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The effects of climate change on rice yield of Pampanga

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Abstract

This study aims to analyze the effects of climate change on rice yield of Pampanga. The climate and yield used was for a period of 20 years between 1998 to 2017.

Descriptive and inferential methods of research were utilized. The rice production in Pampanga showed an increasing trend within the 20 year period. The irrigated rice comprised 97% of the total rice yield while the remaining 3% came from rainfed rice. The correlation of rice yield vs. rainfall and temperature was also examined. It was found out that there is a no significant relationship between rice yield and temperature. While the relationship of rain fall and rice yield is inverse and significant. Taking into account the monthly averages of rainfall and temperature as well as the climatic needs of the different stages of development of rice, a new cropping calendar was proposed. The current cropping calendar is proposed to be moved one month forward so that the ripening phase which is susceptible to excess rainfall be moved to a month where less amount of rain is expected. The results of this research will be communicated to the farmers of Pampanga once approved and examined by the concern government agencies.

Introduction

Climate change is a broad range of global phenomena which is primarily and mostly created by burning fossil fuels, which add heat-trapping gases to the Earth's atmosphere (NASA, 2016). It is one of the biggest challenges facing humanity in the 21st century. The Intergovernmental Panel on Climate Change (IPCC) predicted that throughout the century, climate change will have an effect on the economic growth, food security and crop production (Navarro, 2017). Climate change is a long-term behavior of atmosphere for 30 years.

The impact of climate change on crop yields are estimated to be different in various areas. In some areas, crop yields will increase, and for other areas it will decrease depending on the latitude of the area and irrigation application. Climate change impacts on soil water balance will lead to changes of soil evaporation and plant transpiration, therefore, the crop growth period may shorten in the future impacting on water productivity. (Yinhong et al., 2009)

A chico, coconut and dragon fruit. There are 20 municipalities, two cities, and 538 *barangays*. The province has two pronounced seasons: dry from November to April and wet from May to October. The heaviest rains come in July and sometimes last until October. These rains bring severe flooding to several municipalities. Average temperatures range from an average minimum of 24 degrees Celsius, usually in January, to a maximum of 30 degrees, occurring in May (Delgado et al., 2006).

Harvesting losses are physical grain losses during harvesting. Losses occur at all operations of harvesting and can reach 20% or even higher. To minimize harvest losses it is necessary to count the different losses. Once you know in which operations you have the biggest losses you can optimize these operations (Rickman et al., 2016)

The objective of this study was to study the effects of climate change on rice yield of Pampanga from 1998-2017. It specifically aimed to: describe the temperature, rainfall, rice yield and rice yield losses, relationship between rainfall, temperature, rice yield and rice yield losses, and create a corrective action plan for the farmers in Pampanga.

Methodology

Descriptive and inferential methods of research were applied in this study. Excel and SPSS were used as the research instruments. Bar and Pie graphs were used to show the graphical representation of the data. Trend line was used to determine the pattern of the data. Pearson's Correlationand Spearman's Correlation was used to determine the relationship of the variables.

The datasets in this study were gathered from Philippine Statistics Authority (PSA), San Fernando, Pampanga, Department of Agriculture Office of the Secretary, Quezon City, Department of Agriculture Region 3, San Fernando, Pampanga, and Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Clark, Pampanga.

Results and Discussion

This chapter deals with the analysis and interpretation of data. The gathered data were presented in accordance with the specific problems of this study.

Climate change as described by temperature

Temperature

The average temperature per year of Pampanga as seen in Figure 1.1 is inconsistent. It ranges from 26.62°C to 28.31°C. The trend is positive. It is increasing for the past years. Figure 1.1.1 shows the temperature level of Pampanga per quarter. The lowest recorded temperature for the past 20 years happened in Quarter 1 which is equivalent to the months of January, February and March. On the other hand, the highest recorded temperature happened on the Quarter 2 which corresponds to the month of April, May and June.Figure 1.1.2 shows the temperature anomaly from the annual average temperature. The formula in getting the monthly anomalies is: **MONTHLY ANOMALY = Average Value – Actual Value.** A positive anomaly means that the temperature was warmer than normal; a negative anomaly indicates that the temperature was cooler than normal. Figure 1.1.2 shows the of the temperature anomaly. As observed, all the months varied above the mean. They are all considered as positive anomalies. The months April, May and June obtained the highest anomaly which means that the temperature in these months are high.

CLIMATE CHANGE AS DESCRIBED BY RAINFALL

Rainfall

The data for rainfall were averaged according to year. The changes in rainfall of Pampanga as seen in Figure 1.2 is inconsistent. There are extreme rainfall counts that occurred in 1999 and 2002. Based on Figure 1.2.1, the most number of rainfall that occurred for the past 20 years is in Quarter 3 which corresponds to the month of July, August and September. On the other hand, the quarter that got the lowest rainfall count is the Quarter 1 which is equivalent to the month of January, February and March.Figure 1.2.2 shows the rainfall anomaly of Pampanga. Only the month of November got a positive anomaly. The rest of the months obtained a negative anomaly. This means that the rainfall on the remaining months were greater than the average value of rainfall for 20 years.

RICE YIELD OF PAMPANGA

Figure 2 shows that the rice yield of Pampanga obtained a positive trend. This means that the rice production of Pampanga is increasing for the past years.The rice yield of Pampanga were graphically presented per quarter. Based on Figure 2.1, Quarter 1 obtained the highest rice production with a 121,762.65 tons. This quarter is the dry season. During the dry season, when there is abundant sunlight, the rice plants produce more yield compared during the rainy season. This is because the rice plants receive greater solar radiation during the dry season. Quarter 3 obtained the least because this quarter is said to be the wet season. During the wet season, the rice do not get enough light energy therefore they produce less grains (Pinoy Rice Knowledge Bank, 2018).Figure 2.2 shows the two classifications of rice environment: irrigated and rainfed rice cultivation. The yield of irrigated rice contributes

97% to the total rice yield while the yield of rainfed rice provided the remaining. 3% of the total rice yield.

Rice yield losses

Figure 3 graphically presents the rice yield losses of Pampanga. These losses were caused by typhoons, tropical cyclones, tropical storms, and Southwest Monsoon. 2011 acquired the highest damage in rice yield from 2011-2018. This was caused by the Typhoons Egay, Falcon and Pedring. 2017 obtained the least damage with a losses of 245.32 metric tons. The rice yield losses have a negative trend. It decreases for the past years.

Impact assessment between climate change and rice yield

Effects of temperature and rainfall on rice yield

Pearson's correlation was used to determine if there exist a significant relationship between climate change and rice yield of Pampanga from 1998-2017.As seen on Table 4.1, computed r-value (-.083) and p-value (.463) implies slight inverse and not significant relationship between temperature and rice yield.Table 4.2, shows that computed r-value (-.382) and p-value (.000) implies low inverse and significant relationship between rainfall and rice yield. This result revealed that when rainfall decreases, the yield in rice will increase.

Since the rice yield has a significant relationship with rainfall, Linear Regression Analysis was used to determine the value of the dependent variable which is the rice yield. The regression equation was constructed: **RICE YIELD = 914,479.894 – 28.635(RAINFALL)**. This is derived from the equation of Y = a + bx, where *Y* is the dependent variable, *a* is the constant and the predicted value of Y when x=0, *b* is the independent variable and *x* is the predictor variable. Since the B is negative, this means that for every 1-unit increase in rainfall, the rice yield will decrease by the 28.635.

Effects of temperature and rainfall on yield of irrigated rice

Pearson's correlation was used to determine

If there exist a significant relationship between the temperature, rainfall and yield of irrigated rice of Pampanga from 1998-2017.Table 4.3, shows that computed r-value (-.061) and p-value (.592) implies slight inverse and not significant relationship between temperature and yield of irrigated rice. Table 4.4, shows that computed r-value (-.378) and p-value (.001) implies low inverse and significant relationship between rainfall and yield of irrigated rice. This result revealed that when rainfall decreases, the yield irrigated rice will increase.

Effects of temperature and rainfall on yield of rainfed rice

Pearson's correlation was used to determine if there exist a significant relationship between climate change and yield of rainfed rice of Pampanga from 1998-2017. Table 4.5, shows that computed r-value (-.238) and p-value (.033) implies low inverse and significant relationship between temperature and yield of rainfed rice. This result revealed that when temperature increases, the yield in rainfed rice will decrease. Table 4.5, shows that computed r-value (-.129) and p-value (.254) implies slight inverse and not significant relationship between rainfall and yield of rainfed rice.

Impact assessment between climate change and rice yield losses

Effects of temperature and rainfall on rice yield losses

Spearman's Correlation was used since the given samples are only eight. This test determines if there exist a significant relationship between climate change and the rice yield losses of Pampanga from 1998-2017.As seen on Table 5.1, computed r_s-value (-.762) and p-value (.028) implies high inverse and significant relationship between temperature and rice yield losses. This means that when temperature increases, the rice yield losses will decrease. Table 5.2 shows the computed r_s-value (.833) and p-value (.010) which implies a very high and significant relationship between rainfall and rice yield losses. This means that when rainfall increases, the rice yield losses will also increase.

CORRECTIVE ACTION PLAN

Proposed cropping calendar

Before making a new cropping calendar, the previous one must be taken into consideration. Figure 6.1 shows the current cropping calendar that farmers in Pampanga are using. It has two planting and two harvesting seasons. The first planting season is from May to June. While the second is from November to April. The first harvesting season is from August to November. While the second is from February to July.A 120-day variety is the basis in proposing a new cropping calendar. It spends about 60 days in the vegetative phase, 30 days in the reproductive phase, and 30 days in the ripening phase when planted in a tropical environment (Ricepedia, 2018).

For the first cropping, the planting starts from June to September while the harvesting starts from September to December. For the second cropping, the planting season begins from December to April while the harvesting season begins from February to June. Since the vegetative phase needs a little amount of water, it is best to start on the month of June for the first cropping, and December for the second cropping. As seen on the Table 6.2, the rainfall count in June and December are enough for the vegetative stage. The reproductive phase needs a lot of water so the months that are suitable for it are the months July and August for the first cropping, and January, February and March for the second cropping. The ripening stage needs a few to zero water. Therefore the months that are appropriate in this phase are September for the first cropping, and March and April for the second cropping.During the harvesting of grains, the farm land should be drained (Pinoy Rice Knowledge Bank, 2018). With this, the harvesting season must be on the months with less rainfall. The rainfall count during the harvesting seasons of the proposed cropping calendar is less than the rainfall count of the current cropping calendar. Figure 6.3 presents the proposed cropping calendar for the farmers in Pampanga. There is a slight adjustment in each planting and harvesting periods to avoid the heavy rainfalls during the reproductive stage of rice plant and during the harvesting seasons.Farmers in Pampanga may use this as a reference in revising their existing cropping calendar or if they wish to make a new one.

CONCLUSIONS

1. The temperature in Pampanga is increasing for the past years. On the other hand, the years 1999 and 2002 had extreme rainfall counts.

2. The trend of the rice yield of Pampanga is positively increasing.

3. The losses in rice yield is decreasing for the past years. 2011 acquired the highest damage from 2011-2018.

4. There is a slight and not significant relationship between the temperature and rice yield. While the relationship of rainfall and rice yield is low inverse and significant.

5. There is a high inverse and significant relationship between the temperature and rice yield losses. While the relationship of rainfall and rice yield losses is very high and significant.

6. In proposing a new cropping calendar, the period for the planting and harvesting seasons of the current cropping calendar should be adjusted to avoid the heavy rainfalls during the ripening stage of rice plant and during the harvesting seasons.

RECOMMENDATIONS

1. Data with a range of 30 years or further may be used to acquire more specific and exact results.

2. Another variable like Potato, Sugar Cane, etc. may be used as a variable to correlate with the climate change.

3. The year range of the rice yield losses may be expanded.

4. Another factor like soil PH, fertilizer, variety of rice, etc. may be used as a variable to correlate with the rice yield.

5. Other factors that affect the rice yield losses like the soil type, pests, diseases, and the variety of rice may be studied.

6. Other factors that affect the planting and harvesting seasons of rice may be analyzed to make a more reliable cropping calendar.

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Figures

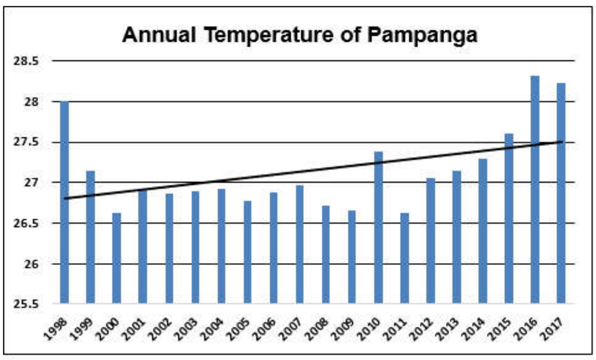

Figure 1.1. Average annual temperature of Pampanga from 1998-2017

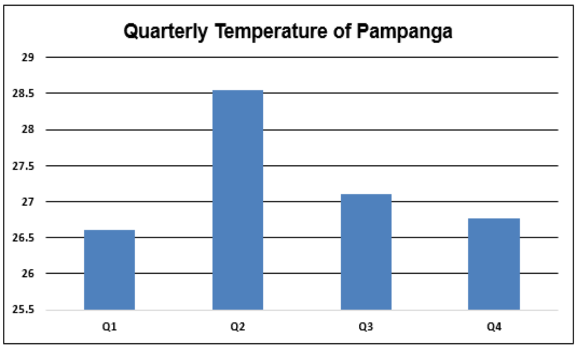

Figure 1.1.1. Average quarterly temperature of Pampanga (1998-2017)

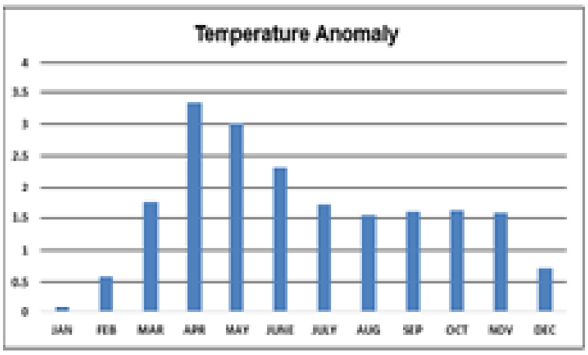

Figure 1.1.2. Average temperature anomaly of Pampanga (1998-2017)

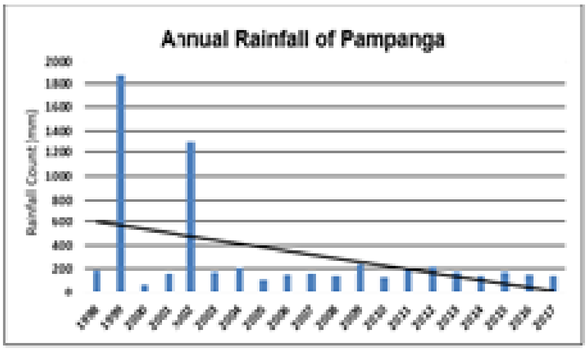

Figure 1.2. Average annual rainfall of Pampanga (1998-2017)

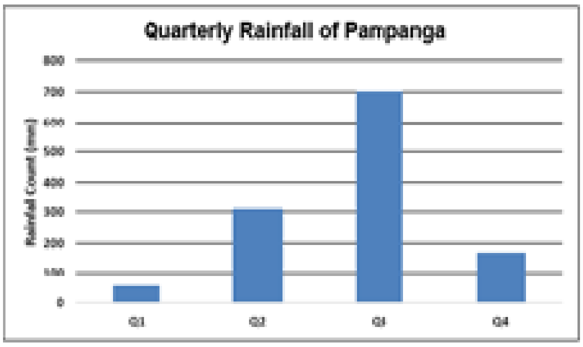

Figure 1.2.1. Average quarterly rainfall of Pampanga (1997-2018)

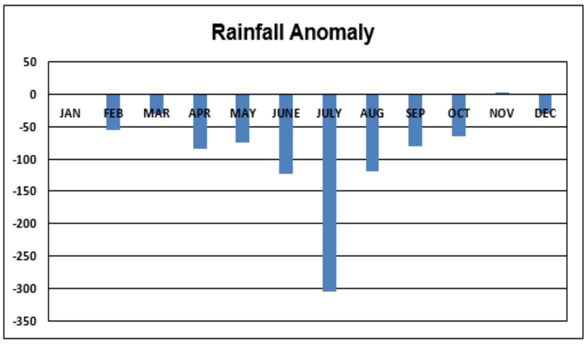

Figure 1.2.2. Average annual rainfall anomaly of Pampanga (1998-2017)

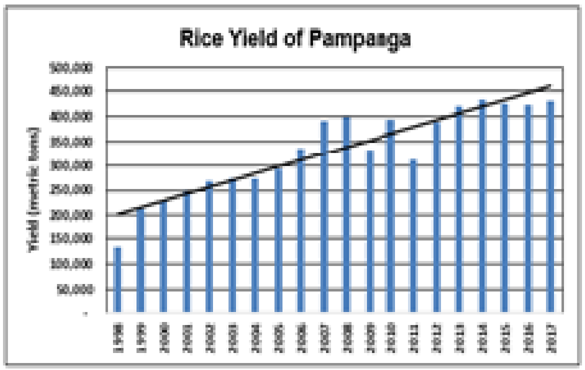

Figure 2. Total rice yield of Pampanga (1998-2017)

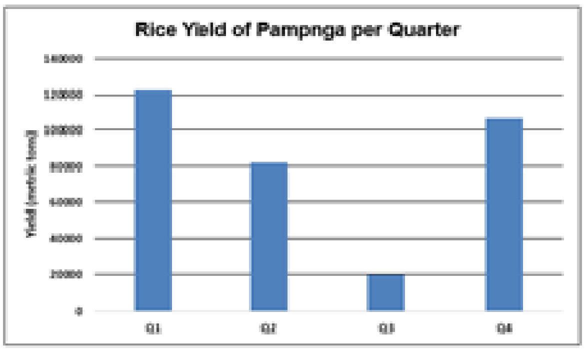

Figure 2.1. Total rice yield of Pampanga per quarter (1998-2017

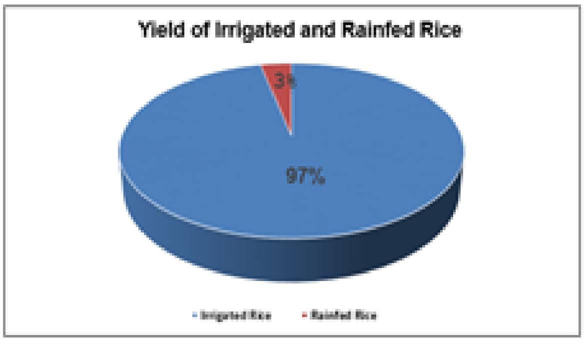

Figure 2.2. Total yield of irrigated and rainfed rice in Pampanga (1998-2017)

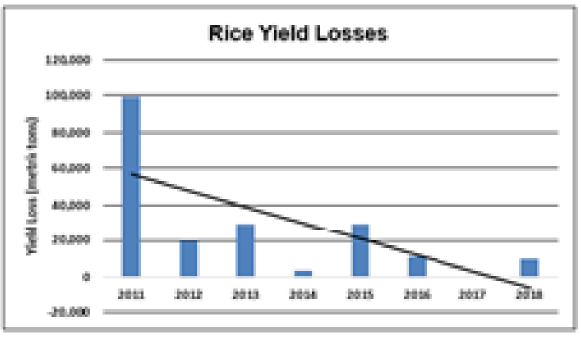

Figure 3. Total losses in rice yield of Pampanga (2011-2018)

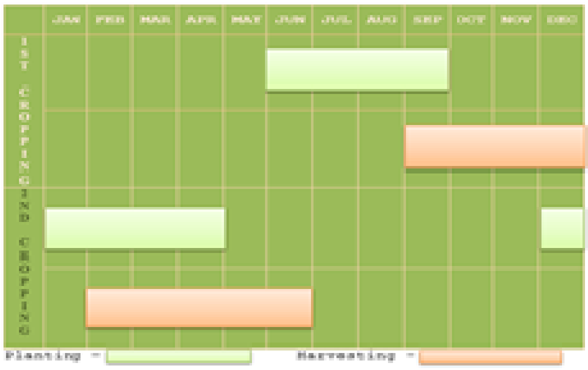

Figure 6.4. Proposed Cropping Calendar for the farmers in Pampanga

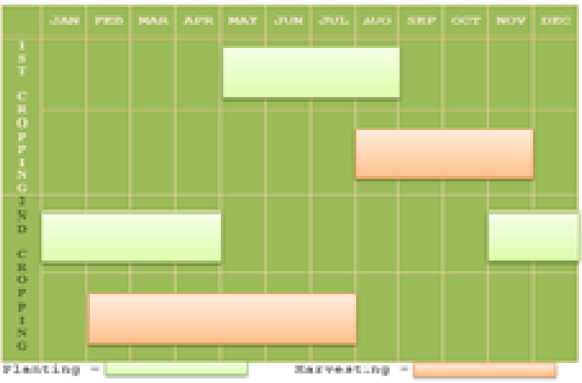

Figure 6.1. Current Cropping Calendar in Pampanga

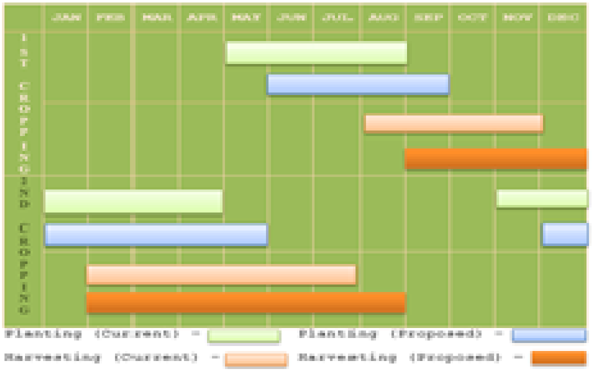

Figure 6.5. Comparison between the current cropping calendar and the proposed cropping calendar of Pampanga

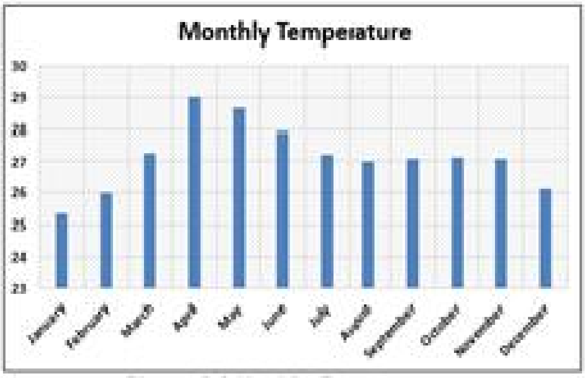

Figure 6.2 Monthly Temperature

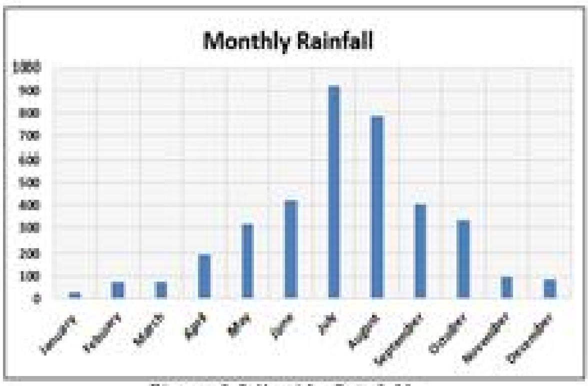

Figure 6.3 Monthly Rainfall

Tables

Table 4.1. Pearson's correlation results for relationship between temperature and rice yield

		Temperature	Rice Yield
Temperature	Pearson Correlation	1	-.083
	p-value		.463
Rice Yield	Pearson Correlation	-.083	1
	Sig. (2-tailed)	.463	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Table 4.2. Pearson's correlation results for relationship between rainfall and rice yield

		Rainfall	Rice Yield
Rainfall	Pearson Correlation	1	-.382
	p-value		.000
Rice Yield	Pearson Correlation	-.82	1
	Sig. (2-tailed)	.000	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Table 4.3. Pearson's correlation results for relationship between temperature and yield of irrigated rice

		Temperature	Irrigated Rice
Temperature	Pearson Correlation	1	-.061
	p-value		.592
Irrigated Rice	Pearson Correlation	-.061	1
	Sig. (2-tailed)	.592	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Table 4.4. Pearson's correlation results for relationship between rainfall and yield of irrigated rice

		Rainfall	Irrigated Rice
Rainfall	Pearson Correlation	1	-.378
	p-value		.001
Irrigated Rice	Pearson Correlation	-.378	1
	Sig. (2-tailed)	.001	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Table 4.5. Pearson's correlation results for relationship between temperature and rainfed rice

		Temperature	Rainfed Rice
Temperature	Pearson Correlation	1	-.238
	p-value		.033
Rainfed Rice	Pearson Correlation	-.238	1
	Sig. (2-tailed)	.033	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Table 4.6. Pearson's correlation results for relationship between rainfall and yield of rainfed rice

		Rainfall	Rainfed Rice
Rainfall	Pearson Correlation	1	-.129
	p-value		.254
Rainfed Rice	Pearson Correlation	-.129	1
	Sig. (2-tailed)	.254	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Table 5.1. Spearman's Correlation results for relationship between temperature and rice yield losses

		Temperature	Rice Yield Losses
Temperature	Pearson Correlation	1	-.762
	p-value		.028
Rice Yield Losses	Pearson Correlation	-.762	1
	Sig. (2-tailed)	.028	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Table 5.2. Spearman's Correlation results for relationship between rainfall and rice yield losses

		Rainfall	Rice Yield Losses
Rainfall	Pearson Correlation	1	.833
	p-value		.010
Rice Yield Losses	Pearson Correlation	.833	1
	Sig. (2-tailed)	.010	

Legend: 0.00 to ±0.20 slight correlation
±0.21 to ±0.40 low correlation
±0.41 to ±0.60 moderate correlation
±0.61 to ±0.80 high correlation
±0.81 to ±1.00 very high correlation

Những tác động của biến đổi khí hậu đến sản lượng lúa của vùng Pampanga

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Thông tin bài viết

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Sản xuất lúa; đánh giá tác động; lịch vụ mùa; số liệu thống kê

Tóm tắt

Nghiên cứu này nhằm phân tích những tác động của biến đổi khí hậu đến sản lượng lúa của vùng Pampanga. Khí hậu và sản lượng được sử dụng là trong khoảng thời gian 20 năm từ 1998 đến 2017.

Nghiên cứu này sử dụng phương pháp nghiên cứu mô tả và suy luận. Sản xuất lúa gạo ở Pampanga cho thấy xu hướng tăng lên trong giai đoạn 20 năm. 97% tổng sản lượng lúa sử dụng nước tưới tiêu trong đó 3% còn lại sử dụng lượng mưa tự nhiên. Nghiên cứu này kiểm định mối tương quan giữa sản lượng lúa, lượng mưa và nhiệt độ. Nghiên cứu đã chỉ ra rằng không có mối quan hệ đáng kể giữa năng suất lúa và nhiệt độ. Trong khi đó mối tương quan về lượng mưa và năng suất lúa là nghịch đảo nhau. Xét đến lượng mưa và nhiệt độ trung bình hàng tháng cũng như nhu cầu về khí hậu của các giai đoạn phát triển khác nhau của lúa, nghiên cứu đã đề xuất lịch canh tác vụ mùa mới. Lịch canh tác vụ mùa hiện tại được đề xuất sẽ được dịch chuyển lên trước một tháng để giai đoạn chín có lượng mưa nhiều sẽ được chuyển sang tháng có lượng mưa ít hơn. Kết quả của nghiên cứu này sẽ được thông báo cho nông dân của Pampanga sau khi được các cơ quan chính phủ phê duyệt và kiểm tra.