respondents felt the increase in degree of hotness of summer days which was also proved by the increasing trend of maximum, average and minimum temperature from Meteorological Station of Dang district. Farmers also added that local community has become more vulnerable to spread of vectors and diseases both to human and livestock affecting livestock production.

**Table-4: Perception of respondents towards the change in weather condition**

| Weather condition | Perception | | | Don't know |
|---|---|---|---|---|
| | Increased | Same | Decreased | |
| Temperature level | 111(92.5) | 4(3.3) | 0(0.0) | 5(4.2) |
| No. of hot days in summer | 114(95) | 4(3.3) | 0(0.0) | 2(1.7) |
| Degree of hotness in summer | 111(92.5) | 7(5.8) | 1(0.8) | 1(0.8) |
| No. of cold days in winter | 5(4.2) | 14(11.7) | 99(82.5) | 2(1.7) |
| Degree of coldness in winter | 51(42.5) | 40(33.3) | 28(23.3) | 1(0.8) |
| Winter rainfall intensity | 20(16.7) | 31(25.8) | 45(37.5) | 24(20.0) |
| Winter rainfall frequency | 16(13.3) | 36(30) | 44(36.7) | 24(20.0) |
| Summer rainfall intensity | 41(34.2) | 6(5.0) | 72(60.0) | 1(0.8) |
| Summer rainfall frequency | 8(6.7) | 8(6.7) | 101(84.2) | 3(2.5) |

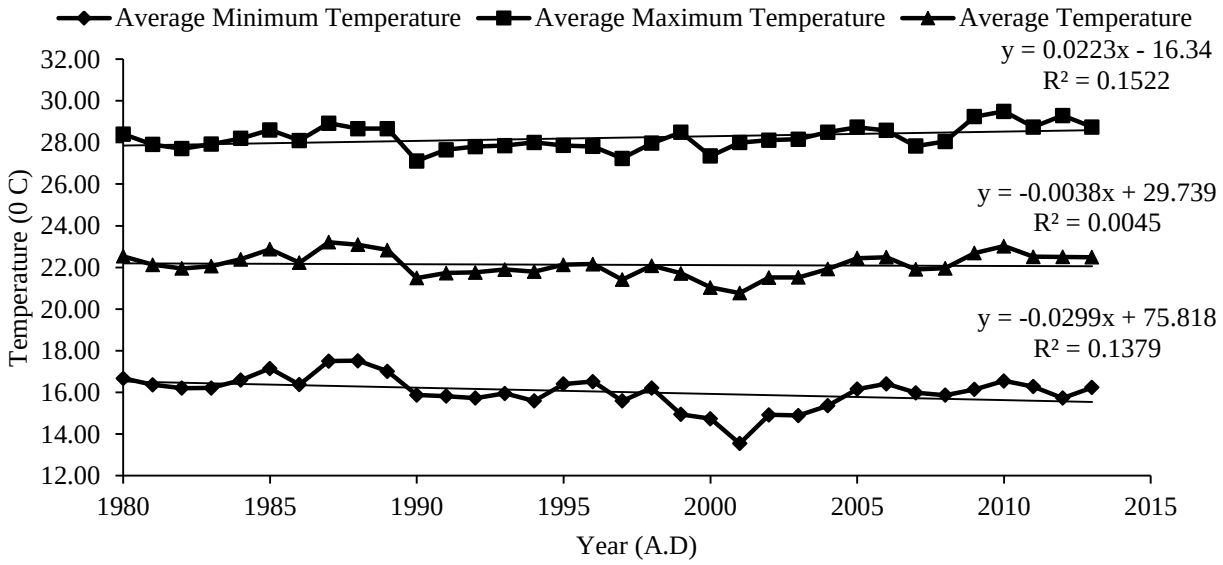


**Fig-2: Maximum, Minimunm and Average temperature as recorded in Meteorological Station, Dang (1981-2013).**

Farmers perceive that there was wide variation in the rainfall pattern as compared to the past. Majority of the farmers, 60% and 84.2% perceived decrease in intensity and frequency of rainfall respectively as compared to the past years. Majority of the respondents, 36.5% reported decline in frequency and 37.5% reported intensity of the winter rainfall as compare to the past.

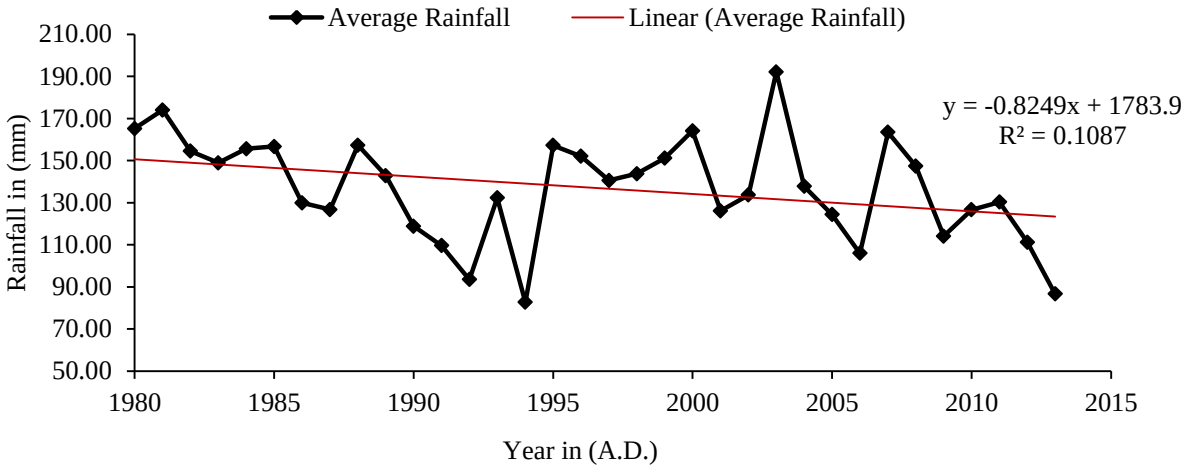


**Fig-3: Average rainfall as recorded in Meteorological Station, Dang (1981-2013).**

**Perception on impact of climate change on livestock**

The climate change impact is widely felt and its effect is experienced across all the regions of the Nepal. Livestock is the most sensitive farming system felt due to climate change About 95.0 percent respondents felt that the incidence of disease and parasites in livestock, 66.70 percent respondent felt the unavailability of feed and grass, 75 percent felt decrease in milk production, 40.8 percent felt death of animal, 22.5 percent felt change in appetite of livestock and 49.2 percent felt heat stress in animal (Table 5).

**Table-5: Major climate change impact on livestock perceived by respondent**

| Major impacts on livestock | Total |
|---|---|
| Unavailability of feed and grass | 80(66.7) |
| Incidence of disease and parasites | 114(95.0) |
| Decrease in milk production | 90(75.0) |
| Heat stress | 59(49.2) |
| Death of animal | 49(40.8) |
| Loss of appetite | 27(22.5) |

Source: Field Survey, 2015

**Barriers to adoption of adaptation strategy**

The analysis of barriers to adaptation to climate change based on the perception of respondents in the study area indicated that there were six major constraints to adaptation. These were lack of government support, lack of availability of suitable adaptation strategy, lack of climate information, lack of appropriate adaptation knowledge, lack of money and poor market access. (Table 6). Around 44 percent of respondents strongly agreed that lack of government support was first most barriers to adoption of adaptation strategies.

**Table-6: Perception of respondent towards barrier to adaptation**

| Reasons | Level of agreement | | | Neutral |
|---|---|---|---|---|
| | Strongly agree | Agree | Disagree | |
| Lack of government support | 52(43.3) | 36(30.0) | 12(10) | 20(16.7) |
| Availability of suitable adaptation strategy | 42(35.0) | 75(62.5) | 1(0.8) | 2(1.7) |
| Lack of climate information | 35(29.2) | 72(60.0) | 7(5.8) | 6(5.0) |
| Lack of technology | 34(28.3) | 81(67.5) | 1(0.8) | 4(3.3) |
| Lack of appropriate adaptation knowledge | 30(25) | 88(73.3) | 2(1.7) | 0(0.0) |
| Lack of credit/Poverty | 25(20.8) | 33(27.5) | 34(28.3) | 28(23.3) |
| Poor market access/transport | 8(6.7) | 85(70.8) | 6(5.0) | 21(17.5) |

Figures in the parenthesis indicate percent
Source: Field Survey, 2015

**Livestock holder's vulnerability to climate change**

Adaptive capacity, sensitivity and exposure are major three components of Vulnerability assessment. The adaptive capacity was taken for socio-demographic, economic, institutional, gender inclusion characteristics. Vulnerability indices were obtained by applying Principal Component Analysis on the adaptive capacity, sensitivity, and exposure variables. Principal component analysis is frequently used in research that constructs indices for which there are no well-defined weights. Principal component analysis generated the weights, based on the assumption that there is a common factor that explains the variance in the vulnerability [4].

The result of Principal component Analysis (PCA) showed that eight component with the Eigen value of one or greater than one accounting for 66.64 percent of total variance. The first component had Eigen value of 3.548 contributing 16.89 percentage of cumulative variance followed by the second component with Eigen value of 2.165 accounted for 27.20 percent of cumulative variance. The weights obtained from PCA are given in Table 8 for the indicators of adaptive capacity, exposure and sensitivity respectively. Only the component score of the first component was used weighing the variables for the construction of vulnerability index.

The vulnerability index for the Dang district was found to be 4.4 (Table 7). The calculation of vulnerability index showed that Dang district had positive value indicating that Dang was less vulnerable. However the index being relative value must be used for comparison with indices of other areas.

**Table-7: Vulnerability index for study area**

| District | Index score | |
|---|---|---|
| Dang | 4.4 | |

**Table-8: Component scores of coefficient for component first through PCA**

| Indicators | Types of variables | Component score |
|---|---|---|
| Age of household head | Adaptive capacity | -0.093 |
| Sex of household head | Adaptive capacity | 0.551 |
| Education of household head | Adaptive capacity | 0.566 |
| Economically active member | Adaptive capacity | -0.028 |
| Land size | Adaptive capacity | 0.393 |
| Livestock holding | Adaptive capacity | 0.266 |
| Information on climate change | Adaptive capacity | 0.346 |
| Credit facility | Adaptive capacity | 0.321 |
| Institutional membership | Adaptive capacity | 0.072 |
| Extension service available | Adaptive capacity | 0.262 |
| Training on livestock | Adaptive capacity | 0.460 |
| Nature of dairy farming | Adaptive capacity | 0.505 |
| Maximum temperature variability | Exposure | 0.022 |
| Minimum temperature variability | Exposure | -0.029 |
| Precipitation variability | Exposure | -0.824 |
| Relative humidity variability | Exposure | 0.142 |
| Summer temperature | Exposure | 0.027 |
| Drought | Exposure | 0.347 |
| Flooding | Exposure | 0.287 |
| Animal death | Sensitivity | 0.318 |
| Income share from natural resource based sector | Sensitivity | 0.861 |
| Income share from non-natural based sector | Sensitivity | -0.861 |
| Dependency ratio | Sensitivity | -0.128 |
| Livestock diversification practices | Sensitivity | -0.082 |
| Employment diversification practices | Sensitivity | -0.340 |

**DISCUSSION**

The study revealed that about two third (65.0%) of respondent's households were male headed with average family size of 5.86. Still, agriculture was found to be most reliable source of household income of majority of sampled household (67.5%) followed by

foreign employment (17.5%) and off farm activities (15.0%). Majority of the surveyed households were of Chhetri ethnicity (57.5%). Livestock holding in study area was (16.81 LSU) ranging from 2.60 to 503.80. The maximum LSU (503.80) may be due to commercial poultry farming. Though the percentage of economically active member was more than 66 percent, there involvement in agricultural activity has declined year after year. The lower profit from agriculture as compared to other livelihood options like wage laboring, remittance and service were considered as a main reason for declining economically active member in agriculture. A large portion of respondents felt that thee was changes in most of the weather patterns like increase in degree of hotness, temperature level, degree of coldness and fluctuations in rainfall intensity and duration. Farmer perception towards weather parameter was further supported by the analysis of meteorological data of Dang district. Vulnerability, the degree to which a system is susceptible to the adverse effects of climate change, is composed of three components: adaptive capacity, exposure and sensitivity [10]. Integrated vulnerability assessment approach was used to determine the climate change vulnerability index of the study area as it overcomes the shortcomings of other methods.

The vulnerability of the study area was found to be 4.4, which falls in the high risk zone [11]. The livestock vulnerability to climate change of Kapilbastu district, neighbor district of Dang, was found to be 7.41 [12]. So the Dang district vulnerability, when compared to Kapilbastu, is said to be higher. Higher vulnerability may be due to higher incidences of drought and higher variation in climate parameter, illiteracy rate, lack of year round irrigation, higher number of economically active population engaged in study.

## CONCLUSION

Livestock farming was one of major source of household income for majority of farming households. Although livestock plays dominating role on the livelihood of marginal and poor people; climate change impact negatively affects the livestock production. Most of the livestock keepers felt that extreme hot, drought, flooding and hailstorm were the perceived climatic hazards and crop disease, livestock disease, loss of forage land and loss of forage diversity were another biological hazard in the study area. Vulnerability of any regions depends upon the adaptive capacity, exposure and sensitivity. The adaptive capacity of the livestock keepers helps to combat the negative effect from the climate change. Age and sex of household head, high education level, number of economically active member, more no. of livestock, institutional membership, more clear weather information, availability of extension service, access to credit were the adaptive capacity of livestock keepers which were seen as strengthening factors for negative changing climate change scenario. The result revealed that vulnerability index of Dang district being positive, implies less vulnerable as compared to vulnerability index with negative value. However, Dang district has been said to be relatively more vulnerable to climate change if compared to other terai district of western Nepal. Therefore, climate change program or policy launched by government or nongovernment sector should focus on awareness raising activities with suitable adaptation strategy and technology intervention.

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