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Weather variations and its effect on farm productivity and returns in Imphal West district of Manipur

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ABSTRACT

Weather variations refer to the changes in the meteorological factors observed locally over a short period of time. Since farming is dependent on these factors, any changes in it will lead to change in the level of crop production. Therefore, the present study was conducted with the objective of studying the weather variations in the selected villages and its effect on farm productivity and returns. A sample of total 107 farm households was selected from two blocks of Imphal West district using simple random sampling technique without replacement method. Findings about the effect of weather variables on crop production using secondary data were mostly inconclusive with the exception of positive effect of pre-monsoon rainfall on pre-*kharif* paddy production and the negative effect of average annual maximum temperature on total oilseed production. Farmers perceived that the summers were warmer and winters were colder in the last 5 years (2016-2020). The majority reported a rise in unexpected rainfall but a decrease in the number of rainy days. Most of the households reported that extreme weather events (EWE) caused up to 20 per cent loss in net household returns. The average loss was 19.55 per cent in net household return and 33.75 per cent in case of net farm return. Hence, the study suggests encouragement of farmers to diversify their enterprises in order to reduce the extent of farm losses brought on by EWE as it provides access to additional sources of revenue outside of crop farming.

1. Introduction

Weather variations refer to a relatively short-term micro-scale phenomenon (Doblas-Reyes *et al.*, 2010). Despite meticulous microscale agronomic planning to fit the local climate, it has been reported that crops are subject to a variety of weather uncertainties from year to year. Almost every year, across different regions and seasons, a higher frequency of weather variations is observed. The most frequent one is a delay at the beginning of the crop season caused by erratic rainfall for rainfed crops as observed in semi-arid tropical regions and erratic temperature swings as observed in tropical regions, temperate zones, and subtropical areas or a continued end-of-season downpour for irrigated crops (Doblas-Reyes *et al.*, 2010). The agriculture sector is most likely to be badly impacted by the increasing weather and climatic unpredictability because production and yield are dependent on meteorological factors like rainfall, temperature, *etc.*, in many regions of the world due to the unavailability of any irrigation infrastructure (Srinivasarao *et al.*, 2020). Choudhury *et al.* (2019) examined the trend of summer monsoon rainfall in the North East (NE) region of India using gridded observed rainfall and sea surface temperature data from the last 114 years (1901-2014) and discovered that the region had seen a decline in monsoon rainfall by about 355mm over the previous 36 years. Khanum (2021) also discovered that the NE region had been experiencing fewer and fewer rainfalls each year, resulting in a drought-like situation in the states of Meghalaya, Tripura, Assam, Arunachal Pradesh, Manipur, and Mizoram, which harmed agricultural activities in the region, which is mostly rainfed.

In Manipur, the mean annual maximum temperature had risen by 0.1°C each decade between 1954 and 2014. Additionally, the average annual lowest temperature had climbed

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noticeably by 0.3°C/decade (Roy *et al.*, 2018). The productivity of agriculture in the state is largely dependent on rainfall because the irrigation facilities in Manipur are falling short of requirements (GoM, 2020). Unpredictable changes in weather have been adversely affecting farm production in the state. From 2006 to 2019, Manipur witnessed an increase in continuous heavy rainfall which led to a severe reduction in the yield of transplanted paddy, maize, pulses and oilseeds. Production of rice, vegetables and fruits, has been negatively affected due to unexpected weather variations in recent years. The farmers in the valley deal with flooded rice fields and low rainfall situations every year (Shirin, 2021). Bhattacharyya *et al.* (2021) examined the effect of meteorological factors on the yield of different agricultural crops and found that rainfall significantly influenced the yield of rice, maize, pineapple and vegetables. Most of the studies focused on long-term effects due to the change in the meteorological variables. Therefore, this paper finds out the short-term implications of weather variations and their effects on farm productivity and returns, as perceived by the farmers.

2. Materials and Methods

Secondary data on daily rainfall (2016-2020) was extracted from high resolution 0.25° x 0.25° daily gridded data and daily temperature (2016-2020) was extracted from high resolution 1° x 1° daily gridded data. Both the gridded rainfall and temperature data were obtained from India Meteorological Department (IMD) to analyze the rainfall and temperature variability in Imphal West district. The gridded data was sorted out for Imphal West district based on its latitude and longitude.

Table 2.1. Co-ordinates of rainfall and temperature stations in Imphal West district

Sl. No.	Rainfall	Temperature
1	24°30'N - 93°45'E	24°30'N - 93°30'E
2	24°45'N - 93°45'E	
3	25°00'N - 93°45'E	
4	24°30'N - 94°00'E	
5	24°45'N - 94°00'E	
6	25°00'N – 94°00'E	

The effect of weather variability was studied by two approaches: first by using secondary weather and crop production data and second by using the primary survey data. The monthly, seasonal, and annual (as specified by the IMD, March to May – pre-monsoon, June to September – monsoon and October to February – post monsoon) rainfall and temperature data from 2016 to 2020 were analysed to study the weather variations in Imphal West district. It was further analysed against rainfall and temperature data to study their possible relationship graphically and statistically using tools like correlation and linear regression after verifying the data by conducting normality tests. Paddy and oilseed production were used as dependent variables and one climatic factor *i.e.,* rainfall or temperature were used as independent variable one at a time due to limitation in the degrees of freedom. The crops considered were paddy and oilseeds as they were the most widely grown crops by the sample households. Additionally, primary data was collected from a sample of total 107 farm households selected from two blocks of Imphal West district by using simple random sampling technique without replacement method. It was analysed to study the perception of the farmers about the weather variations and its effect on farm productivity and returns.

3. Results and Discussion

The descriptive statistics for maximum and minimum seasonal and annual temperatures for the last 5 years are given in Table 3.1.1. The average maximum and minimum seasonal temperatures were highest in the monsoon season (31.24°C and 23.35°C), and lowest in the post-monsoon season (26.57°C and 13.73°C) respectively. The analysis of extreme values revealed that the seasonal maximum temperature was as high as 32.85°C in the monsoon season and as low as 22.00°C in the post-monsoon season. Similarly, the seasonal minimum temperature was the highest in the monsoon season (24.11°C) and lowest in the post-monsoon season (8.88°C). The maximum and minimum average annual temperatures were 28.80°C and 18.08°C, respectively in the district during the study period.

Table 3.1.1. Seasonal and annual temperatures in Imphal West district (2016–2020)

Particulars	Minimum temperature (in °C)				Maximum temperature (in °C)			
	Average	Range		SD	Average	Range		SD
		Maximum	Minimum			Maximum	Minimum	
Pre-monsoon	18.41	20.99	14.83	0.33	29.27	30.48	27.00	0.32
Monsoon	23.35	24.11	22.75	0.13	31.24	32.85	30.16	0.30
Post- monsoon	13.73	22.16	8.88	0.44	26.57	31.53	22.00	0.57
Annual	18.08	24.11	8.88	0.21	28.80	32.85	22.00	0.22

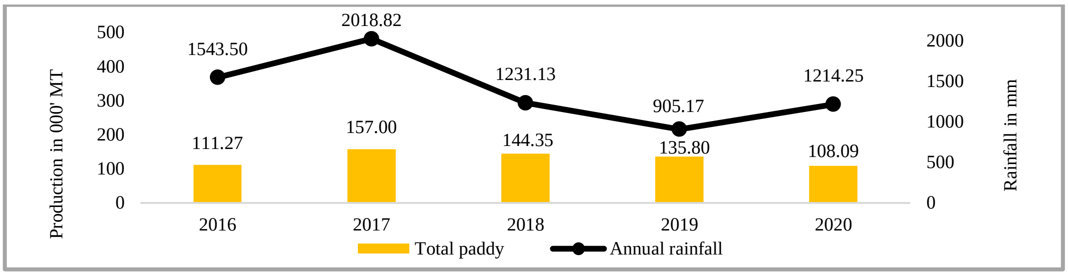
Table 3.1.2. Seasonal and annual rainfall in Imphal West district (2016–2020)

Particulars (in mm)	Extreme values		Average rainfall	Percentage contribution	CV (%)
	Maximum	Minimum			
Pre-monsoon	562.43	176.78	381.01	27.56	46.39
Monsoon	1101.38	562.32	788.99	57.07	24.94
Post-monsoon	355.00	73.43	212.57	15.37	48.97
Annual rainfall	2018.82	905.17	1382.57	-	30.47

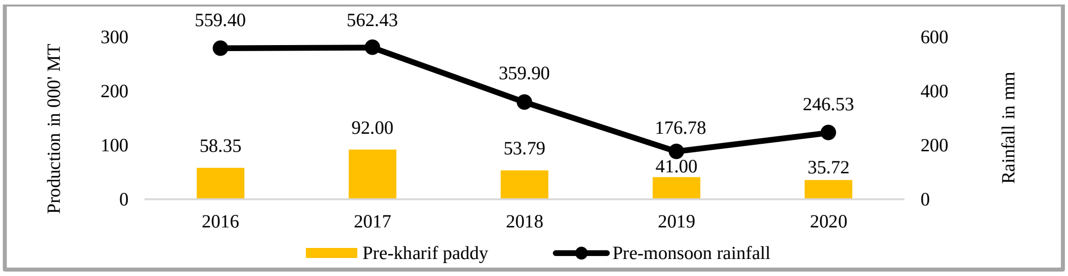
The data on rainfall was divided into three seasons: pre-monsoon (March to May), monsoon (June to September), and post-monsoon (October to February). The estimated statistics are presented in Table 3.1.2. In the last 5 years, the highest average seasonal rainfall was observed in the monsoon season (788.99 mm) contributing about 57.07 per cent of the annual rainfall, followed by pre-monsoon (27.56%) and post-monsoon (15.37%) seasons. The highest seasonal rainfall of 1101.38 mm was received in the monsoon season whereas the seasonal rainfall was least in the post-monsoon season (73.43 mm). The inter-year variations in seasonal rainfall in the post-monsoon (48.97%) and pre-monsoon (46.39%) seasons were quite high. The annual average rainfall in Imphal West district was 1382.57 mm during the study period, with a maximum annual rainfall value of 2018.82 mm and a minimum of 905.17 mm. The inter-year variation in annual rainfall was calculated to be 30.47 per cent during 2016-2020.

3.2 Effect of weather variables on production of paddy and oilseed in Imphal West district (2016-2020)

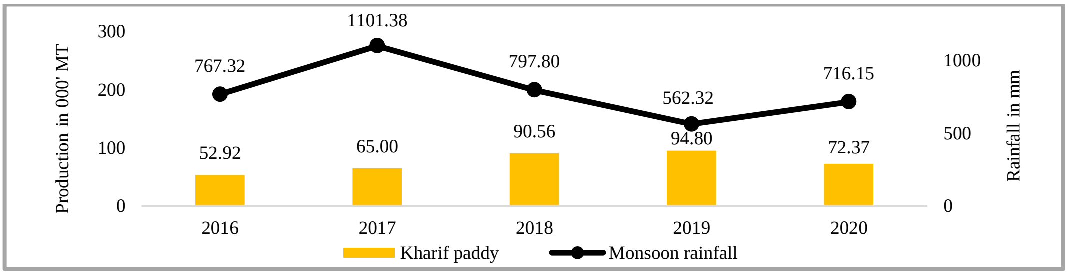
3.2.1 Effect of annual and seasonal rainfall on paddy production (2016-2020)



(a) Total paddy production



(b) Pre-*kharif* rice production



(c) *Kharif* paddy production

Figure. 3.2.1.1. Graphical representation of the relationship between paddy production and annual and seasonal rainfall in Imphal West district (2016-2020)

The total, pre-*kharif* and *kharif* paddy productions in Imphal West district were plotted against rainfall for the last 5 years (2016-2020) in Fig. 3.2.1.1. The total paddy production increased from 111.27 thousand MT in 2016 to 157 thousand MT when the district registered an increase in annual rainfall from 1543.50 mm in 2016 to 2018.82 mm in 2017. In the next consecutive two years, annual rainfall declined to 1231.13 mm and 905.17 mm, when the total paddy production also declined to 144.35 thousand MT in 2018 and 135.80 thousand MT in 2019. The production dipped further to 108 thousand MT in 2020, despite an increase in annual rainfall, which could be attributed to the major reduction in the area under paddy cultivation from 42.58 thousand ha in 2019 to 33.46 thousand ha in 2020 (GoM, 2022).

The pre-*kharif* paddy production in Imphal West was highest in the year 2017 (92 thousand MT) which coincided with the highest pre-*kharif* rainfall of 562.43 mm during the last 5 years under study. Next two years, pre-*kharif* rainfall declined significantly to 359.9 mm and 176.78 mm when the pre-*kharif* paddy production also declined to 53.79 thousand MT and 41 thousand MT in 2018 and 2019, respectively. Though pre-*kharif* rainfall increased slightly in 2020 but, pre-*kharif* production went down marginally. This could be explained by the reduction in the area under pre-*kharif* paddy from 13 thousand ha to 9.40 thousand ha (GoM, 2022). In the case of *kharif* paddy, the production level increased from 52.92 thousand MT in 2016 to 65 thousand MT in 2017 when the monsoon rainfall also increased. In the next two years, though the monsoon rainfall declined to 797.8 mm and 562.32 mm, the production showed a steady increase from 90.56 thousand MT and 94.80 thousand MT. The *kharif* paddy production declined drastically to 72.37 thousand MT in 2020 despite a slight improvement in monsoons rainfall which could be due to a reduction in the area under production from 29.58 thousand ha to 24.06 thousand ha (GoM, 2022).

The correlation coefficient and the slope coefficient output of annual and seasonal rainfall with paddy production are presented in Table 3.2.1.1

Table 3.2.1.1. Correlation and regression output of annual and seasonal rainfall against annual and seasonal production of paddy

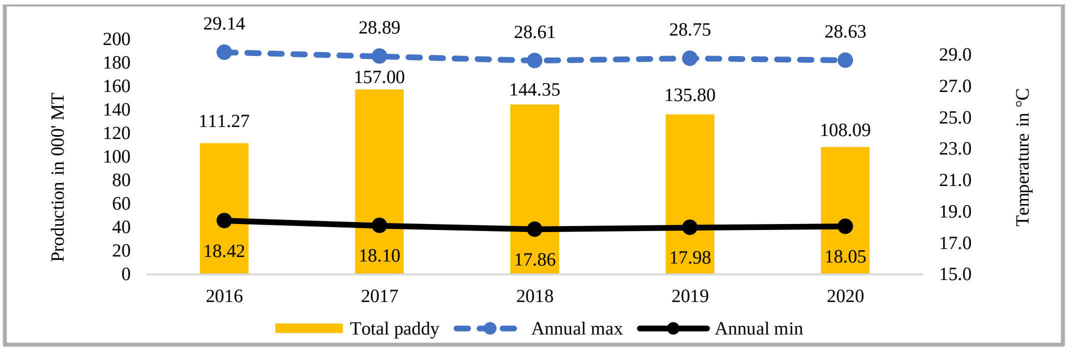
Rainfall	Correlation		Regression		
	r	p	β_2	p	r^2
Annual	0.362	0.549	0.0181	0.549	0.13
Pre-monsoon	0.820*	0.089	0.1023*	0.089	0.67
Monsoon	-0.493	0.398	-0.0439	0.398	0.24

*Significant at 10% level

It was found that there was a significant positive correlation ($r=0.82$, $p<0.10$) between pre-monsoon rainfall and pre-*kharif* paddy production. It was also found that the quantum of pre-monsoon rainfall had a significant effect ($\beta_2 = 0.102$, $p<0.10$) on the pre-*kharif* production of paddy. The annual and monsoon rainfall had a positive and negative influence on the annual and *kharif* paddy production respectively but were statistically insignificant.

3.2.2 Effect of annual and seasonal temperature on paddy production (2016-2020)

The total, pre-*kharif* and *kharif* paddy productions in Imphal West district were plotted against annual and seasonal temperatures for the last 5 years (2016-2020) in Fig. 3.2.2.1, Fig. 3.2.2.2 and Fig. 3.2.2.3 respectively.



Note: Annual max= Average annual maximum temperature, Annual min= Average annual minimum temperature

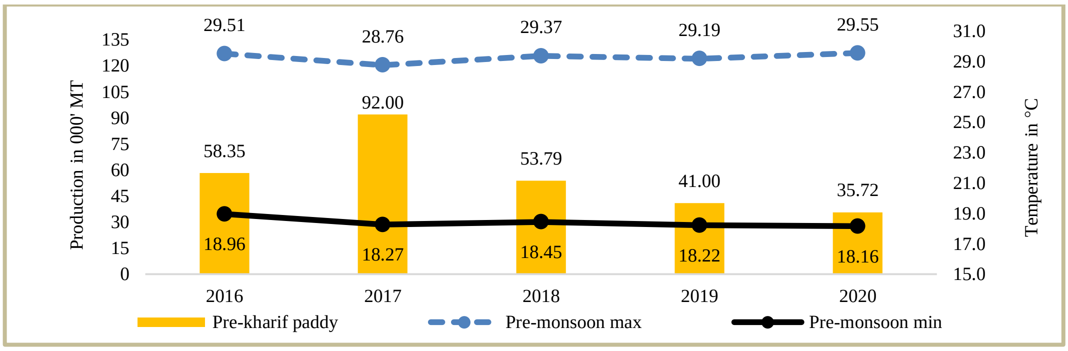
Figure. 3.2.2.1. Graphical representation of the relationship between total paddy production and annual temperatures in Imphal West district (2016-2020)

The total production of paddy increased from 111.27 thousand MT in 2016 to a maximum production of 157 thousand MT in 2017, following which it saw a year-on-year decline till 2020 to 108.09 thousand MT. The annual average maximum temperature, however, was the highest (29.14 °C) in the year 2016 and saw a drop in the next two consecutive years to 28.89°C in 2017 and 28.61°C in 2018. It saw a minor increase to 28.75°C in the year 2019, followed by a marginal fall again to 28.63°C (Fig. 3.2.2.1). No clear-cut relationship between annual average maximum temperature and total paddy production could be visualised from the figure. The annual average minimum temperature also showed a similar pattern, where it was the highest (18.42°C) in the base year (2016), followed by a drop in the next two consecutive years to 18.10°C in 2017 and 17.86°C in 2018. It increased to 17.98°C in 2019, followed by a further marginal increase to 18.05°C in 2020 (Fig. 3.2.2.1).

Table 3.2.2.1 Correlation and regression output of annual and seasonal temperature against annual and seasonal production of paddy

Temperature	Correlation		Regression		
	r	p	β_2	p	r^2
Annual average maximum	-0.178	0.777	-17.037	0.777	0.03
Annual average minimum	-0.504	0.387	-50.895	0.387	0.25
Pre-monsoon maximum average	-0.795	0.108	-54.571	0.109	0.63
Pre-monsoon minimum average	0.143	0.819	9.668	0.818	0.02
Monsoon maximum average	0.338	0.578	19.943	0.578	0.11
Monsoon minimum average	0.556	0.330	71.712	0.330	0.31

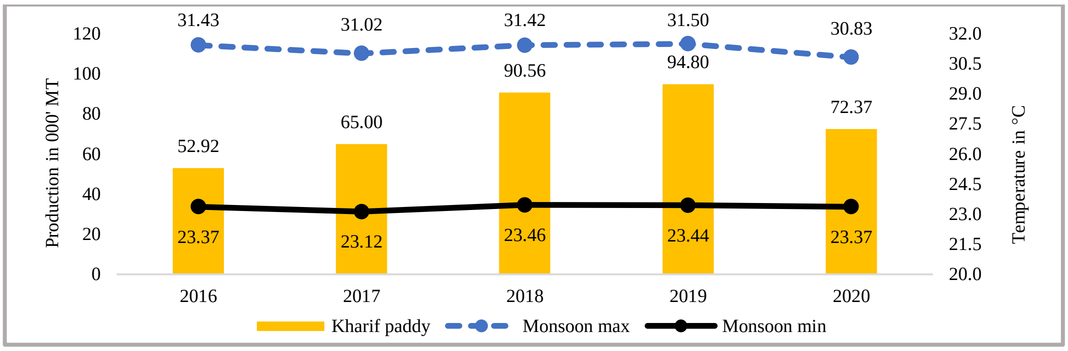
The correlation coefficient and the slope coefficient output of the annual and seasonal paddy production with annual and seasonal temperatures are presented in Table 3.2.2.1. It was observed that even though, a high negative correlation coefficient was observed between the annual average minimum temperature and total paddy production, it turned out to be insignificant, including the regression coefficient for the same. Similarly, no significant relationship was found between annual average maximum temperature and total paddy production.



Note: Pre-monsoon max=Pre-monsoon average maximum temperature, Pre-monsoon min=Pre-monsoon average minimum temperature

Figure. 3.2.2.2. Graphical representation of the relationship between pre-*kharif* paddy production and pre-monsoon temperatures in Imphal West district (2016-2020)

The pre-*kharif* paddy production increased significantly from 58.35 thousand MT to 92 thousand MT when both average minimum (-0.69°C) and maximum (-0.75°C) pre-monsoon temperature declined. The pre-*kharif* production declined consecutively for the next three years in the district when the average pre-monsoon maximum temperatures were higher than in 2017 but the pre-monsoon average minimum temperature increased to 18.45°C in 2018 and then declined in 2019 and 2020 (Fig. 3.2.2.2). It was observed that there was a very high negative correlation between average pre-monsoon maximum temperature and pre-*kharif* paddy production in the district, however, it was not statistically significant. In the same way, there was no relationship between the pre-monsoon average minimum temperature and pre-*kharif* paddy production. The calculated regression coefficients also turned out to be insignificant (Table 3.2.2.1).



Note: Monsoon max=Monsoon average maximum temperature, Monsoon min=Monsoon average minimum temperature

Figure. 3.2.2.3. Graphical representation of the relationship between *kharif* paddy production and monsoon temperatures in Imphal West district (2016-2020)

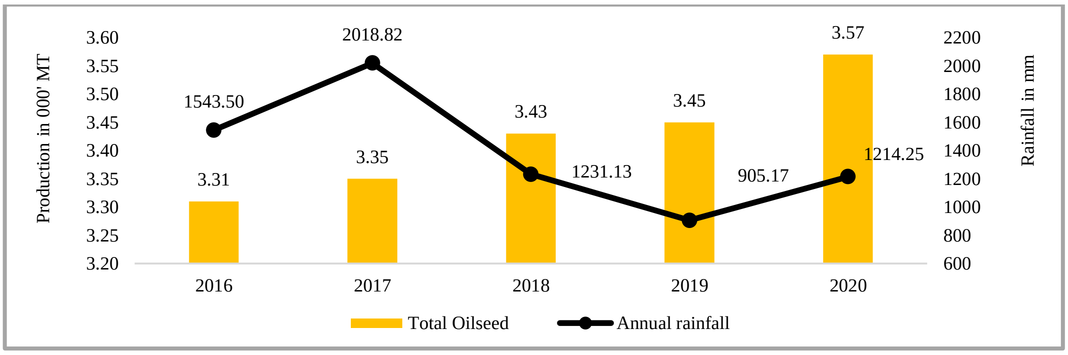
The monsoon average maximum temperature dropped from 31.43°C in 2016 to 31.02°C in 2017, while the *kharif* paddy production registered an increase in production. It also experienced an increase in the next two consecutive years, when the monsoon maximum temperature also rose to 31.42°C and 31.50°C in 2018 and 2019 respectively, followed by a decrease in the year 2020 to 30.83°C, along with a fall in *kharif* paddy production (Fig.3.2.2.3). The monsoon average minimum temperature decreased in 2017 from 23.37°C in 2016 to 23.12°C. It increased to 23.46°C in 2018, followed by a marginal fall in the next two consecutive years to 23.44°C in 2019 and to 23.37°C in 2020 (Fig.3.2.2.3). Even though there was a positive correlation between monsoon average minimum temperature and *kharif* paddy production in the district, it was not significant statistically. The regression coefficients also suggested that there was no significant effect of monsoon temperature on *kharif* paddy production (Table 3.2.2.1).

3.2.3 Effect of annual and seasonal rainfall and temperature on oilseed production (2016-2020)

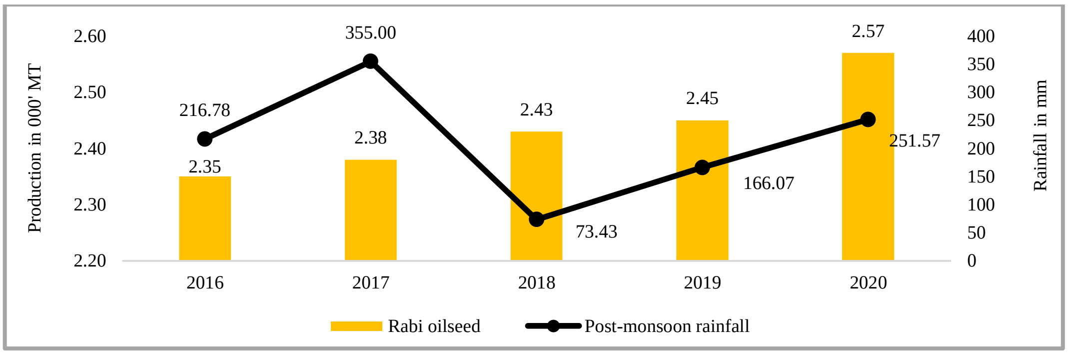
The total and post-monsoon oilseed production in *Imphal* West district was plotted against rainfall for the last 5 years (2016-2020) in Fig. 3.2.3.1. The total oilseed production increased marginally from 3.31 thousand MT in 2016 to 3.35 thousand MT in 2017, when the district recorded an increase in rainfall from 1543 mm to 2018 mm. The next two consecutive years saw a decline in rainfall to 1231 mm and 905 mm, but the total oilseed production increased to 3.43 thousand MT in 2018 and 3.45 thousand MT in 2019. The production increased significantly in 2020 (3.57 thousand MT) when the rainfall increased to 1214.24 mm.

In the case of *rabi* oilseed, the production increased from 2.35 thousand MT in 2016 to 2.38 thousand MT in 2017, while the post-monsoon rainfall also increased from 216.78 mm in 2016 to 355 mm in 2017. The district experienced a steep drop in post-monsoon rainfall to 73.43 mm in 2018, however, the production still increased to 2.43 thousand MT. The production showed a consistent increase to 2.45 thousand MT in 2019 and then to 2.57 thousand MT in 2020 when the rainfall also increased to 166.07 mm in 2019 and then to 251.57 mm in 2020.

The correlation coefficient and the slope coefficient output of annual and post-monsoon rainfall with oilseed production are presented in Table 3.2.3.1.



(a) Total oilseed production



(b) *Rabi* oilseed production

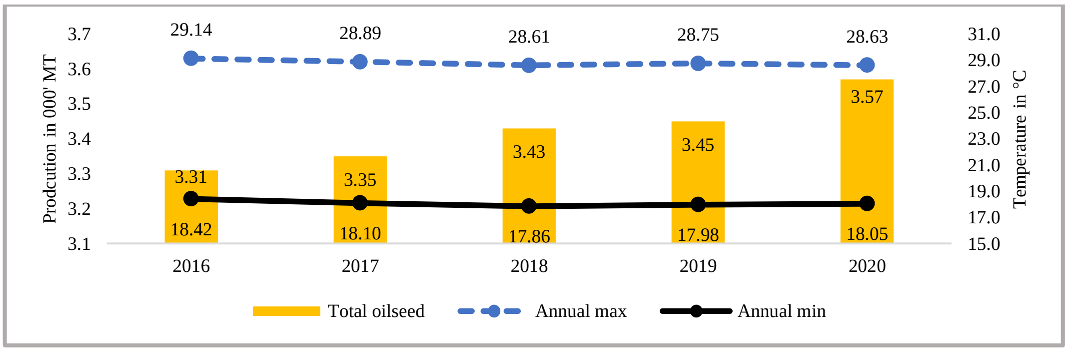
Figure 3.2.3.1. Graphical representation of the relationship between oilseed production and annual and seasonal rainfall in Imphal West district (2016-2020)

Table 3.2.3.1. Correlation and regression output of annual and seasonal rainfall against annual and seasonal production of oilseed

Rainfall	Correlation		Regression		
	r	p	β_2	p	r^2
Annual	-0.609	0.275	-0.0001	0.275	0.37
Post-monsoon	-0.083	0.894	-6.757×10^{-5}	0.894	0.01

Though the calculated correlation coefficient for annual rainfall was high, it was not significant. Similarly, there was no significant relationship between post-monsoon rainfall and *rabi* oilseed production in the district. The regression coefficients were found to be statistically insignificant as well.

3.2.4 Effect of annual and seasonal rainfall and temperature on oilseed production (2016-2020)



Note: Annual max= Average annual maximum temperature, Annual min= Average annual minimum temperature

Figure. 3.2.4.1. Graphical representation of the relationship between total oilseed production and annual temperature in Imphal West district (2016-2020)

The total and post-monsoon oilseed production in the Imphal West district was plotted against annual and seasonal rainfall for the last 5 years (2016-2020) in Fig. 3.2.4.1 and Fig. 3.2.4.2. The total oilseed production increased for three consecutive years from 3.31 thousand MT in 2016 to 3.43 thousand MT in 2018, when the annual average maximum temperature saw a decline from 29.14°C in 2016 to 28.61°C in 2018. The annual average maximum temperature increased marginally to 28.75°C in 2019, followed by a marginal decrease to 28.63°C in 2020, but the total oilseed production in the district continued to increase to 3.45 thousand MT and then to 3.57 thousand MT in 2019 and 2020 respectively. Similarly, the annual average minimum temperature registered a year-on-year decline from 18.42°C in 2016 to 17.86°C in 2018 but increased marginally in the following years of 2019 and 2020.

Table 3.2.4.1 reveals that there was a very high and significant negative correlation between average annual maximum temperature and total oilseed production ($r= -0.83$, $p<0.10$). The effect of average annual maximum temperature on total oilseed production was negative and significant ($\beta_2 = -0.379$, $p<0.10$). Although there was a high negative correlation observed between the average annual minimum temperature and total oilseed production, it was found to be insignificant.

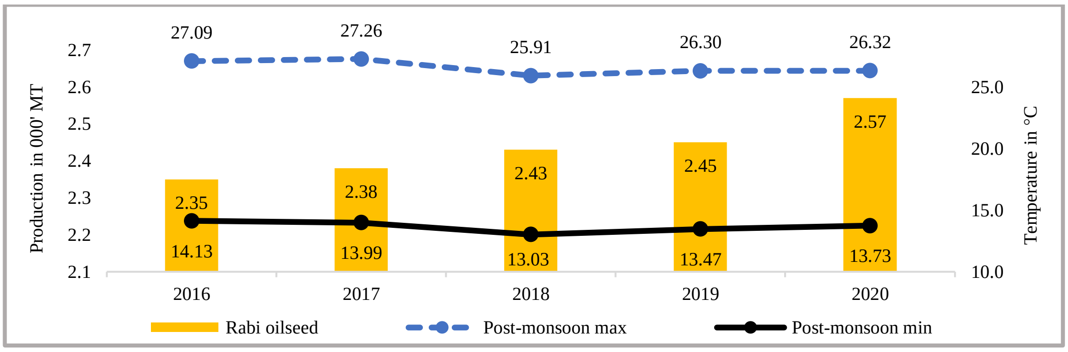
Table 3.2.4.1. Correlation and regression output of annual and seasonal temperature against annual and seasonal production of oilseed

Temperature	Correlation		Regression		
	r	p	β_2	p	r^2
Annual maximum average	-0.826*	0.085	-0.379*	0.085	0.68
Annual minimum average	-0.576	0.309	-0.277	0.309	0.33
Post-monsoon maximum average	-0.601	0.285	-0.089	0.285	0.36
Post-monsoon minimum average	-0.326	0.592	-0.063	0.592	0.11

*Significant at 10% level

The *rabi* oilseed registered a steady increase in production from 2.35 thousand MT in 2016 to 2.57 thousand MT in 2020. The post-monsoon average maximum temperature in contrast, marginally increased from 27.09°C in 2016 to 27.26°C in 2017, followed by a decrease to 25.91°C in 2018. It increased in the year 2019 to 26.30°C and again marginally to 26.32°C in 2020.

The post-monsoon average minimum temperature was the highest in the base year, after which it declined marginally for the next two consecutive years to 13.99°C in 2017 and to 13.03°C in 2018. It kept increasing in the following two years to 13.47°C in 2019 and 13.73°C in 2020.



Note: Post-monsoon max= post-monsoon average maximum temperature, Post-monsoon min= post-monsoon average minimum temperature

Figure 3.2.4.2. Graphical representation of the relationship between *rabi* oilseed production and post-monsoon temperature in Imphal West district (2016-2020)

A negative but insignificant correlation was found between post-monsoon maximum temperature average and *rabi* oilseed production. The regression coefficients also showed that there was no significant effect of post-monsoon temperatures on *rabi* oilseed production (Table 3.2.4.1).

3.3 Perception of farmers about weather variations and its effect on farm productivity and returns (2016-2020)

The majority of the respondents (47.66%) experienced high rainfall or submergence situations in the study area in the last five years. About 33 per cent reported that they experienced drought or low rainfall conditions whereas 19.63 per cent stated that they faced no weather-related stress at all (Fig. 3.3.1).

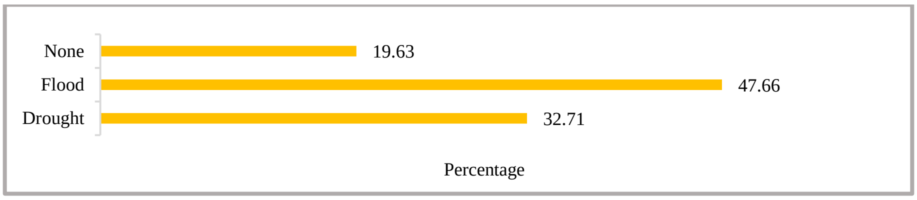
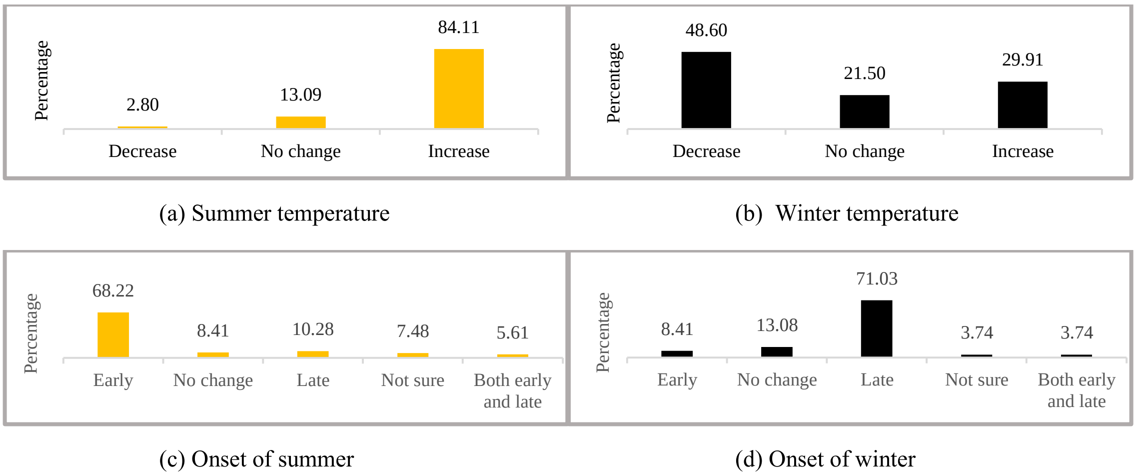


Figure. 3.3.1. Weather stress faced by the farm households

3.3.1 Perception of summer and winter season

The perception of respondents about the changes in summer and winter seasons in the last 5 years (2016-2020) is depicted in Fig. 3.3.1.1.



(a) Summer temperature (b) Winter temperature

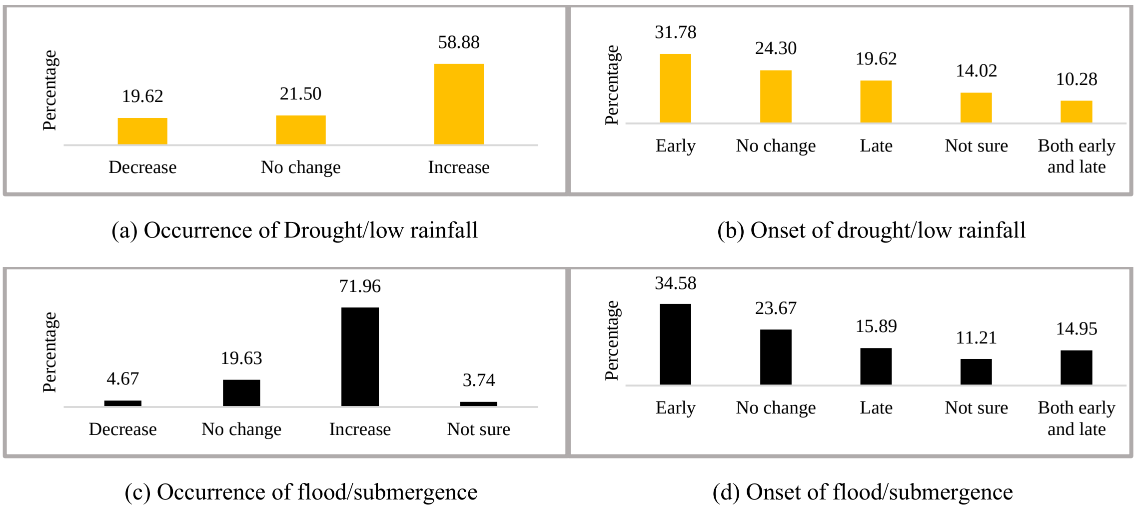
(c) Onset of summer (d) Onset of winter

Figure. 3.3.1.1. Perception of farmers about the summer and winter season intensity and timing

When asked about the experience of the summer season over the last 5 years, 84.11 per cent of the respondents felt that the summer temperature has increased considerably from the temperature 5 years back. The majority of them also felt that the summer season was arriving sooner than usual (68.22%). Almost half of the respondents (48.60%) felt that the winters were colder than usual in the last 5 years, while around 30 per cent of people stated that the winters were actually warmer. About 22 per cent of the respondents didn't notice any change in winter. However, the majority of them (71.03%) noticed that the winter season has been delayed.

3.3.2 Perception about drought and flood incidence

Majority of respondents (58.88%), stated that they had frequent experiences with drought/low rainfall circumstances over the previous five years (Fig. 3.3.2.1). Approximately 32 per cent of the households reported that they experienced a higher frequency of early-season instances of low rainfall conditions, whereas 24 per cent claimed that they noticed no change in the timing. An increase in submergence conditions in the fields over the last 5 years was reported by 72 per cent of the sampled respondents. About 35 per cent of them claimed to have encountered submergence situations earlier than normal, while 23.67 per cent saw no difference in timing.



(a) Occurrence of Drought/low rainfall (b) Onset of drought/low rainfall

(c) Occurrence of flood/submergence (d) Onset of flood/submergence

Figure. 3.3.2.1. Perception of farmers about the occurrence of drought/low rainfall and flood/submergence conditions along with their timings

3.4 Effect of weather variations on farm returns

The reduction in crop productivity, net farm returns and net household returns due to weather variations are depicted in Fig.3.4.1.

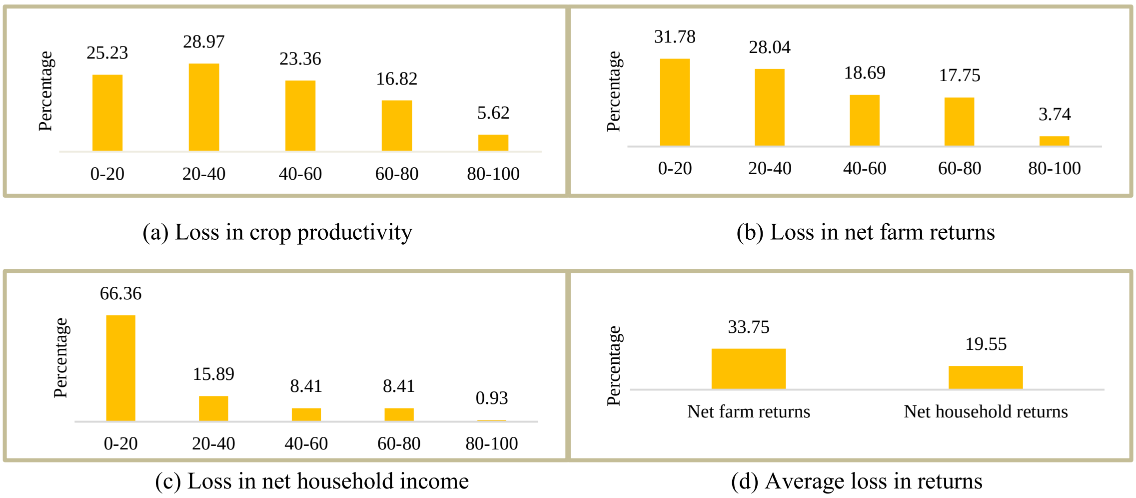


Figure. 3.4.1. Effect of weather variations on farm productivity, net farm returns and net household income

More than half of the sample households (54.2%) reported up to 40 per cent reduction in crop productivity in the last 5 years due to extreme weather events (EWE). Approximately 23 per cent of the households faced crop loss ranging from 40 to 60 per cent, while 16.82 per cent of the households faced crop loss ranging from 60 to 80 per cent. Complete crop failure was reported by only 5.62 per cent of the households. In years with EWE, almost 60 per cent of the sample households faced up to 40 per cent reduction in net farm returns, while 18.69 per cent faced a reduction in the range of 40 to 60 per cent. Loss in net farm returns by 60 to 80 per cent was reported by 17.75 per cent of households whereas only 3.74 per cent of the households reported having almost no returns. This minor shift can be explained by the mixed farming systems which were followed by the majority of the selected farm households. The net household returns, however, did not see much reduction in the years with EWE, as a majority of the households (66.36%) reported a reduction of up to 20 per cent only. This could be attributed to the fact that all the households had both primary and secondary occupations apart from farming, like government jobs, private jobs, business and other employment activities *viz*., driving, weaving, *etc*. The average loss in net farm returns was around 34 per cent, while it was 20 per cent for net household returns.

4. Conclusions

The analysis of the data revealed that there was largely no conclusive association between crop production and weather variables, with the exception of pre-monsoon rainfall with pre-*kharif* paddy production which had positive effect, and annual average maximum temperature with total oilseed production which had negative effect. The majority of the respondents reported that they witnessed high rainfall or submergence condition in the study area over the last five years. They also reported experiencing warmer summers and colder winters which were in line with the observed values. Most of them perceived that the total annual rainy days have declined but the occurrence of unexpected rainfall had increased considerably. Every household had a primary and secondary occupation besides farming such as a government job, a job in the private sector, business, or some other type of employment like weaving, driving, *etc.* which accounted for the little decline in net household returns during the years with EWE. Government agencies may also take action to encourage farmers to diversify their enterprises in order to lessen farm losses brought on by EWE since this will provide them access to additional sources of revenue outside of crop farming alone.

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