Impact of Climate Variability on Paddy Productivity in Shaba Gewog, Paro

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ABSTRACT

Rainfall fluctuations are largely random with no systematic change detectable on either annual or monthly scale. Inadequate rainfall during the growing season and heavy rainfall during harvest season reduce rice yield. This paper aimed to analyze the impacts of climate variability on paddy productivity based on questionnaire survey, data on paddy yield and meteorological data for the last 15 years,. Eighty representative households were randomly selected from a total of 265 farming households growing paddy in Shaba Gewog, Paro. Result showed that 48.8% of the farmers were aware of the climate change issues while 51.2% of farmers were not. About 25% of the respondents felt the need to shift paddy cropping calendar so that it is not affected by rain during harvest. Pearson's correlation coefficient on paddy yield and climate variability result showed that temperature (T Max) had positive correlation with paddy yield (r = .149, P = .596). The mean rainfall in October month also showed negative correlation with paddy yield (r = -.381, P = .161). The result showed that at the study site the differences in rainfall and temperature during paddy harvest season did not impact yield. About 7.5% of the respondents practiced climate change adaption techniques such as shifting of cropping calendar and change of rice variety. Reason for not adopting climate change adaptation practices was lack of awareness program in the gewog (73.8%). Majority of the farmers (97.5%) have not received any training on climate change impacts on agriculture. This study recommends capacity building programs to adopt adaptation and mitigation strategies in order to combat climate change impacts on agriculture.

Keywords: *Climate change, Impacts, Paddy yield, Rainfall, Temperature*

1. Introduction

Agriculture is the backbone of Bhutan as more than 58% of the population depends on agriculture for livelihood (Dorji, Olesen, Bocher, & Seidenkrantz, 2016). Agriculture is largely subsistence with 2.93% of the total land under cultivation. Rice and maize are the major cereal crops of Bhutan (BMCI & ICIMOD, 2016). Rice is the staple food of the Bhutanese. However, Bhutan is only 47% self sufficient in rice and as of 2018 only 28% of the total cultivable land is used for rice cultivation (GNHC, 2012). Bhutan's target for rice self-sufficiency through increase in productivity of its rice-

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based cropping systems in the 11 five year plan was 65- 60% (GNHC, 2012). Bhutan has approximately 51,368 acres of wetland that produces about 86,385 MT of paddy (DoA, 2017).

Natural calamities such as rainstorms during the harvest and lack of rainfall during the transplantation season contribute to reduction in yield. There is considerable impact of the variability of rainfall and temperature on rice yield. However, studies suggest that the impact is now stronger than before (Onifade, Olagunju & Ojo, 2016). Annual rice yield and the amount of annual rainfall varied significantly from year to year and there is a significant relationship between annual rice yield and annual temperature or annual rainfall variability (Onifade, Olagunju & Ojo, 2016). According to Chophel (2017) weather and rainfall pattern have changed over the years. Bhutanese farmers experience unpredictable rainfall such as heavy rainfall during harvest season and lack of rainfall during summer.

The Intergovernmental Panel on Climate Change (IPCC) assessment report 2007, revealed that adverse impacts of climate change are expected to affect agricultural sector in Southeast Asia, including Bhutan mainly due to increase in occurrence of droughts, intense rains, and rise in temperature. Climate change will impact the productivity of both irrigated and rain fed agriculture across the globe. The occurrence of droughts is predicted to result in crop failure in areas with rain-fed cultivation, while occurrence of intense rains will result in decline in crop yield from crop damages (FAO, 2011).

Some observed signs of climate change impacts on agriculture in Bhutan include loss of crops to unusual outbreaks of pests and diseases (BMCI & ICIMOD, 2016). Heavy rainfall during the harvest season affected paddy yield. Paddy harvest in Paro valley starts from the first week of October and ends at the end of same month. Over the years, the country has experienced rapid changes in average temperatures, precipitation patterns, and increased risks of climate hazards, including excessive rains, flash floods, windstorms, hailstorms, and droughts, causing massive losses and damage to farming households (DoA, 2016).

Rice is indispensable in Bhutanese culture, tradition, religion as well as for farmers' livelihood (NBC, 2015). Climate change impacts are a reality as its consequences are already being felt. Impact of climate variability leads to reduction in rice yield due to inadequate rainfall during the growing season and heavy rainfall during harvest season. There is urgent need to focus on research works to understand and mitigate the impacts. Therefore, the main objective of the study was to assess the effect of weather variability and rainfall pattern on paddy production and productivity over the last 15 years (2003-2017), and also to analyze the level of awareness on climate change among the paddy growers.

2. Materials and Method

2.1 Study area

The study was conducted in Shaba gewog 27°22'11.83"N and89°27'45.092" under Paro dzongkhag. It has a total cultivated area of 19,817 acres from which 522.7 acres are under wetland category.

Shaba gewog is generally warm and has temperate climate with average annual temperature of 12.4ºC. In winter, there is much less rainfall than in summer with average annual rainfall of 1,820mm. The study site has sandy-loam and clay- loam soil which is favorable for agricultural activities.

In 2017, the gewog produced approximately 1,402.2 MT of paddy from 492 acres with an average yield of 2.85MT per acre. From a total of 438 households in the gewog, 265 households grow paddy. It is one of the major rice producing gewogs under Paro Dzongkhag.

2.2 Sampling Method and Sample size

From the sampling frame of 265 farming households in the Gewog, 30% of the paddy growing households were selected. Therefore, 80 representative households from the Gewog were randomly selected using a simple random sampling technique. The household list of paddy growers was collected from the gewog agriculture extension supervisor.

2.3 Data Collection

Both primary and secondary data were collected. Primary data was collected through household interview using a semi-structured questionnaire. The pre-tested questionnaire comprised both close and open-ended questions. The respondents were asked questions on climate variability and its impact on paddy production amongst others. To obtain qualitative output the heads of the sampled households or household members who are fully involved in agriculture activities were interviewed.

Secondary data for climatic parameter such as rainfall and monthly maximum and minimum temperature data of the last 15 consecutive years were collected from the National Centre for Hydrology and Meteorology (NCHM), Thimphu. Agriculture statistics through publications for the last 15 successive years (2003-2017) was collected from Dzongkhag Agriculture Sector, Paro and the Department of Agriculture (DoA), Thimphu.

2.4 Data Analysis

Meteorological data of last 15 years (2003-2017) were used to compare the variation of weather variables such as precipitation, temperature and humidity over the years and to analyze the effect of variables on paddy production, in order to study the intensity of rainfall during paddy harvest season. Agriculture statistics of the last 15 years (2003-2017) were used to assess the paddy production variation over the years in relation to rainfall intensity.

The data were analyzed using Statistical Package for Social Sciences (SPSS) (version 23). Correlation analyses were conducted to see the relationship between paddy production and rainfall intensity during the harvest season. Descriptive analyses were used to assess respondents' perception on climate change impacts on paddy yield and adaptation strategies.

3. Results and Discussion

3.1 Demography

The details of the respondents such as gender, age and education backgrounds are presented in Table 1. Result showed that 70% of respondents were female and 30% male indicating more female respondents since men remained away from their home for off-farm activities during winter season. The maximum age of the respondent was 85 years old and the minimum 25 years while the mean age was 53 years old. Maximum respondents were uneducated (62.5%). Less than 12% had attended High School and college.

Table 1. Demographic details of the respondents

Gender		Education background		Age (Years old)	
	Respondents (%)		Respondents (%)		
Male	30	None	62.5	Mean	53
Female	70	NFE	10	Minimum	25
		Primary School	15	Maximum	85
		High School	7.5		
		College	3.8		
		Others	1.3		

(n=80)

3.2 Paddy variety cultivated at study site

At the time of study there were 12 varieties of paddy cultivated in five chewogs in the gewog. The most commonly cultivated variety was Yuseray Maap, locally known as "Satra", which accounts for 45% of paddy production in the gewog. More than 28.8% of the farmers at the study site cultivated Dumja followed by Thimja (6.3%). Other varieties were grown in small quantities.

The Dzongkhag Agriculture Office, Paro and neighbors were the main source of paddy seeds at 38.8% and 37.4% respectively. About 23.8% of the respondents also saved their own seeds, particularly Dumja variety.

Table 2. Paddy variety cultivated and seed source

Paddy variety cultivated	Respondents (%)	Seed source	Respondents (%)
Yuseray Maap (Satra)	45	Neighbor	37.4
Janam	2.5	Agriculture	38.8
Japanrice	5	Self saved	23.8
Dumja	28.8		
Yuseray Kaap	2.5		
Napele	1.3		
Thimja	6.3		
Jarey	1.3		
Parochina	2.5		
Upa Thungku	1.3		
Jawtshering	2.5		
Tantshering	1		

(n=80)

3.3 Cropping calendar in the study site

From early February through late March farmers prepare their land and manure the field from early March to late April. Seeds are sown in early February in the nursery. The paddy is transplanted early May. Weeding is done thrice- first weeding is done in the first week of June, second a month later and the third is also a month after the second weeding in August. Harvesting and threshing of paddy starts from the first week and ends in the third week of October (Figure 2).

Farmyard manure at the rate of 1.5 ton/ac is applied during field preparation followed by butachlor (pre-emergence herbicide) application after 2-3 days of transplanting. Suphala (46% nitrogen, 16% phosphorus, 60% potassium) and urea (46% nitrogen) is applied in July at the time of second weeding. Butachlor, suphala and urea are applied at the rate of 10 kg/ac, 20 kg/ac and 10 kg/ac, respectively. At the study site, irrigation is done on rotation basis among the farmers if there is no enough rainfall during the cropping season. Irrigation is usually done 1-2 days before weeding and during paddy flowering stage in July.

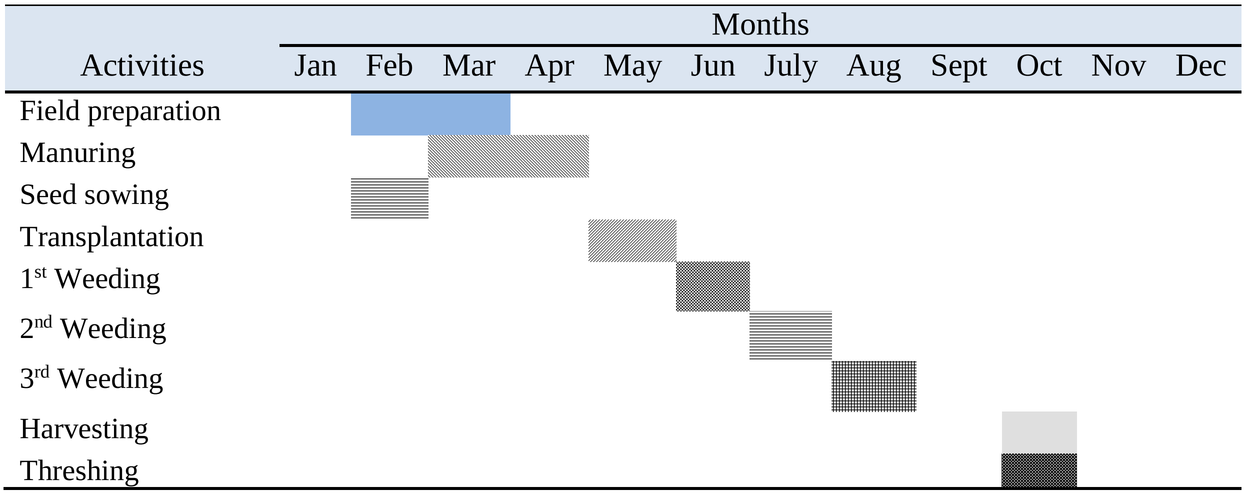

Figure 2. Cropping calendar.

3.4 Farmers' perception on climate change

From the total 80 sampled households, 48.8% of the respondents were aware of climate change issues while 51.2% were not. Those who were aware of the climate change issues stated that their source of awareness was their own experiences (40%). The media was also a source of information for 7% of the respondents (see Table 3). Therefore, the result showed the need for awareness program among the farming communities since more than 50% of the farmers were unaware of climate change issues.

SNV & DoA (2015) also reported that access to climate forecasting and advisory service for farmers is non-existent or is very poor and the availability of climate-smart technologies for adaptation is limited. Overall, preparedness and adaptive capacity for climate related risks and disasters are poor in farming communities in the country.

Table 3. Source of climate issue awareness (80)

Knowledge on climate change		Source of information	
	Respondents (%)		Respondents (%)
Yes	48.8	Media	8.8
No	51.2	Agriculture staff	0
		Gup	0
		Awareness programs	0
		Self experiences	40
		School children's	0

3.5 Perception on climatic parameters

Twenty percent of the respondents felt that rainfall (drizzling) started from February-March and 33.8% of the respondents felt that moderate rainfall (not too much, not too little rainfall) was received in June and July. Further, 22.5% of the respondent noted that heavy rainfall (greater than 100mm in 24 hours) was received from August to September. About 48.8% of the respondents reported no rain in December and January.

Table 4. Respondents (80) perception on rainfall intensity

Rainfall intensity	Month	Respondents (%)
Drizzling	Feb-March	20
Moderate rainfall (Not too much not too little)	June-July	33.8
Heavy rainfall (Grater than 100mm in 24 hours)	Aug-Sept	22.5
No rainfall	Dec-Jan	48.8

Table 5 shows that 83.3% of the respondents felt a rise in summer temperature whilst 55% felt rise in winter temperature. Twenty percent of the respondents felt winter temperature has decreased while 1.3% felt so for summer temperature. About 53.8% of the respondents felt a decline in summer rainfall while 48.8% felt decline in winter rainfall.

Table 5. Respondents' perception on climate anomalies in the last 15 years (2003-2017)

Anomalies		Temperature	Rainfall
		Respondents (%)	Respondents (%)
Summer	Increasing	83.8	12.5
	Decreasing	1.3	53.8
	Same	8.8	13.8
	Don't know	6.3	20
Winter	Increasing	55	11.3
	Decreasing	20	48.8
	Same	16.3	23.8
	Don't know	8.8	16.3

To compare the respondents' perception on climatic parameters, meteorological data of the last 15 years (2003-2017) was collected from the National Centre for Hydrology and Meteorology (NCHM), Thimphu. Due to the lack of meteorological station in the study site (Shaba Gewog), the Department provided the data collected from the National Seed Centre (Chundudingkha, Paro) which is 4 km away from the study site. The result presented in Figure 4 show that over the last 15 years, there was slight decrease in summer temperature and a gradual decline in winter temperature as well, which reached negative 0.4°C in 2017. Similar results were reported on the decline of winter mean temperatures in temperate regions (DoA, 2016). According to Shahnawaz & Strobl (2015) higher parts of the Himalayas receive a lot of snow during winter months and the cold winds blowing downward bring instant changes in the temperatures to the lower elevations. The temperatures on clear winter nights often fall to -10° C at altitudes between 2,000-3,000 masl.

Therefore, without considering micro-climatic condition of the region, farmers' perception that temperature during summer and winter are increasing does not corroborate with the data from Hydro-Met Service. Kusters & Wangdi (2013) also reported that it is difficult to identify general patterns in the region, since precipitation is highly location-specific, depending on the local topography and micro-climatic factors.

Rice grown under flooded condition in cool climates may be subjected to sub-optimal water temperature at any stage of the crop cycle. Plants in this surrounding area experience delayed heading, heads do not fill, or maturity is not reached by the end of the normal growing season, which result in decline of yield (Roel, Mutters, Eckert, & Plant, 2005).

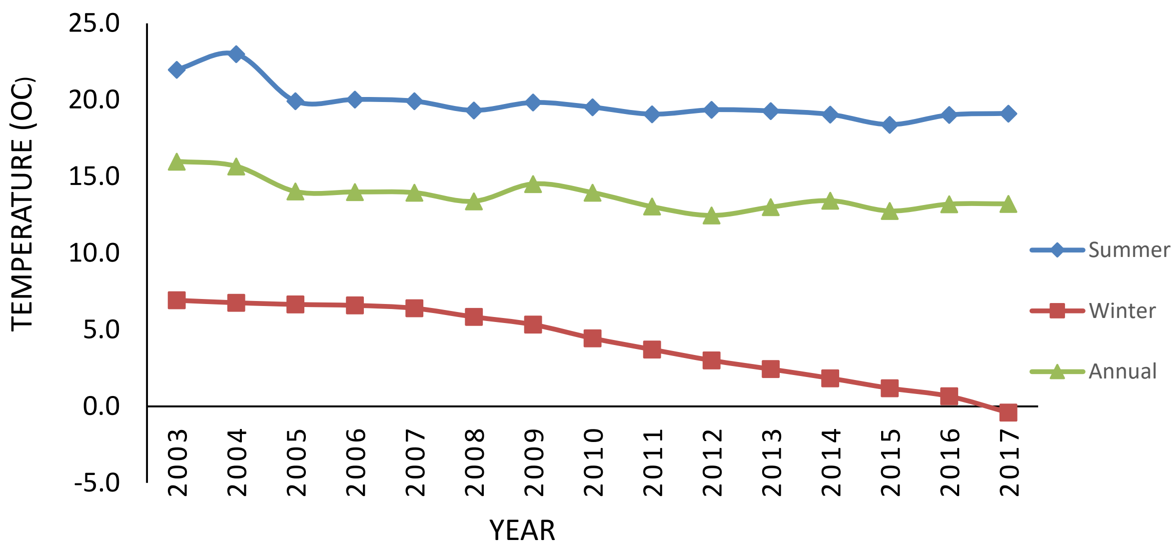

Figure 3. Average temperature of summer, winter and annual of the last 15 years

The rainfall data collected from the NCHM, Thimphu, revealed that the intensity of winter rainfall steadily increased over the last 15 years (2003-2017). There is not much variation in summer rainfall except for 2006 with exponential increase in rainfall intensity (355 mm) compared to other years.

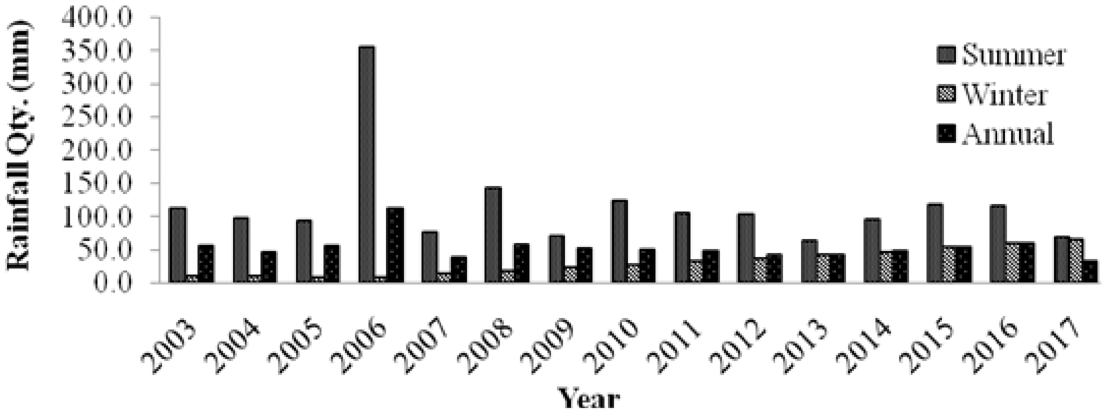

Figure 4. Average annual, summer and winter rainfall for the last 15 years

3.6 Rainfall intensity during paddy harvest and transplantation season

During paddy transplantation season, more than 60% of the respondents received enough rainfall against 37.5% who did not. Some respondents felt they received rain early by a month (2.5%) while 17.5% of the respondents felt that they received rain late by two weeks during the transplanting season.

Majority of the respondents (83.8%) believed that late monsoon rain coincided with paddy harvest. Seventy-five percent of the respondents felt that monsoon rain started in late May and ended in the second week of October (37.5%) (Table 6).

Table 6. Farmers' perception on rainfall timing during paddy transplantation season and harvest season in the last 15 years

Adequate rainfall during transplantation

		Early		Late	
	Respondents (%)		Respondents (%)		Respondents (%)
Yes	63	Two weeks	1.3	One week	2.5
No	38	Three weeks	1.3	Two weeks	18
		One month	2.5	Three weeks	3.8
				Four weeks	1.3
				One month	8.8

Rainfall during harvest season (October month)

		Start		End	
	Respondents (%)		Respondents (%)		Respondents (%)
Yes	84	First week	75	First week	33
No	15	Second week	7.5	Second week	38
		Fourth week	2.5	Third week	7.5
				Fourth week	7.5

Arrival of monsoon rain in the gewog was perceived to be late in the last 15 years according to 42% of the respondents. Figure 5 shows that 24% of the respondents were unsure about the timing of the monsoon rain. Generally, monsoon in Bhutan starts in early June, lasting through late September, and it usually brings significant amount of rainfall that triggers rise in water levels, flooding and landslides (NCHM, 2017).

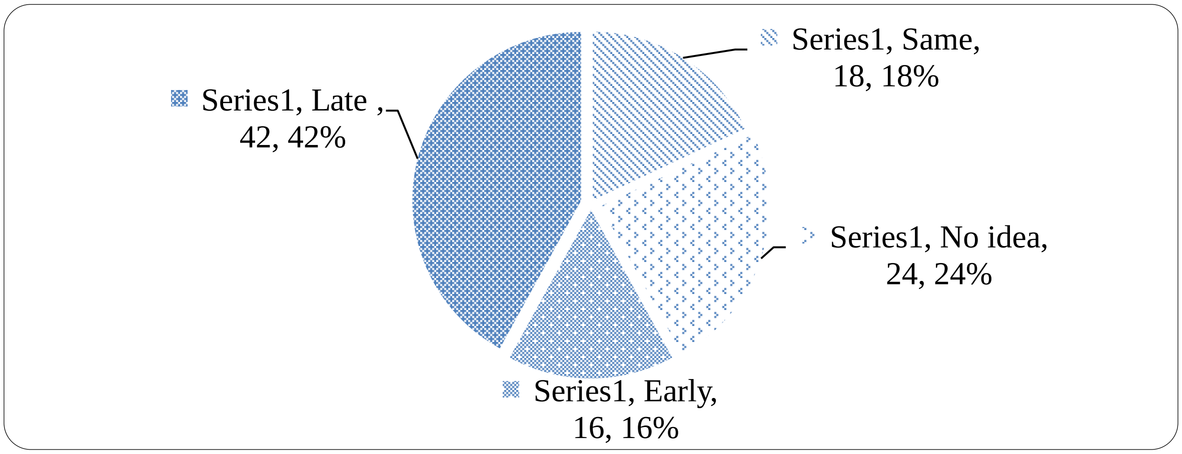

Figure 5. Respondents' perception on start of monsoon rain in the last 15 years

3.7 Paddy production variation over the last 15 years

Paddy yield has increased over the last 15 years as presented in Table 7. About 73.8% (59) of the respondents felt paddy yield increased while 26.3% (21) of them did not think so. The mean yield increased to about 1,541.1 kg/ac from 1,379.3kg/ac in 2002. At the time of this study, the maximum yield was about 2,400 kg/ac. The result is supported by agriculture statistics of the last 15 years (2003-2017). In 2003, the mean yield was 1,309 kg/ac and in 2017 the yield increased to 2,500 kg/ac.

The improvement in yield is attributed to use of improved seed varieties provided by the Dzongkhag Agriculture Sector, Paro in collaboration with the research centre in Yusipang and the National Seed Centre. Kusters & Wangdi (2013) also reported that paddy yield has been increasing because of access to improved technologies, including the use of chemical fertilizers, pesticides and improved seeds.

Table 7. Variation in paddy production for the last 15 years (2003-2017)

	%		Average Present yield (kg/ac)	Average Yield before 15 years (kg/ac)
Yes	73.8	Mean	1,541.1	1,379.3
No	26.2	Minimum	100	300
		Maximum	2,400	1,800

3.8. Climate variability impact on paddy yield

To find the relationship between climate variability and paddy yield, the average climate data of October month and paddy yield data of the last 15 years (2003- 2017) were analyzed. Pearson's correlation coefficient on paddy yield and climate variability result showed that maximum temperature (T Max) had positive correlation with paddy yield (r = .149, P = .596). There was a significant negative relationship between minimum temperature (T Min) and paddy yield (r = -.554, P = .032). Therefore, results show that grain yield decreased with increase in minimum temperature (P< .05). The mean rainfall of October month also showed negative correlation with paddy yield (r = -.381, P= .161). Results indicate that at the study site the rainfall during paddy harvest season did not impact yield.

Table 8. Relationship between paddy yield and climate variability

	T Max	T Min	Rainfall	Paddy yield
T Max	1.000	-.355	-.211	.149
Sig. (2-tailed)		.194	.449	.596
T Min		1.000	.356	-.554*
Sig. (2-tailed)			.193	.032
Rainfall			1.000	-.381
Sig. (2-tailed)				.161
Paddy yield				1.000
Sig. (2-tailed)				

* Correlation is significant at 0 .05 level (2-tailed).

3.9 Paddy loss (kg) due to natural calamities

Out of 80 respondents, only 6% experienced natural calamities such as flood, drought and hailstones impacting paddy production over the last 15 years. The study (Table 9) show that flood in 2008 and 2017 affected 3.30 acres of paddy field which resulted in a loss of 3,750 kg of paddy. In 2011 and 2018, due to less rainfall during the cropping season 1.9 ac of paddy field was affected, resulting in a loss of about 607.50 kg of paddy. In 2013 and 2014, due to hailstorm 1.3 ac of paddy field was affected that resulted in loss of about 860 kg of paddy.

The study showed (Table 9) that there was not much pest and disease outbreak associated with excessive and scanty rainfall during the cropping season. In 2013, armyworm (pest) outbreak in paddy nursery damaged around 25.2 ac. However, this did not affect production because seeds were re-sown or paddy seedlings were purchased from neighborhood within the gewog.

Table 9. Paddy quantity loss (kg) due to natural calamities

Respondents (%)		Causes	Damage area (acre)			Estimated loss (kg)		
			Min	Max	Sum	Min	Max	Sum
Yes	7.5	Flood	0.3	3	3.3	300	3,450.0	3,750.0
No	92.5	Drought	0	1	1.9	22.5	360	607.5
		Hail stone	0.3	0.6	1.3	20	600	860
		Pest outbreak due to heavy rain fall	0	0	0	0	0	0
		Disease outbreak due to heavy rain fall	0	0	0	0	0	0
		Pest outbreak due to shortage of rain fall	0	2	25.2	0	0	0
		Disease outbreak due to Shortage of rain fall	0	0	0	0	0	0
Total			0.6	6.6	31.6	342.5	4410	5217.5

3.10 Farmers' perception on cropping calendar shift

Figure 2 shows that majority of farmers (81.3%) in the study site sow paddy seeds in the first week of February and transplant the seedlings in the first week of May. Harvesting is done from the first week of October onwards. Out of 80 respondents, 25% felt the need to shift paddy cropping calendar by a week later than their earlier practice as presented in Table 10, because they felt that they receive rain a week later than the usual time. With this shift in seed sowing and transplantation time, the respondents expect to harvest their paddy crop in the second week of October month. This way paddy will not be affected by rainfall at harvest.

Seventy five percent of the respondents felt that they do not require cropping calendar shift, because weather condition is erratic anyway and therefore, they felt they will not be in a position to determine when exactly to start their work. As such they were comfortable with their usual practice. The other reason for the reluctance to shift cropping calendar was because of the traditional belief wherein wealthy farmers in the community are expected to lead the work first after performing religious rituals. Those who do not adhere to this traditional practice and who start working their fields earlier or later than the ritual ceremony, are obliged to bear all costs incurred in the event of any disaster occurring in that particular year.

Table 10. Perception on cropping calendar shifting

	Respondent (%)	Activity	Month	Respondent (%)	Week	Respondent (%)
Yes	25		Feb	22.5	1	2.5
No	75	Seed sowing	Mar	1.3	2	13.8
			Apr	1.3	3	6.3
					4	2.5
			Apr	1.3	1	6.3
		Transplantation	May	21.3	2	10
			Jun	2.5	3	6.3
					4	2.5
			Sept	1.3	2	11.3
		Harvesting	Oct	23.8	3	10
					4	3.8

3.11 Response on climate change adaptation practices

Out of 80 respondents 7.5% (6) practiced climate change adaption techniques such as shifting of cropping calendar and change of crop variety. Among three techniques such as cropping calendar shift, change of variety and rain water harvesting, 5 respondents out of 6 had adopted paddy seed replacement technique since 2012. Farmers observed that the increase in paddy yield was due to adoption of new seed variety (Yuseray Maap) in place of their local seed.

The reason for not adopting climate change adaptation practice was lack of awareness program in the gewog (73.8%). About 10% of the respondents had no idea of such techniques (Table 11). Many adaptation strategies for the agricultural sector are constrained by a lack of information on regionally specific climate change impacts on key crops (Chogyel & Kumar, 2018; Parker et al., 2017).

Table 11. Response on climate change adaptation practices

Respondent (%)		Adaptation techniques	Respondent (%)	Year of adoption	Reasons of not practicing	Respondent (%)
Yes	7.5	Cropping calendar shift	1	2014	Not interested	1.2
No	93				Expensive	1.3
					No support	6.2
		Change of variety	1.1	2012	Not aware	73.8
			1.1	2013	No idea	10
			1.2	2016		
			3.1	2018		
		Rain water harvesting	0	Nil		

3.12 Constraints on climate change adaptation practice

Out of 80 households interviewed 97.5% (78) of the respondents have not received any training on impact of climate change on agriculture (Table 12). About half (48.8%) of the respondents mentioned that they are ready to participate in any forms of climate change adaptation trainings and awareness programs. Many (32.4%) of the respondents felt that training on weather forecasting would help them. The farmers also suggested the need for information on weather forecasting for at least 10 days or more before planning field work.

Remaining 15% of the respondents felt that training on cropping calendar shift and awareness or training on cultivation of right crop at right time to combat crop loss to erratic weather conditions are also equally important for building climate resilience. According to Kusters & Wangdi (2013) adaptation practices can be enhanced through better understanding of farmers' constraints on adaptation strategies. This will also help policymakers to develop strategic interventions to minimize crop loss and damages. There is also a need to enhance resilience of farming community on the impacts of climate change through enhanced cross-sectoral strategic options such as enhanced investment, technology generation, and research and development (Chhogyel & Kumar, 2018).

Table 12. Proposed training/awareness to farming community

	Respondents (%)	Categories of training/awareness programs	Respondents (%)
Yes	2.5	Need on cropping calendar change	10
No	97.5	Timing on different crop cultivation season	5
		Weather forecasting	32.4
		Adaptation practices	3.8
		Any climate related trainings	48.8

4. Conclusion

Rice is a staple food crop of the Bhutanese people. The impact of climate change on rice productivity is of particular interest due to its importance as a major food source of the country. Bhutan is already under pressure from climate stresses which increase vulnerability to further climate change impacts and reduce adaptive capacity. The resilience of paddy production systems to changes in climate can be enhanced by improved understanding of impacts and responses of crops to changing climate.

Adverse impacts of climate change are expected to affect agriculture sector in Southeast Asia including Bhutan mainly due to increase in occurrence of droughts, intense rains, and rise in temperature. Natural calamities such as rainstorms during the harvest season and lack of rainfall during the transplantation season contribute to reduction in crop yield. There is considerable impact of the variability of rainfall and temperature on rice yield.

The major adaptation practice to climate change found in rice farming was the selection of new rice varieties for higher resilience. The major climatic factor affecting rice production in the study area is temperature (T Min). The mean rainfall in October also shows negative correlation with paddy yield. In the last 15 years (2003-2017), natural calamities such as flood, inadequate rainfall during paddy cropping season and hailstorms resulted in substantial loss of paddy. Therefore, under changing climatic conditions it is necessary to introduce crops which can withstand fluctuating temperature and other natural factors.

It is observed that climate change adaptation practices adopted by farmers are limited. This study reveals the cause for not adopting climate change adaptation practice as lack of awareness programs. Therefore, there is an urgent need for awareness and advocacy programs for the farming communities on climate change issues.

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