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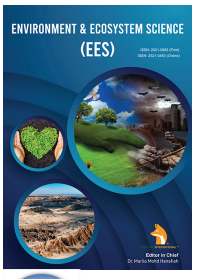

RESEARCH ARTICLE

IMPACT OF CLIMATE CHANGE ON WHEAT PRODUCTION IN NAWALPARASI (B.S.W) DISTRICT, NEPAL

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ABSTRACT

Survey research was conducted in Nawalparasi (B.S.W) district to assess farmers' perception on climate change and the impact of climate change in wheat production. The survey was conducted in four municipalities (rural municipality). A total of 83 respondents were involved in this study. The primary data were collected through survey questionnaire, direct observation, focus group discussion, whereas secondary data on wheat area, production and productivity from different sources were also collected. The majority of the respondents (90.4%) perceived about climate change while 9.4% respondents were not aware about climate change. Furthermore, out of the respondents mentioning changes in temperature, rainfall duration, rainfall amount, dew and winter monsoon around 95.2%, 91.9%, 92.4%, 94% and 90.3% of them opinionated that there were changes in wheat production because of these factors respectively. Moreover, t-test and probit model analysis showed that there was great impact of climate change in wheat production and impact is increasing yearly in Nawalparsi(B.S.W) district. So, Government and policymakers should focus on climate resilient adaptation strategies formulation for crop cultivation through intensive research and extension packages. Adoption of technology to reduce the impact of climate change should be encouraged to gain optimum wheat production.

KEYWORDS

temperature, dew, rainfall, winter monsoon.

1. INTRODUCTION

Nepal is a landlocked country which lies along the Himalayan belt (26° 22' - 30° 27' N and 80° 04' - 88° 12' E) with the altitudinal variation extending from a mere 60 m to 8,848 m above the sea level. It is divided into 3 distinct ecological regions Viz. Mountain, Hill and Terai. As agriculture has contributed 26.5% of GDP of our country, it is mainstay of economy and it is obvious that without the development of agriculture, development of nation is not possible (CBS, 2020). It is estimated that more than 60% of Nepalese are dependent upon agriculture for food and livelihood (Poudel et al., 2017). Nawalparasi (B.S.W) district lie 27° 31' 59.99"N latitude and 83° 39' 59.99" E longitude and around 99 m above the sea level. About 64.1% of people are involved in agriculture in Nawalparasi (B.S.W) district. The main crops grown in Nawalparasi (B.S.W) are rice and wheat. In this district rice is planted especially in summer while wheat in winter season. Farmer community depends upon these crops for their livelihood. Wheat is an important food crop after rice and maize in Nepal (Krishi Diary, 2075). Although the best temperature to grow wheat is 21 to 24 degree celsius , it is grown in Terai, river basins, mid-hills, and high-hills of Nepal during winter season i.e. October to July (Koirala, 2001). Among the cereal crops, wheat ranks third in importance in hill and mountains regions and ranks second in Terai belt in terms of human consumption. According to average yield of wheat in Nepal is 2.84 ton/ha which is very low as compare to other South Asian countries (CBS, 2020). Due to recent improvement in technology and method of cultivation in wheat, global wheat areas is increased by 7 fold, production by 14 fold and productivity by 2 fold with an increasing rate of 0.8%per year from 1960s (Lantican et al., 2016).

Wheat contributes 20.91% to total cereal production in Nepal (CBS, 2020). The production and productivity of wheat in Terai belt is higher than the Mid Hills and High Hills. Mexico, India and Nepal are the origin for 35 cultivars of wheat (Joshi et al., 2006). L52 first improved cereal variety to be released in history of cereal breeding in Nepal was of wheat. R.R. 21 is considered as the most popular variety of wheat in Nepal (Joshi, 2017). Observing the recent data of country shows that the productivity of wheat was 2.32 t/ha (2072/73), 2.55 t/ha (2073/74), 2.75 t/ha (2074/75) and 2.84 t/ha (2075/76) respectively Wheat is one of the most important crops cultivated in Nawalparasi (B.S.W) district (CBS, 2020). Almost all farmers' cultivate wheat as main crop in winter season in this region. The

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main varieties cultivated in this area are Gautam, Bijaya, Bhrikuti and N.L.172 (PMAMP, 2076). Wheat productivity is low in Nawalparasi (B.S.W) district as compare to national average i.e. 1.5 to 2.5t/ha (AKC, 2075).

The weather condition prevailing in a place in a general or over a long period of time is climate. In recent year topic climate change is gaining importance and is being the most important subject to discuss. There is wide range of climate found in our country from high Himalaya to low belt Terai. However, several changes are being seen in climate of our country Nepal. Glaciers which are retreating at the rate of 30 m/year, rise in >0.06 °C of temperature, unusual rainfalls and increase of natural calamities like flood and droughts are some examples of problems faced by Nepal in recent years. There are several effects of climate change in agriculture like decrease in the yield of several winter crops, decreased maturity in crops like wheat and rice, off season flowering in several horticultural crops like pear and peach, increased dry days and soon (Malla, 2008). The rainfall seems to be non-uniform around the country. In some places of country there is heavy rainfall whereas some lacks causing the droughts. Similarly, changes are being seen in other climatic parameters like temperature, hailstorm, snowfall, dew and soon.

Climate change is not only effecting the agriculture but it is presenting itself as a problem for farmers' who are doing subsistence farming and relay on climate for several agricultural activities like irrigation. Hence, they are highly vulnerable and will be forced to face the negative consequences due to lack of capacity and knowledge to solve climate related problem (Marasini, 2012). Due to these changes in climate even agricultural sector of country is facing a severe problem which may lead to food crisis in near future. Several effects are being seen in productivity and production of crop. It has a harmful effect in crop production. Even wheat production is also being affected due to change in climate.

The impact of climate change is considered as one of the major challenges of crop production globally. Hence it is obvious that Nepal too will be affected. Due to diminishing farm size and lack of new technology, wheat production is not being improved. In addition to it, climate change have become another problem. Considering the Nawalparasi, wheat production is affected by recently arrived insects like armyworm, several diseases like loose smut, brown rust and soon along with other weakness like lack of proper management and climate change (AKC, 2075). Untimely rainfall, rise in minimum temperature and incidence of several fungal diseases due to high humidity are the problems created by change in climate that caused decrease in production of wheat in the district. Erratic rainfall patterns, loss of soil moisture, untimely panicle formation and fluctuating temperature are other problem creating unfavorable situation for cultivation and production of wheat (PMAMP, 2076). Hence to obtain the goal of sustainable and self sustain agriculture it is necessary to follow the Climate Smart Agriculture (CSA).

About 80 percent of Nepalese agriculture is rain-fed and are already vulnerable to drought (IPCC, 2019). Hence Nepalese farmers' are already in problem due to climate change. National level planning should integrate the way to mitigate this problem. One way to mitigate is to adapt. Understanding about effects of climate change is very important for several reasons. First of all farmers' in this region are highly dependent upon the wheat cultivation for livelihood. Hence reduction in the production of wheat will obiviously affect the livelihood causing low income and economy ultimately resulting into food shortage. Similarly practices that are followed for wheat production are highly sensitive to climatic parameters like temperature, precipitation and dew, hence risk is prevailing throughout the region. Recent climate data of Nawalparasi shows that the climatic parameters are changing which will affect the agricultural production in this region (Joshi K.). Rainfall patterns are shifting or late rainfall is creating the problem. Hence, it is necessary to perform the climate friendly agricultural practices along with measures to mitigate it.

In order to implement the environmental friendly practices it is utmost important to know about the perception of farmers' regarding the climate change. First we should increase the awareness level of farmers' regarding the climate change, its impact in the agricultural activity along with production and yield. Therefore, this research will work as way to know about perception and awareness level of farmers'. It is also very important to know about the level of adaptation technologies followed by the farmers' in the respective region. It will be the best if adaptation techniques will be developed and identified in local level by respective stakeholders and followed to reduce the impact of climate change (Odgen et al., 2008). This research will contribute in finding the proper adaptation level followed by farmers' in study site. In order to formulate any strategy or plan regarding the climate change it is very necessary to know the adaption level of farmers' and this research will contribute to it. This research will aid the future research on adaption technology to be followed in this region. Moreover, this study will contribute for several governmental and non- governmental organization to find out the mitigation strategy that is to be followed along with the program or project to be launched in this area.

Hence, the study regarding the climate change and its impact on wheat production is very important. Firstly it is very important to know about the perception of farmers' regarding climate change and its impact on wheat production. The study specifically aimed to:

- To assess the impact of climate change in wheat production in Nawalparasi district, Nepal.
- To appraise the understanding of farmers' about change in climate and its effect in its impact on wheat prouction in Nawalparasi(B.S.W) district.
- To identify major changes in climatic variables that are affecting the wheat yields in study area

2. METHODOLOGY

2.1 Study Site

The study site selected was Nawalparsi (B.S.W) district. Nawalparasi (B.S.W) district lies 27° 31' 59.99"N latitude and 83° 39' 59.99" E longitude and around 99 m above the sea level. In Nawalparasi (B.S.W) district also four municipality and rural municipalities were selected. Sunwal Municipality, Ramgram Municipality, Sarawal Rural Municipality and Palhi Nandan Rural Municipality were those places. In these regions most of the farmers are involved in wheat cultivation.

2.2 Sample and sampling technique

Out of 635 farmers' in record of PMAMP Nawalparasi (B.S.W) wheat zone, 83 farmers' were selected randomly for the survey. Sample size was determined using following formula:

$$\text{Sample size} = \frac{\frac{z^2 * p(1-p)}{e^2}}{1+\frac{z^2 * p(1-p)}{e^2 N}}$$

Where, z = the number of standard deviation a given proportion is away from mean.

p = Confidence level
e = Margin of error
N = Population size

2.3 Data source and data types

Both primary and secondary sources of data were used.

2.3.1 Primary data

Household survey, focus group discussion, key informant survey and questionnaire survey were used to collect primary data.

2.3.1.1 Household survey

Pre-tested standard questionnaire was prepared to collect response of the respondents. All experienced household head were selected for the face-to-face interview in his/her residence or any convenient places by using structured questionnaire.

2.3.1.2 Focus Group Discussions

In order to triangulate the information via collecting information, FGD was organized. Among the villagers who cultivate wheat as their major crop were gathered and discussion was conducted. Discussion was focused on production, productivity and problems that were seen previously. Similarly, discussion was conducted on their perception regarding climate change and the measures they apply.

2.3.1.3 Key Informant survey

In the same way, at least 10 key informant interviews were organized. It included key experts into survey for collecting their problems, opportunities regarding climate change effect.

2.3.1.4 Questionnaire survey

Questionnaire survey was focused on several changes that were seen in climate in recent years. As well as it focused in perception of local people regarding the changes in climate and measures were applied for mitigation of those changes.

2.3.1.5 Secondary data

This data was obtained from several organizations including AKC annual report, libraries, several websites, MoALD, Department of Agriculture, CBS, Municipality office and reports of several NGOs. These data were helpful gaining more knowledge regarding climate change, local periphery and agriculture.

2.4 Data Analysis

The collected data were processed, tabulated, analyzed and interpreted. SPSS, MS Excel MS Word and state like tools were used. The following statistical measures were used in study.

Mean: it is the sum of score divided by their number. It was used to categorize the variables into small, medium and high

$$\text{Mean}=\frac{\text{Sum of observed value}}{\text{no.of observation}}$$

Frequency: It was used to know the distribution pattern of respondents.

Percentage: Any proportion in relation to whole is known as percentage. This was used for simple comparisons

Standard deviation: this measure was used to categorize dependent and independent variable into low, medium and high categories. Formula for standard deviation is given as:

$$s_{x=}\sqrt{\frac{\sum x^2}{n}-\bar{x}^2}$$

Where,

$S_{x=}$ standard deviation, $\bar{x}$ = mean of set of number

X= set of number, n= total population

Independent t-test: The independent t-test was conducted to find out the association of variables singly i.e. keeping other variables constant. Here production of wheat was considered as dependent variable whereas age, sex, occupation, land holding, temperature, rainfall, dew and winter monsoon as independent variables. The formula for independent t-test is as follow:

Let us consider that A and B represent the two groups to compare.

Similarly, let m_A and m_B represent the means of groups A and B, respectively.

In the same way, let n_A and n_B represent the sizes of group A and B, respectively.

The t test statistic value to test whether the means are different can be calculated as follows:

$$t=\frac{mA-mB}{\sqrt{\frac{s^2}{nA}-\frac{s^2}{nB}}}$$

S^2 is an estimator of the common **variance** of the two samples. It can be calculated as follows:

$$S^2=\frac{\sum(x-mA)^2+\sum(x-mB)^2}{nA+nB-2}$$

Probit model: In statistics, a probit model is a type of regression tool where the dependent variable can take only two values. It was used to determine the combine effect of variables on wheat production. The variables value for the model is described table below.

Table 1: Description of variables

Variables	Descriptions
Dependent	
Wheat production	1 if production increased
	0 if production decreased
Independent	
Temperature	1 if increased
	0 if decreased
Rainfall	1 if increased
	0 if decreased
Dew	1 if increased
	0 if decreased
Timing of winter monsoon	1 if early
	0 if late
Age	Age was kept in years
Sex	1 if respondent was male
	0 if respondent was female
Occupation	1 for agriculture
	0 for other than agriculture
Land holding	Kept in hectare

3. Result and Discussion

3.1 Descriptive analysis

In this study, out of 83 respondents 14(16.9%) were young farmers', 56(67.5%) were adult farmers' and remaining 13(15.7%) were old farmers'. Similarly, out of total respondents 64(77.1%) of male and 19 (22.9%) of female were present in study. Furthermore, Out of total respondents 55(66.3%) of respondents were involved in agriculture as main source of income. Similarly, 3(3.6%), 14(16.9%) and 11(13.33%) of people were involved in service, business and other occupation respectively. In the same way, farmers' were divided into 3 categories according to land holding i.e. small, medium and large. Out of total respondents 24.1%, 64.4% and 15.5% of farmers' were small, medium and large farmers' respectively. Moreover, out of total respondents most of the respondents mentioned that wheat and rice were major crops grown in field i.e. 54(65.1%). Similarly, 12(14.5%) and 17(20.5%) of respondents mentioned wheat and rice as major crop respectively.

Similarly, while surveying on knowledge of farmers' regarding climate change and status of wheat production in last 10 years, it was found that 90.4% (75) respondents knew about the climate change while remaining 9.6%(8) people mentioned that they are unknown about the phenomenon of climate change. Similarly, while studying about the perception of farmers' regarding wheat production in last 10 years then it was found that only 4.8% of respondents believed that there is no change in production while other remaining mentioned that there is change in production which can be either increasing(8.4%), decreasing(21.7%) or increasing then decreasing(65.1%). In this study, most of the farmers' (95.2%) mentioned that this year temperature was decreased. Contraily, 4.8% of of farmers' mentioned that temperature was increased. Similarly, farmers' mentioned that due to change in temperature there is effect in production too. 75.90%(63) of farmers' mentioned that due change in temperature production decreases.

Similarly, 16.86%(14) and 7.2%(6) mentioned that change in temperature have positive impact and no impact in wheat production respectively.

Rainfall is one of the most important variables of climate that have great effect in every crop. Hence, it is obvious that wheat is also not the exception. According to the respondents this year there was more rainfall compare to other year. Around 84.3% of respondents mentioned it. Similarly, out of the farmers' who clearly told about change, they also mentioned that there was in production of wheat due to this change. Out of them 20.5% mentioned that there was an increase in production, 72.3% confirmed decrease in production while other 7.2% told there was no change in production, although rainfall amount was change. Similarly, 84.3% of farmers' told that there was increase in dew amount. Moreover, 15.7% of respondents told about decrease in amount of dew this year.

Similarly those farmers' who told about changes in dew amount also confessed that it was affecting the wheat production. 22.9%, 71.1% and 6.0% of farmers' told that production was increasing decreasing and constant respectively. According to farmers' from who face to face interview was done, winter monsoon plays important role for production. Out of total respondents 12% of them told that winter monsoon was early. However, 88% of them told that monsoon was late. The highest number of respondents (71.1%) mentioned of decreased production. While 24.1% and 4.8% told that production was increased and was constant respectively.

3.2 Independent t-test

Table 2: Association between farmers' characteristics and climate change with wheat production

SN	Factors	t-test
1	Age	0.077
2	Sex	-1.294
3	Occupation	-0.279
4	Land Holding	5.884***
5	Temperature	- 2.031**
6	Rainfall Amount	-3.555***
7	Dew	-3.555***
8	Winter Monsoon	-2.235**

** denotes significant at 5% level of confidence, ***denotes significant at 1% level of confidence.

Table 2 presents the results of differences between means of characteristics describing the relationship between variables of climate change and wheat production. Land holding, rainfall amount, dew and time of winter monsoon was found to be significant with wheat production at 1% level of significance while temperature and timing of winter monsoon was found to be significant at 5% level of significance. Contrarily, age sex and occupation did not show any relationship with wheat production. Hence, we can conclude that changes in land holding, temperature, rainfall, dew and timing of winter monsoon changes wheat production too.

3.3 Probit model analysis

Table 3: Results of probit model analysis.

Wheat production	Coef.	Std. Err	Z	P>Z	dy/dx
age	0.002	0.025	0.08	0.937	0
sex	-0.702	0.537	-1.34	0.179	-0.099
land holding	0.946***	0.313	3.24	0.001	0.133***
occupation	-0.122	0.345	-0.35	0.723	-0.033
winter temperature	0.822*	0.498	1.73	0.084	0.116*
rainfall	-1.209**	0.566	-2.35	0.019	-0.17**
dew	-1.026*	0.55	-1.95	0.051	-0.144*
winter monsoon	0.45	0.684	0.66	0.507	0.063

***, significant at 1 %: **, significant at 5%: *, significant at 10%

Number of observations : 83
LR chi2(8) : 60.99
Prob > chi2 : 0.0000
Pseudo R2 : 0.6005
Log likelihood : -20.289543

From above Table 3 it is clear that there is 60% (pseudo R2) probability of impact of climate change in wheat production. Similarly, all this indicates that all the independent variables or explanatory variables included in the model jointly influence the production of wheat.

The dependent variable i.e. wheat production was regressed with eight independent variables namely age of household, sex, occupation, land holding, temperature, rainfall, dew and winter monsoon. From above table3 it is clear that land holding is positively co related with wheat production (1%). This means likelihood of increment on wheat production increases with increase in land holding and with increase in 1 ha of land, wheat production increases by 13.3%. Similarly, winter temperature is also positively correlated with production of wheat (10%). With increase in temperature, wheat production increases by 11.6%. Similarly, above table3 reveals that rainfall and dew are negatively correlated with wheat production at 5% and 10% level of confidence respectively. Therefore, probability of decrease on wheat production increases with increase in these factors. Increment in rainfall and dew causes decrease in wheat production by 17% and 14.4% respectively.

4. Conclusion

The impact of climate change on wheat production was studied in four municipalities and rural municipalities of Nawalparasi (B.S.W) district. Data on sociodemographic characteristics and wheat production dynamics were collected using survey questionnaire and from secondary sources. Out of total respondents adult farmers' were in the greatest number i.e. 67.5%. Similarly, 16.9% of young farmers' and 15.7% old farmers' were present. During the study presence of male was more as compare to female. 77.1% of male and 22.9% of female were present during the study. Moreover, farmers' with medium land holding were high. Out of total respondents they occupied 61.4%. In the meantime small farmers' and large farmers' occupied around 24.1% and 14.5% of respondents. Majority of respondents have agriculture (66.3%) as main source of income followed by business (16.9%), service (3.6%) and others (13.3%). The association age, sex and occupation with wheat production was insignificant.

While the association between land holding, temperature, rainfall intensity, rainfall duration, rainfall amount, dew and winter monsoon was found to be significant with wheat production. It was proved by field survey and t-test. The probit model analysis of dependent and independent variables revealed that age, sex and occupation were insignificant, while temperature and land holding were positively correlated with wheat production. Hence change in these variable are probably directly proportional to wheat production. In contrast, rainfall and dew were found negatively correlated which means that increase in thses factors probably results into the decrease of wheat prouction. Since this study is more focused on perception of farmers', more research should be conducted in Nawalparasi(B.S.W) to get more information in impact of climate change on wheat production.

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