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Assessing the Value of Seasonal Climate Forecasts on Farm-level Corn Production through Simulation Modeling*

by

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Abstract

Rainfall variability greatly influences corn production. Thus, an accurate forecast is potentially of value to the farmers because it could help them decide whether to grow their corn now or to delay it for the next cropping opportunity. A decision tree analysis was applied in estimating the value of seasonal climate forecast (SCF) information for corn farmers in Isabela.

The study aims to estimate the value of SCF to agricultural decision makers under climate uncertainty. Historical climatic data of Isabela from 1951 to 2006 from PAGASA and crop management practices of farmers were used in the Decision Support System for Agrotechnology Transfer (DSSAT) to test the potential impact of climate change on corn. The approach is developed for a more accurate SCF and to be able to simulate corn yields for wet and dry seasons under different climatic conditions -- El Niño (poor year), La Niña (good year) and Neutral (neutral year) conditions.

In order for the forecast to have value, the "with forecast" scenario should lead to better decision making for farmers to eventually get increase production over the "without forecast" scenario. While SCF may potentially affect a number of decisions including crop management practices, fertilizer inputs, and variety selection, the focus of the study was on the effect of climate on corn production. Improving SCF will enhance rainfed corn farmers' decisionmaking capacity to minimize losses brought about by variable climate conditions.

Keywords: decision tree analysis, seasonal climate forecast (SCF), climate uncertainty, Decision Support System for Agrotechnology Transfer (DSSAT)

* This paper is part of the outputs of the ACIAR-sponsored project on "Bridging the gap between seasonal climate forecasts (SCFs) and decisionmakers in agriculture."

1. Introduction

The use of farm and policy levels case studies in the Philippines is important to gain practical appreciation of how decision makers use SCF and how to bridge the gap between potential and actual use of SCF. The better management of climate variability has the potential to improve resource use efficiency providing economic benefits through improved crop planting and management. Also, the farm level case study will provide social benefits to the poorest farmers vulnerable to climate variability. As part of the project entitled "Bridging the Gap between Seasonal Climate Forecasts and Decision Makers in Agriculture", Isabela was chosen as the study site because it is considered as the top corn-producing province in the country. In Isabela, corn is usually grown rainfed. This is why climate variability is a very important factor in the decision-making of corn farmers in Isabela.

The study aims to develop an approach to valuing the contribution of SCF to decision-making under climate uncertainty. To test the potential impact of climate change on corn crops in Isabela, climatic data from PAGASA was collected and crop management practices of farmers using Decision Support System for Agrotechnology Transfer (DSSAT) was used. The approach is developed for a more precise SCF and simulates outcomes of corn yield.

If the farmer had better tools for understanding how rainfall vary from normal to La Niña and El Niño seasons, they would be better equipped to adjust their practices to ensure the best yield possible. Fortunately, much progress has been made in understanding what causes variations in seasonal climate, and this progress has allowed researchers to create tools to better understand crop yield risks associated with climate variability.

2. Corn Farming in Isabela

The second most important cereal crop in the Philippines is corn. In terms of corn production, Isabela retained its position as the top province yielding 906,478 metric tons in 2007. The province was number one in 2000 to 2004 and in 2006 (BAS). There are two cropping seasons per year in Isabela – wet season cropping from May-August and dry season cropping from November - February. Monocropping of corn is predominantly practiced in Isabela.

The top corn varieties being planted in Isabela are sourced from giant corporations such as Pioneer, Monsanto and Syngenta. It was estimated that these corporations are supplying as much as 70% of the seed requirements of farmers. Presently, the most common varieties planted by farmers are DK818, Pioneer 30B80, and TSG81.

Historically, there are no pronounced dry or wet seasons in Isabela. It is classified as Type II which is relatively dry in the first half of the year and wet during the second half. Average rainfall is 1,844 mm per year, mean temperature is 29 degrees Celsius and relative humidity is 66%. In general, the climate and the vast plains of Isabela is suitable to corn production. (Lansigan, W. L. delos Santos and Hansen 2007). Since most corn farms are rainfed, starting date of planting is not definite. Farmers wait for the onset of rains before they begin planting.

3. Review of Literature - The impact of climate variability on corn production

Countries in Southeast Asia and the Pacific region, together with Australia, experience the highest rainfall variability in the world (Nicholls et al. 1997). El Niño events in the Philippine local climate are marked by drier than normal weather conditions which could last for one or more seasons, causing dry spells or even drought in many parts of the country. These dry weather conditions are caused by suppressed tropical cyclone activity in the western equatorial Pacific, weak monsoon activity characterized by “breaks”, and the delayed onset of or early termination of

> monsoon rains (PCARRD 1999). In agriculture, shortage of water has caused serious damage to farmlands. The Department of Agriculture estimated damages in 2005 due to drought and flooding amounted to PhP838M and the impact on livelihood and socio-econ condition of farmers are great

Over the recent years, there are several research activities done in order to achieve a more targeted approach in application of climate forecasting. In Australia they use simulation modeling. Simulation modeling allows a more integrated approach whereby farmers and others are able to apply climate forecasting more directly to their on-farm management as the climate forecasting information has been translated, through this approach, into more useful terms of direct significance to the user. For example, it may be valuable to know the more likely forecast potential yield a crop may achieve before that crop is planted, rather than simply being provided with a rainfall forecast, in order to determine amounts of nitrogen to purchase and apply and to help in marketing that crop (including forward selling the crop).

A further key aspect in the successful development of an effective climate forecasting-agricultural management system is the need to clearly identify those decision points in the agricultural system where knowledge of a climate forecasting system would make a marked difference in that decision. It is then important to quantify what contribution climate forecasting would have in improving the profitability or sustainability of that industry through improving decision making. It is also particularly important to consider the industry as a whole as changes in the management system through use of climate forecasting at the farm scale may impact through all sections of the value chain. In the corn industry there are studies on how climate forecasting can aid management decisions at the farm production scale, at the harvesting scale, and at the whole of industry marketing scale.

Some key features associated with successful development and application of climate forecasting in north-east Australia has been through the following initiatives:

1. use of probabilistic climate forecast output including the output of analogue seasons or years,
2. use of an integrated approach whereby climate forecasting models are directly linked or integrated into agricultural production simulation models (allowing use of scenario analysis),
3. investigation of climate forecasting application at all scales of agricultural industry including addressing issues across the entire values chain (from paddock scale to marketing scale at a national level).

4. When to Use SCF

Statistical tests to evaluate the skill of seasonal forecasts are useful. They help to remove erroneous results in the data, and to reveal where tools such as the Southern Oscillation Index (SOI) and Sea Surface Temperature (SST) have “real” rather than “artificial” skill as indicators of future events. Users should avoid, or at least be very cautious, of using seasonal forecasts that are statistically “not significant”.

When statistically significant relationships are observed in the historical data then users can be more confident that the SOI or SST can be used as seasonal forecast tools. When statistically “not significant” relationships between ENSO indicators and rainfall are observed in the data, then users should dispense with the use of the ENSO indicator for that location/season, and instead use the all-years climate information for the seasonal forecast. Perhaps the most important of these is the all-years climatology. The “All-Years Climatology” simply uses the climate that has been observed and recorded in each year of the past to provide a forecast for the future. For example, the average or median rainfall for a season, or the “All-years” chance that rainfall will be above some threshold (say 400 mm), or perhaps the amount of rain that occurs in 7 in 100 years for a particular location. Seasonality is usually the strongest forecast signal and often the differences between wet season and dry season are very large.

5. Forecast Methodology

The effect of the El Niño Southern Oscillation (ENSO) phenomenon on seasonal climatic patterns and rainfall variability can be evaluated using RAINMAN. The RAINMAN software is an integrated package about rainfall information to help those experiencing a highly variable climate make better management decisions. Seasonal rainfall analysis is an important feature of the RAINMAN software and can be done with daily and monthly data. The spatial analysis capabilities in RAINMAN were used to assess the seasonal forecasts based on the planting calendar dates in the province of Tuguegarao. Chance of rainfall for the station was computed using the SST Forecast Phase System (Pacific Effects) and the Average SOI (RAINMAN version 4.1). The SST Phase Forecasting System uses sea surface temperature data from both the Pacific and Indian Oceans. The SST menu options in RAINMAN enable the SST Phase analyses to be done as follows: The Pacific Phase System enables the main effects of the Pacific Ocean to be tested namely: Cooler Pacific Ocean pattern (La Niña): Phases 1,4,7 are combined, Neutral Pacific Ocean pattern (Neutral): Phases 2,5,8 are combined and the Hotter Pacific Ocean pattern; Phases 3,6,9 (El Niño) are combined. Phases 3,6,9 are associated with below the median rainfall conditions while Phases 1,4,7 are associated with above median rainfall.

Seasonal rainfall forecasts were done for four seasons (JFM, AMJ, JAS, OND) and seasonal forecasts skills were evaluated in the project site. The relationship of ENSO indicators with seasonal rainfall varies with location, time of year, lead-time and the status of ENSO. RAINMAN enables measurement of changes in the statistical significance of forecast skill on both temporal and geographic scales.

5.1 SST Phase Forecasting System

The main seasonal forecast tool used in the analysis is the SST Forecasting System. The first SST Forecast Phase System is the All Years Climatology. This simply uses the climate that has been observed and recorded in each year in the past to provide a forecast for the future. The second SST Forecast phase system used is the Pacific Effects. The phase system enables the main effects of the Pacific Ocean to be tested namely, Cooler Pacific Ocean pattern where Phases 1, 4 and 7 are combined, Neutral Pacific Ocean pattern where Phases 2, 5 and 8 are combined and Hotter Pacific Ocean pattern where Phases 3, 6 and 9 are combined. Pie charts showing the probability of rainfall for each category are then mapped for the four regular seasons to show the spatial distribution of rainfall that are likely to occur in station depending on the condition of sea surface temperature. The relationship of ENSO indicators with seasonal rainfall varies with location, time of year, lead-time and the status of ENSO. RAINMAN enables measurement of changes in the statistical significance of forecast skill on both temporal and geographic scales.

5.2 Average SOI Forecasting System

The basis of this forecast system is:

- all seasons in the historical record are stratified into three groups based on the average value of the SOI during the forecast period with default SOI boundary values to form the groups of SOI below –5 (negative group), -5 to +5 (neutral group), and SOI above +5 (positive group)

- the default period for calculating the SOI is the 3 months prior to the rainfall season

- the average value of the SOI during the forecast period is calculated from the monthly values of the SOI (these values are derived from the Bureau of Meteorology website (www.bom.gov.au).

The default boundaries of –5 and +5 are used as this separates monthly values of the SOI into 3 approximately equal groups. The number of cases in the central group (SOI neutral) increases when the SOI is averaged over several months.

An advantage of the average SOI method is that it can be used for concurrent or simultaneous analyses where the predictor (the average SOI) and the predictand (the rainfall period) are set to the same time. Concurrent analyses enable you to gain an understanding of how ENSO has historically impacted on rainfall, and this can often provide useful insights. When first investigating relationships for a location or season, it is often best to begin with a concurrent analysis before investigating the strengths and weaknesses of the forecast analysis.

6. Skill of Forecasts

The relationship between ENSO and variations in rainfall has been studied using the RAINMAN 4.1[+]. Current predictions, based on the state of the El Nino / Southern Oscillation (ENSO) show some skill during cool and warm events for both SST Phase forecasting System and the Average SOI (See Figure 1 and 2) .

Figure 1 & 2: Example of seasonal forecast analysis from Rainman version 4.1 [+]. Analyses give the reliability and accuracy of seasonal forecasts including a probability-based risk profile, several statistical tests and forecast skill.

Figure 1.

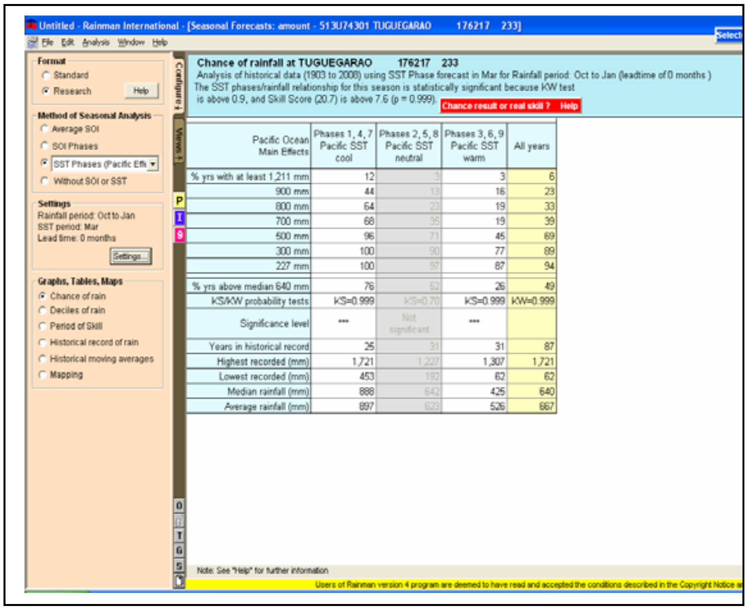
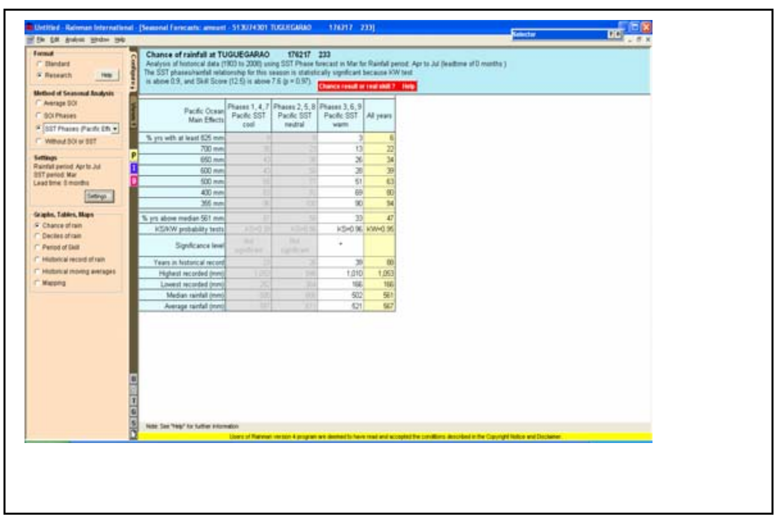


Figure 2:



Results of analyses show that the SST Forecast Phase System of RAINMAN has considerable skill for the period October to March (OND & JFM), using one month lead time. However the skill of the forecast starts to decrease from April to September (AMJ & JAS). The peak response of ENSO on rainfall occurs during the winter season October to March (OND & JFM) and tapers down during the summer monsoon (AMJ & JAS) of the following year and this is corroborated by the results of previous studies (Jose, et al.1997). The SST Forecast Phase System show low skill during the so-called "predictability barrier" MJJ and JAS (See Figure 3 and 4).

Figure 3 & 4: Some examples of rainfall analyses in RAINMAN (a) effects of lead time on skill of forecasting rainfall on Tuguegarao (b) Probability distributions of long-lead forecasts of rainfall at Tuguegarao

Figure 3.

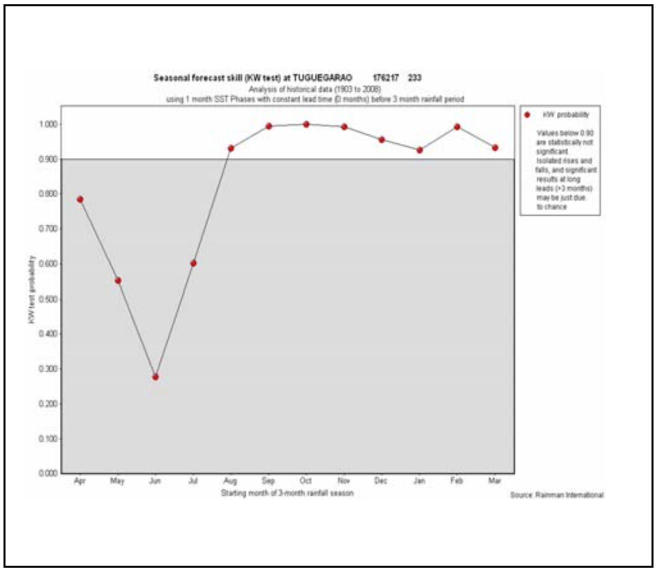
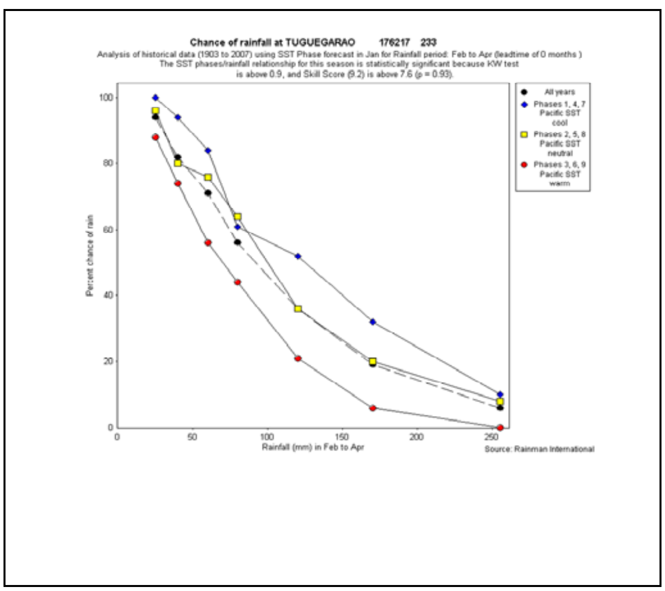


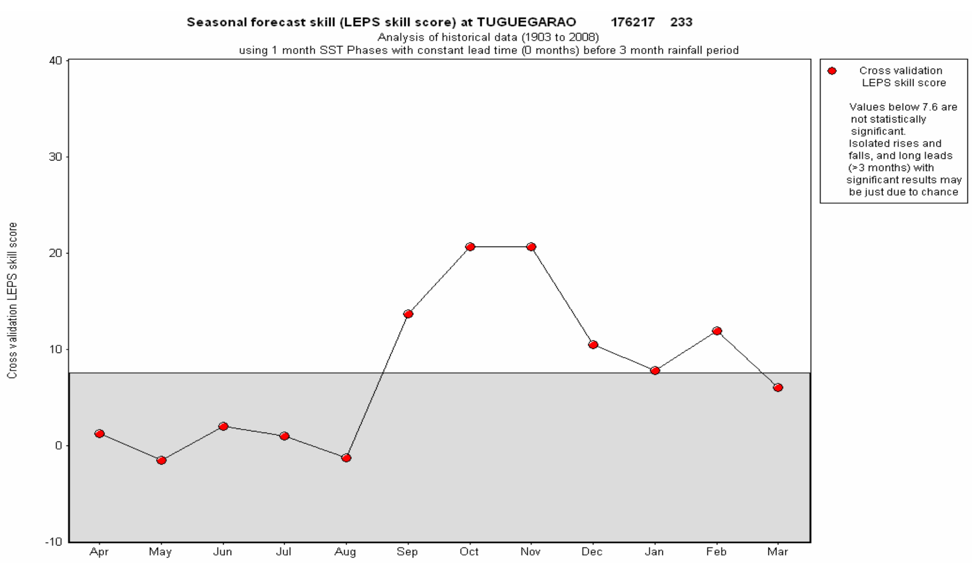
Figure 4.



The forecast skill was low at lead-times of two months or longer but there were reasonable levels of skill during cool (La Niña) and warm (El Niño) years at some locations at zero and one-month lead times. Based on the analyses there is a great influence of ENSO on median rainfall with lead-times of up to one month; however, the forecast skill was not statistically significant at lead-times longer than one month at most locations.

The LEPS Skill Scores calculated in Rainman use a cross-validated approach that enables each year to be used as independent data to test the accuracy of the forecast system as shown in Figure 5. Skill score for Tuguegarao indicate that for the months of September to February values are greater than 7.6. Standardized LEPS Skill Scores that equal or exceed a threshold of 7.6 are statistically significant and indicate that the forecast system being tested has skill (forecasts with values below 7.6 are not sufficiently skillful and forecasts with skill scores below 0.0 have no skill). Consequently, dry season was used in this study because the forecast has skill.

Figure 5. LEPS Score for Tuguegarao at constant rainfall period



7. Approaches to Valuing SCF

Farmers face many decisions in their agricultural production that eventually have an effect on farm production. In estimating the value of SCF information for Isabela corn farmers, a decision tree analysis and DSSAT were used.

7.1 Decision Tree Analysis Approach

This is a pictorial representation of a decision situation, usually used in discussions of decision-making under uncertainty or risk. For this study, it shows decision alternatives -- with forecast or without forecast with probabilities attached to it and conditional benefits and losses. The expected values of competing alternatives are also calculated to provide farmers clear understanding whether to use the forecast or not.

7.2 DSSAT Approach

The DSSAT was used to simulate corn yields. The simulated yields were then used to calculate farmers' income. DSSAT allows the simulation of different corn varieties and cropping systems, targeting issues such as climate variability, crop rotations, and management alternatives. The simulation study was carried out in both Angadanan and Echague. Aside from giving a more precise SCF, the approached is developed to be able to simulate corn yields under different climatic conditions.

8. SCF Evaluated

This study mainly adopts the framework presented in a parallel study on seasonal climate forecasts in Bohol province, Philippines[†] and in Northern NSW, Australia[‡].

[†] Homes, Zayra May B. and Predo, Canesio. 2007. Economic Assessment of Using Seasonal Climate Forecasts in Corn Production Decisions of Farmers in Bohol Province, Philippines.

[‡] Crean, Jason, Hayman, Peter, Mullen, John and Parton, Kevin. 2005. Seasonal Climate Forecasts for an Opportunity Cropping Decision in Northern NSW.

The probability of a good, average and poor season outcomes was taken using the RAINMAN 4.1+ based on the average SOI system type of forecast. The output includes chance of rain that is presented in a pie chart and shows the probability of exceeding certain amounts of rain including the median, and the rainfall likely to be exceeded in 5 or 95% of years, over the designated season as calculated by the selected method of analysis. The pie chart divides rainfall into terciles which are the upper third, middle third or lower third for all years. Different pies can be selected by phases or average of the SOI or by the average or trend of the SST.

The gross margin for the outcome of each season was calculated through SIMETAR, an excel add-in, to generate the cumulative distribution function of expected (SCF) value of choice for both "with and without" climate forecast scenario. A forecast has value if the "with forecast" scenario leads to different decisions and improved outcomes over the decisions and outcomes of the "without forecast" scenario. While a forecast may potentially affect a number of decisions including crop areas, input levels, and variety selection, the focus of the study was purely the effect of historic climatic data on corn production.

7.1 Steps in Valuing SCF

In determining returns of "with and without" forecast the first step was to simulate the yields for each cropping season for each year of weather data under different climatic episodes. Output from DSSAT was used to accurately capture the interaction between corn management and climatic variability.

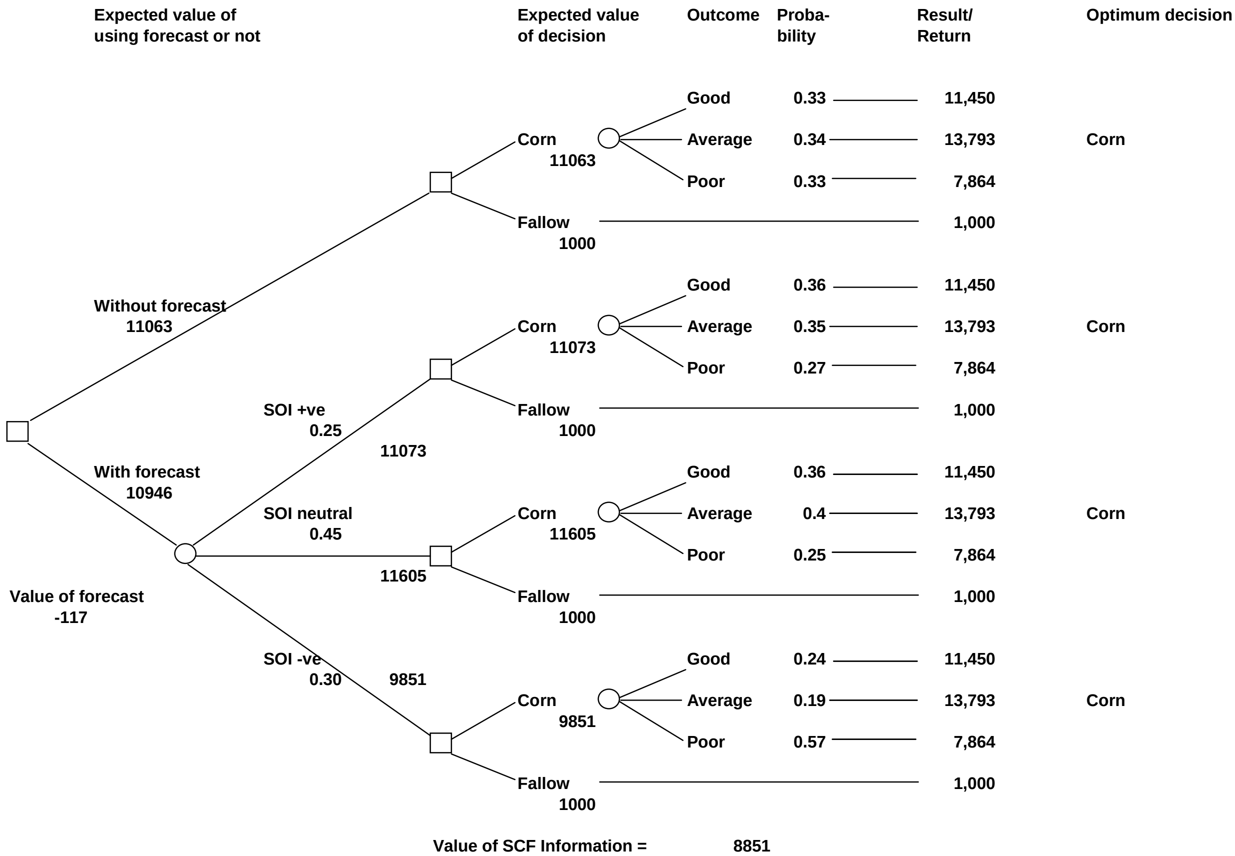
Corn yields were simulated with DSSAT for wet and dry seasons for Pioneer corn variety. The crop parameters used were within the observed values reported in the survey, implying that crop growth and development were simulated realistically. Hence, the simulation provides confidence that the DSSAT is able to capture the sensitivity of corn productivity to climate over a long time series. Yields were also simulated under different climate variability during El Niño (poor year), La Niña (good year) and Neutral (neutral year) conditions. The amount of rainfall is a very significant variable that greatly influences corn production. Therefore, an accurate forecast is potentially of value to the farmers because it could help them decide whether to grow their corn now or to delay it for the next cropping opportunity.

The second step involved the estimation of economic returns for each cropping option for each weather year under different climatic episodes. This was done by multiplying the yields from DSSAT with the price of corn collected during the interview process.

The without forecast scenario is determined by the historical distribution of climatic years and past optimal yield. The with forecast scenario is determined by the subsequent probability of the optimal yield. The basic structure of the decision tree is depicted in Figure 5. One distinctive feature of decision trees is that they may be drawn so that the sequence in which decisions are taken and events occur is reflected, as decisions move from left to right across the decision tree.

Potential yield is determined by maximum and minimum temperature, rainfall, solar radiation, soil texture, drainage type, planting date, planting distribution and fertilizer used as recommended by agricultural scientist.

Figure 5. Decision Tree



7.2 Difference between Actual and Potential Value

Some of the reasons that limit the yields of corn below the potential yield are: (1) undependable weather in terms of onset of rainy season and amount of rainfall and its distribution during the corn growing period; (2) inappropriate soil and water management practices; (3) imbalanced use of fertilizers; (4) infestation by weeds, pests and diseases; (5) lack of high yielding and tolerant corn varieties; and (6) inaccessibility to climate knowledge and inputs of improved technologies and low adoption of crop production practices.

8. Sources of Data

The survey was carried out in Angadanan and Echague – the top corn producing municipalities of Isabela province. From the two municipalities, three barangays were chosen based on their land types – river/flood plain, broad plain and hilly/rolling. The agroclimatic condition, which mainly determines the timing and number of cropping a rainfed farmer can have in a year, is dry to moist for Echague and moist for Angadangan. The traditional start of corn planting seasons in Echague and Angadangan are April-June for wet season cropping and October to December for dry season cropping. Each cropping season lasts approximately 120 days or 4 months.

The minimum required weather data used are historical climatic data (1951-2006) of Tuguegarao which includes daily values of solar radiation (MJ/m2-day), daily maximum and minimum air temperature (C), and daily rainfall (mm) collected from PAGASA and crop management practices of farmers based on the survey were used. The climate data in Tuguegarao was used in the absence of longer climate record in Isabela. Furthermore they have the same climate type as the study area. To ensure the integrity and reliability of data, the quality control, processing, and archiving of meteorological, climatological and allied data are done in accordance with World Meteorological Organization (WMO) recommended practices and standards.

9. Results and Discussion

Using weather data from Tuguegarao, corn yields were simulated using **DSSAT approach** to produce yield from 1951 to 2006.

9.1 Actual Value

To evaluate the actual value of SCF information, the expected gross margins of each Pioneer corn variety was calculated at various climatic conditions (Table 1). Also, three other corn varieties namely Dekalb, Cargill and IPB were simulated for comparison of yields (Annex 1). During the wet season, the good years (PhP16,962), on average, yielded more than the neutral years (PhP12,487). However during the dry season, neutral years (PhP18,210) yielded more than the good years (PhP15,651). Thus, it appears more beneficial for farmers to plant the Pioneer variety during the dry season under different climatic variabilities.

Table 1. Expected gross margin (PhP/ha/season) of Pioneer at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	LA NIÑA	NEUTRAL	EL NIÑO
WET (Apr-June)	16,962	12,487	12,288
DRY (Oct-Dec)	15,651	18,210	14,542

For seasonal climate forecasts to have economic value, the relationship between forecasts and rainfall must translate into differences in crop yields and, ultimately, into differences in profitability. The average SOI system of forecast was analyzed using the RAINMAN 4.1[+] The historical monthly rainfall in Tuguegarao is presented in Figure 6. The number of years recorded during the analysis ranged from 56 to 67 years. Results show that the highest mean rainfall recorded is obtained during the months of July to November. Lowest mean rainfall levels are observed during the months of January, February, March and April.

Forecasts are categorized into three groups in the average SOI system namely SOI negative (SOI below –5), neutral (SOI between –5 to +5) and SOI positive (SOI above +5). A negative SOI value is associated with lower average rainfall, a neutral value means a close to normal conditions and a positive value generally increases the probability of receiving above average rainfall (Table 2).

Table 2. Chances of rainfall, Tuguegarao

Pacific Ocean Main Effects	SOI below -5	SOI -5 to +5	SOI +5	All years
% yrs with at least 1,222 mm	12	3	4	6
900 mm	44	13	11	22
800 mm	64	23	14	33
700 mm	68	37	14	39
500 mm	96	70	43	69
300 mm	100	90	75	88
226 mm	100	97	89	95
% yrs above median 637 mm	76	53	21	49
KS/KW probability tests	KS=0.999	KS=0.53	KS=0.999	KW=0.999
Significance level	***	Not significant	***	
Years in historical record	25	30	28	83
Highest recorded (mm)	1,721	1,227	1,307	1,721
Lowest recorded (mm)	453	192	62	62
Median rainfall (mm)	888	641	413	637
Average rainfall (mm)	897	622	496	663

Analysis of historical data (1903 to 2007) using SST Phases in Sept for Rainfall period: Oct to Jan (leadtime of 0 months)
The SST phases/rainfall relationship for this season is statistically significant because KW test is above 0.9, and Skill Score (20.7) is above 7.6 (p = 0.999).

During **decision tree analysis approach**, a farmer is first subjected to two main decisions: to use SCF or not to use SCF in cropping production. If the farmer decides to neglect the SCF in his farm decision making, he has the option to either plant corn or to fallow the area. Once he decides to plant corn, he now faces three weather outcomes -- good, average, and poor seasons. The benefits from leaving the land fallow is derived from the increase in soil fertility. Corn production, during good season, results to an expected gross margin of PhP16,962. The farmer can gain an average gross margin of PhP12,487 in the neutral season and PhP12,288 in the poor season. Thus without SCF information, the farmer would obtain an average gross margin of PhP for all seasons for his decision to plant corn. On the other hand, if the farmer decides to fallow the area, he would get a gross margin of PhP1,000 (Macandoy et. al, 1997). Therefore, the decision would be to plant corn because this provides higher net returns without SCF information.

If the farmer decides to use SCF in his farming decision, one of the three possible forecasts – positive, neutral or negative -- is received at the following event node. When the farmer receives the forecast, he now decides whether to plant corn or simply fallow the area. In the positive years, the chances of getting a good, average, and poor season is 38%, 35%, and 27%, respectively. The average gross margin of planting corn was PhP16,962 and fallowing the area provided a gross margin of PhP1,000. Thus, planting corn during SOI positive years could be considered a good decision since it results to higher profits. Assuming the farmer receives a neutral forecast with 36%, 40% and 25% chances of getting good, average and poor seasons respectively, the best decision would be to plant corn since this will give the farmer higher net returns of PhP12,487 and PhP1,000 in fallow situation. The chances of getting a good, average and poor season in SOI negative forecast were 57%, 19% and 24%, respectively. The average gross margin of planting corn during this type of forecast was PhP12,288.

The expected gross margins for both “with or without” scenarios were simulated with 100 iterations. Summary of simulated gross margins is presented in Table 5. When SCF was used, results show that the average gross margin of cropping would be about PhP 15,342.58. This is comparatively higher than a cropping decision without SCF (PhP 15,069.45). These figures are then used to quantify the value of SCF information.

9.2 Potential Value

The expected gross margins from corn production using the recommended fertilizer (8-10 bags @ 50kg/bag) use was also calculated at various climatic conditions (Table 3). During the wet season, the good years (PhP17,730), on average, yielded more than the neutral years (PhP13,062). On the other hand during the dry season, neutral years (PhP19,491) yielded more than the good years (PhP17,595). Again, Pioneer variety is estimated to have higher gross margin during the dry season across different climatic variabilities.

Table 3. Expected gross margin (PhP/ha/season) at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	LA NIÑA	NEUTRAL	EL NIÑO
WET (Apr-June)	17,730	13,062	13,532
DRY (Oct-Dec)	17,595	19,491	15,128

The results show that there was a small difference between the potential value and the actual value (Table 4) of gross margins for Pioneer variety. The actual values were less than potential values because the majority of the farmers do not use recommended fertilizer management practices. It is advised that fertilizer application should be done at the start of planting and one month after actual planting date. Split application for nitrogen fertilizer is advised, too. The farmers do not apply adequate amount of fertilizer to meet the nutrient losses and, thus, the small gap between the potential and actual values. Also, the planting dates might have an effect on the gap between the potential and actual value. The farmers are constrained with timely access to knowledge -- particularly on climate information, which they need because they are rainfall-dependent. Onset of the rainy season, duration of rainy days, rainfall distribution and drought and typhoon occurrence are some examples of climate information that should be made available to them.

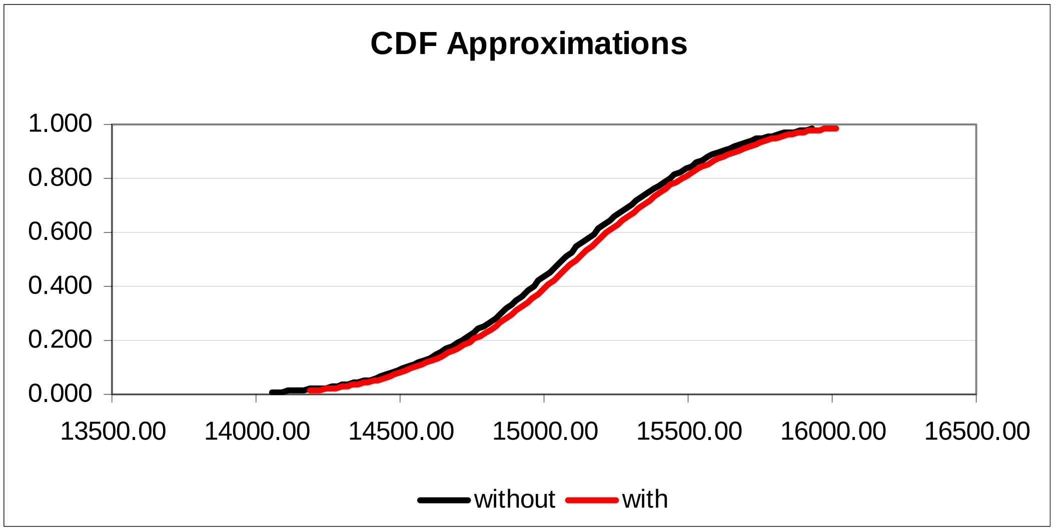
Table 4. Potential and Actual gross margin (PhP/ha/season) of Pioneer and their gaps at various climatic variabilities during wet and dry season.

Season/Climate	Potential	Actual	Gap	Percentage Gap
WET				
La Niña	17,730	16,962	768	2.39
Neutral	13,062	12,487	575	2.09
El Niño	13,532	12,288	1244	4.45
DRY				
La Niña	17,595	15,651	1944	6.07
Neutral	19,491	18,210	1281	3.78
El Niño	15,128	14,542	586	1.98

10. Cumulative Distribution Function (cdf)

The cdf of a random variable is the chance that the random variable is less than or equal to *x*, as a function of *x*. Figure 8 shows the cdf of farmers who were using SCF and those who do not use SCF. Farmers who were using SCF have 50% chances of getting a gross margin about PhP15, 000 and they also have a chance of obtaining a yield greater than P16, 000. The probability of farmers who were using SCF attain higher gross margin than those who were not using the forecast.

Figure 8. Cumulative distribution function of gross margins for Pioneer variety with and without forecast in Tuguegarao



11. Conclusion

The actual value of SCF information can be computed as the difference of gross margin between with and without SCF scenarios. Therefore, the value of SCF obtained was about **PhP 273.12.** While these figures could be considered very marginal for the individual subsistence farmers whose landholdings average is 3.56 hectares, translating this to the total land area planted to corn in the Philippines (2.6 million hectares as of 2007), SCF might be of great significance for Philippine agriculture. Thus, it would be very useful to improve the access to SCF forecast by corn farmers and other decision makers in agriculture.

Table 5. Average gross margin of using SCF and not using SCF

GROSS MARGIN	USING	NOT USING
Mean	15342.58	15069.45
Standard Deviation	3675.34	3649.25
Coefficient of variation	24.32	24.22
Minimum	5881.32	5891.37
Maximum	24367.88	24231.68

Assessment of potential and actual value is essential for improving crop production. Corn is very susceptible to climate variations due to the plant's requirement for water for cell elongation and its inability to delay vegetative growth. Therefore, there is always the danger of yield loss regardless of the timing of planting. The amount of yield loss that occurs during climate variations depends on what growth stage the corn is in and how severe the climate conditions may become. Highest yields will be obtained only where environmental conditions are favorable at all stages of growth.

Figure 6. Monthly rainfall (mm) recorded at Tuguegarao

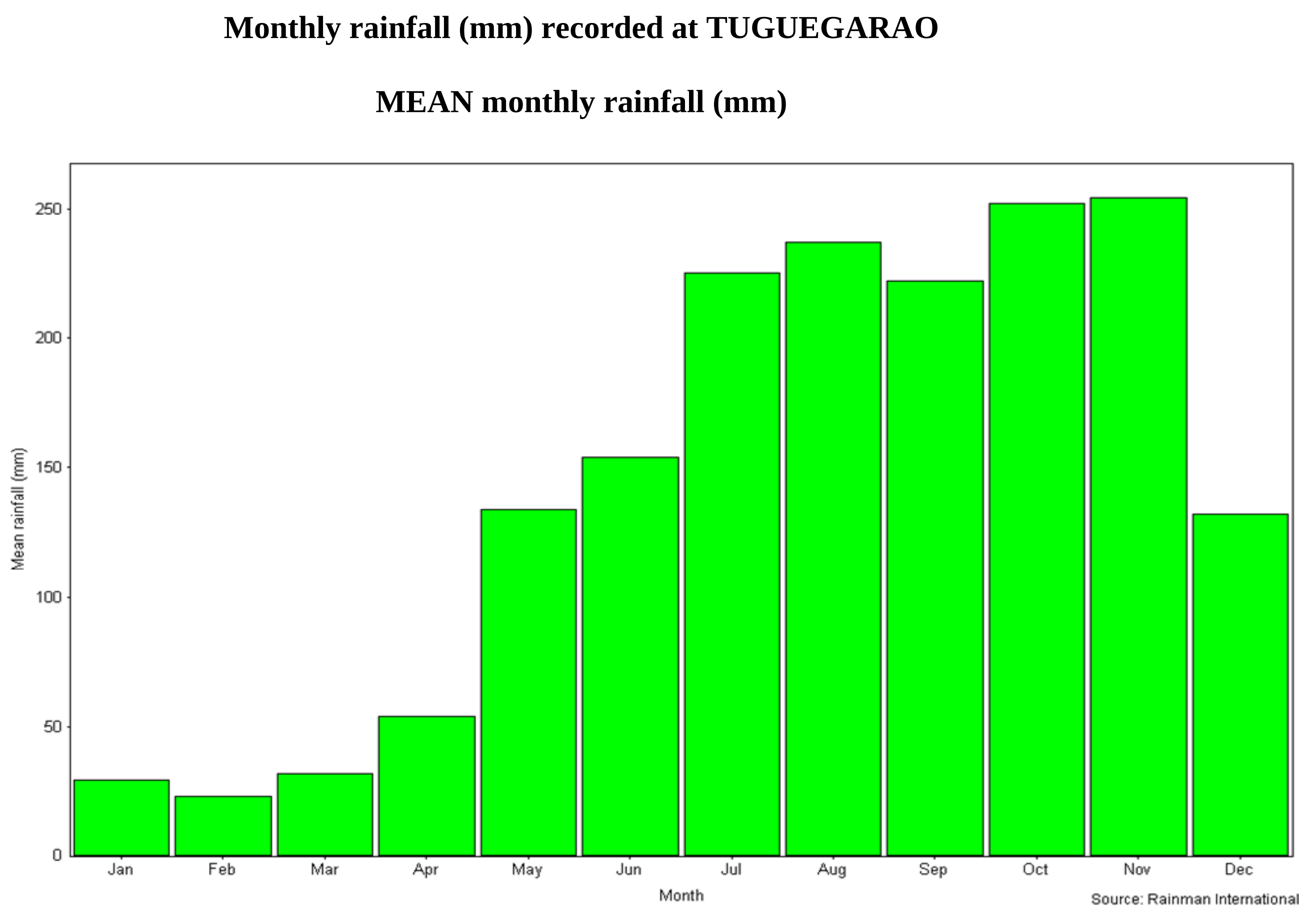


Figure 7a. Chances of rainfall in Tuguegarao at various SOI forecast (SOI neutral)

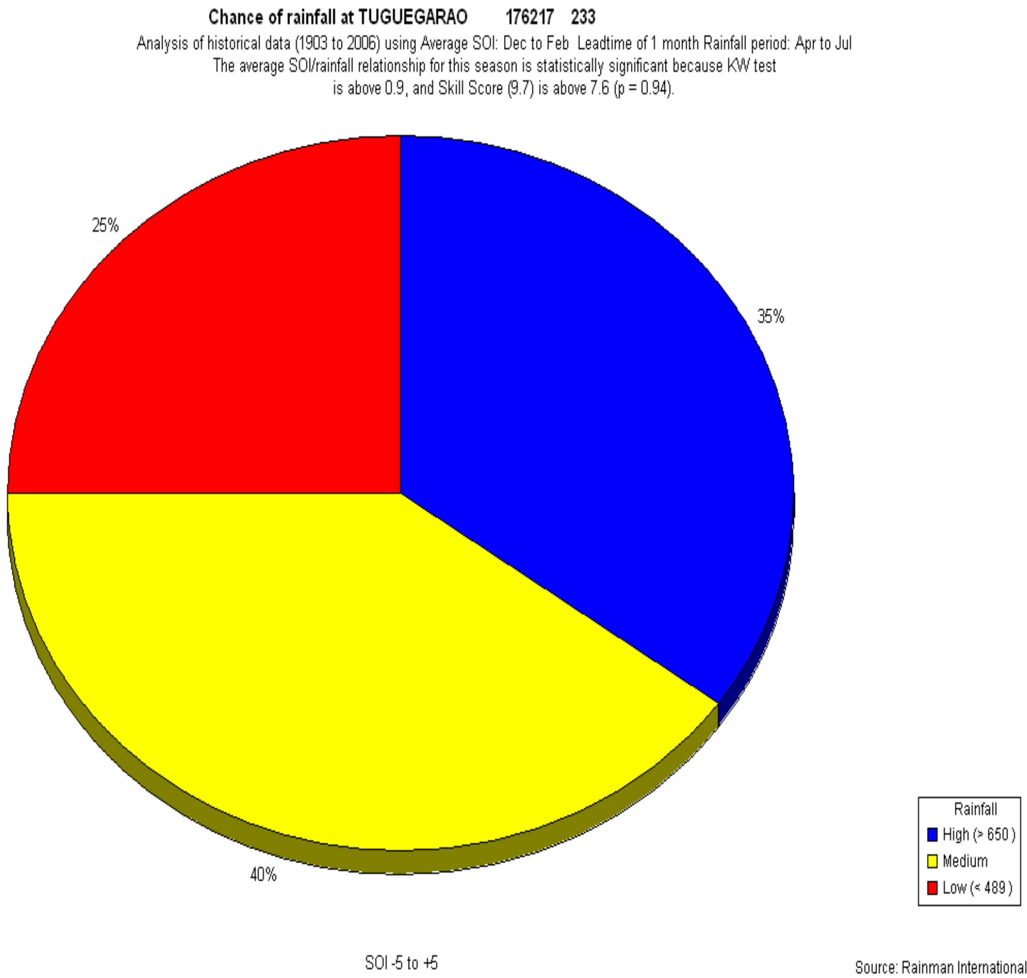


Figure 7b. Chances of rainfall in Tuguegarao at various SOI forecast (SOI negative)

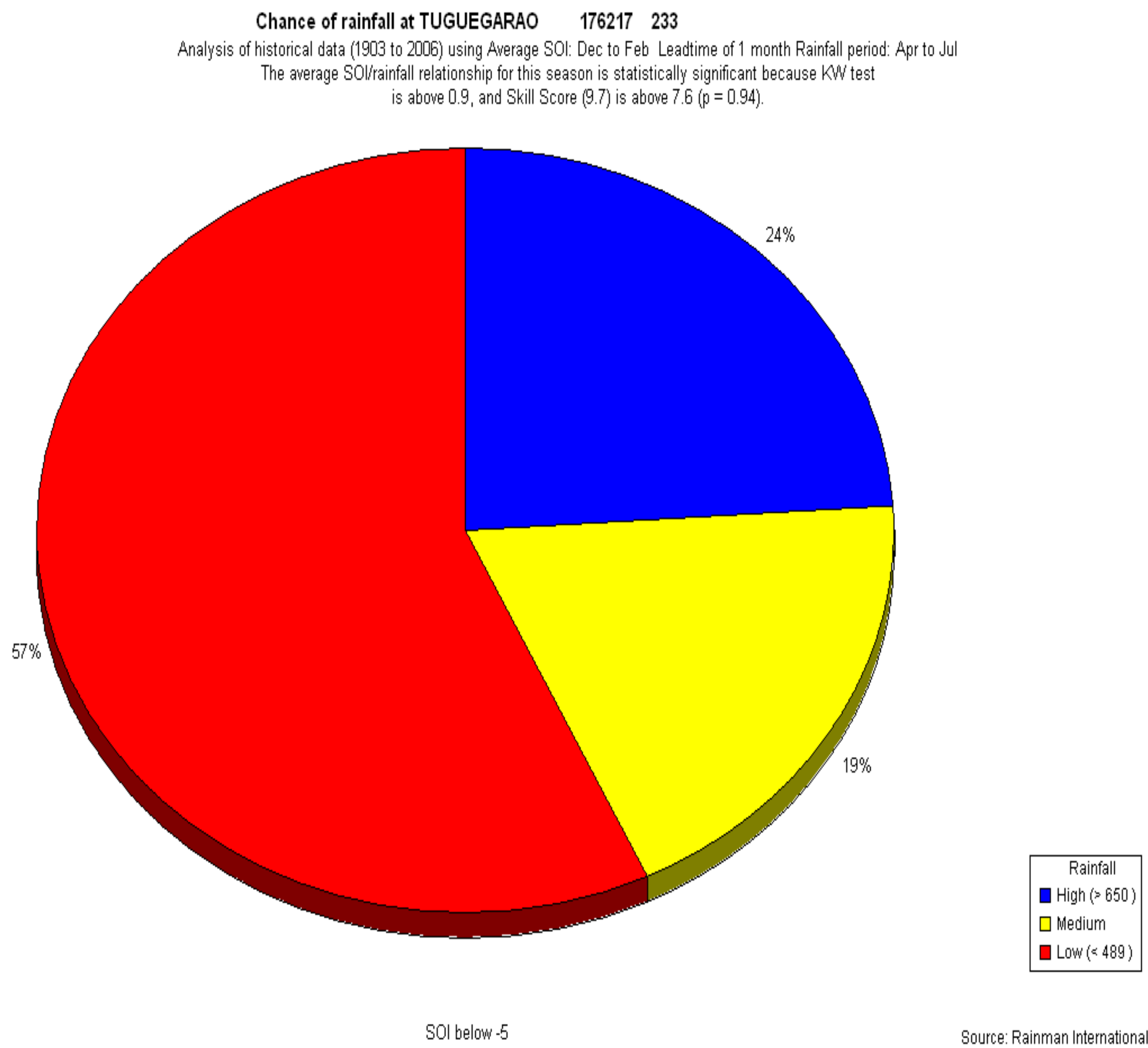


Figure 7c. Chances of rainfall in Tuguegarao at various SOI forecast (SOI positive)

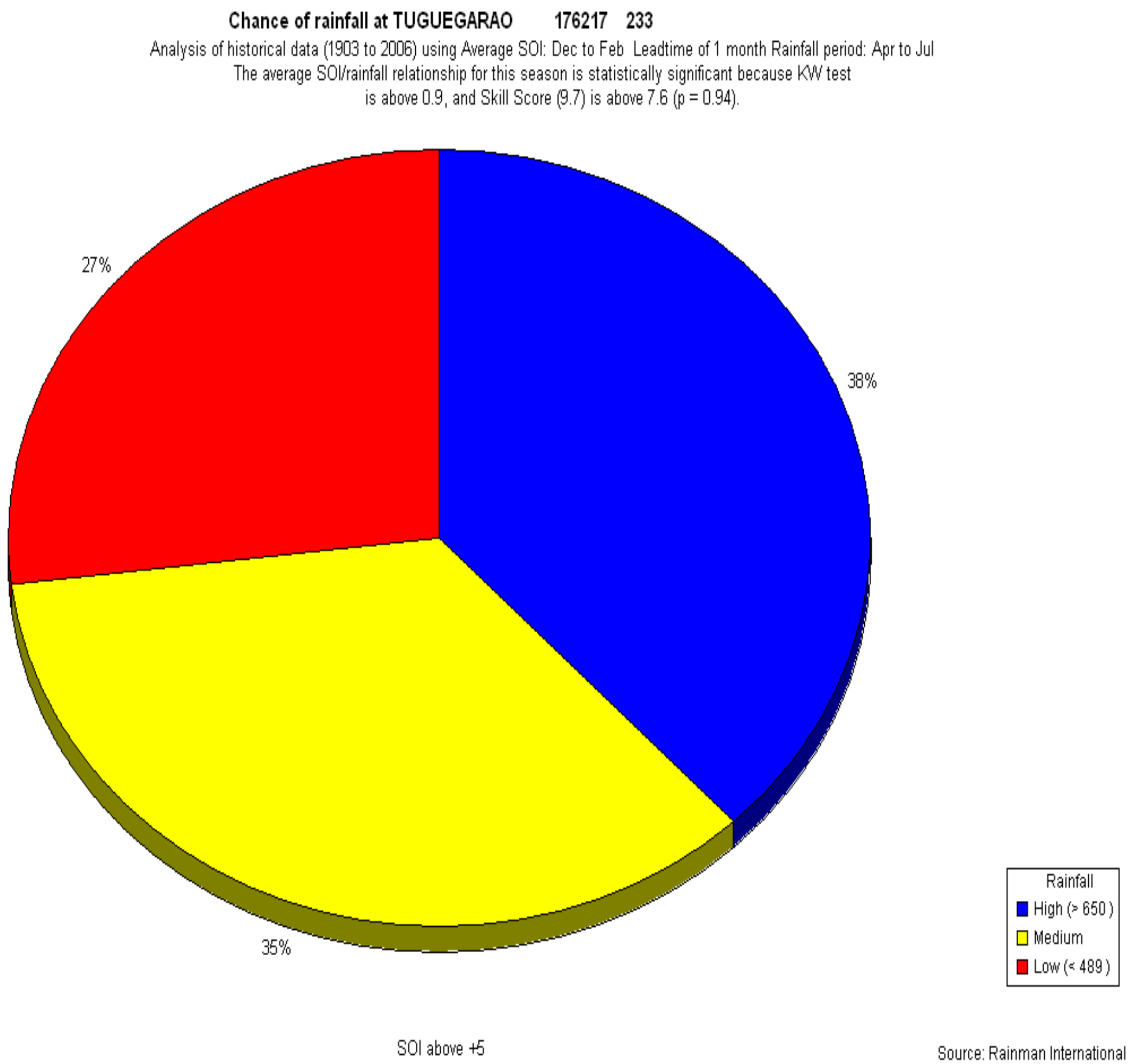


Table 1. Expected gross margin (PhP/ha/season) of Cargill at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	GOOD	NEUTRAL	POOR
WET	10,824	7,754	7,804
DRY	19,024	20,028	18,504

Table 2. Expected gross margin (PhP/ha/season) of IPB at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	GOOD	NEUTRAL	POOR
WET	6,583	3,633	3,914
DRY	12,041	13,339	12,595

Table 3. Expected gross margin (PhP/ha/season) of Dekalb at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	GOOD	NEUTRAL	POOR
WET	16,074	12,680	13,585
DRY	14,542	11,610	16,393

Table 1. Expected gross margin (PhP/ha/season) of Cargill at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	GOOD	NEUTRAL	POOR
WET	11,238	11,540	10,585
DRY	21,084	22,025	19,451

Table 2. Expected gross margin (PhP/ha/season) of IPB at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	GOOD	NEUTRAL	POOR
WET	8,544	7,599	7,402
DRY	16,882	17,815	10,869

Table 3. Expected gross margin (PhP/ha/season) of Dekalb at various climatic variabilities during wet and dry season.

SEASON/CLIMATE	GOOD	NEUTRAL	POOR
WET	18,554	15,586	17,034
DRY	15,134	12,922	18,373

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