Estimation of pure premium based on analysis of crop yield and weather for the introduction of crop insurance program in Malaysia

マレーシアにおける作物保険導入ための作物単収と気象の相関分析に基づく純保険料推計

47216811, George Karung Barat
Supervisor: Professor Koshi Yoshida

Keywords: Crop Insurance, Pure Premium, Crop Yield, Weather, Malaysia

1. INTRODUCTION

Rice is Malaysia's main staple food; rice consumption per capita in 2020 was around 79.3 kg/year, while rice's self-sufficiency level (SSL) was about 62.9% (MAFI Malaysia, 2021). According to the data from EM-DAT, Peninsular Malaysia experienced 50 significant floods, most of which happened during the monsoon seasons (CRED, 2023). Between 2017 and 2021, floods have contributed to RM128.8 million in losses covering 40,828 hectares of paddy area, while drought has caused RM21.6 million in losses covering 9,336 hectares (Malay Mail, 2021). Currently, the government provides post-disaster assistance through Paddy Crop Disaster Fund with rates between RM876 to RM1,800 per hectare, covering a maximum of 3 hectares for each farmer (NSTP, 2023) and in early 2023 announced Food Crop Insurance Scheme as a replacement (Bernama, 2023).

A study assessing Thailand's crop insurance indicates that the main reason for low adoption by farmers is that the premium is not affordable, and the compensation received needs to be bigger (Sinha, 2016). Dick, W. et al. (2010), citing a 2008 World Bank survey, indicates that the government mainly supports crop insurance programs through premium subsidies, estimated at 44 % of the original gross premium. Pure premium or premium ratings are primarily studied in China, as they rapidly expand their national crop insurance program but lack historical data (Wang, 2023). Therefore, this study aims to analyse the relationship between paddy yield and weather variables, calculate the pure premium based on the historical loss yield data, and discuss the challenges in introducing a crop insurance program in Malaysia.

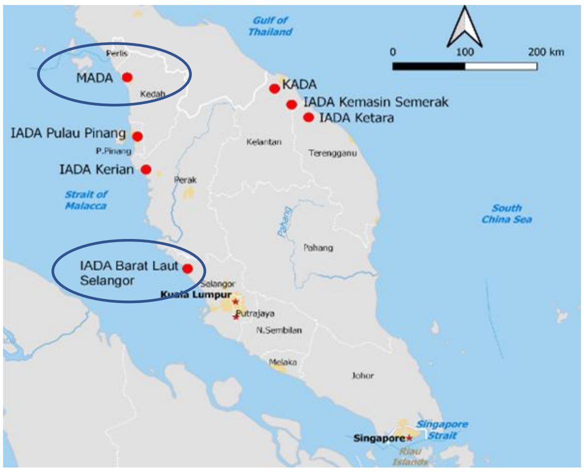

Figure 1: Location of the study locations and other paddy irrigations area in Peninsular Malaysia

2. METHODOLOGY

The Muda Agriculture Development Authority (MADA) Irrigation Scheme and Barat Laut Selangor (BLS) Integrated Agriculture Development Area are selected as study locations (Figure 1). Crop data for 33 years, from 1986 until 2018, was obtained from the Ministry of Agriculture and Food Security Malaysia. Monthly precipitation amounts, rainy days, and temperature data for 33 years from 1986 until 2018 were acquired from the Department of Meteorological Malaysia.

Crop Yield Loss and Pure Premium Calculation

To find the relationship between crop yield and weather, Pearson's Correlation Coefficients and multiple linear regression were conducted separately for the main and off-season using the R statistical software. Simple Moving Averages (SMA) method is used to back cast and estimate the theoretical value from the actual yield value. The ratio of crop yield loss for each year of each granary, therefore, could be determined by calculating the difference between the actual yield and the theoretical yield using Eq. (1), where L_{ig} is the yield loss rate of the granary area g in the year i, $Y_g{}'_{(i)}$ is the theoretical value of yield of the granary area g in the year i and Y_{ig} is the actual yield of the granary area g in the year i. (Wang, 2023):

$$L_{ig} = \{max[\,(Y_g{}'_{(i)} - Y_{ig}\,),0]\,/Y_g{}'_{(i)}\} \qquad (1)$$

To calculate the average loss ratio for the period of data, which is 33 years, using Eq. (5) where P_g is the average loss rate of granary area g, n is the number of years of data history, $\frac{1}{n}$ is the probability of occurrence of yield loss in the data history and L_{ig} is the yield loss rate of the granary area g in the year i (Wang, 2023):

$$P_g = \frac{1}{n}\sum_{i=1}^{n} L_{ig} \quad (i = 1,2, \ldots.., n) \qquad (2)$$

The pure premium price is calculated using the empirical rate method (Eg. (3)), where the expected loss is the yield loss over the historical data period, sum insured is the insured amount which here uses the rice Guarantee Minimum Price (RM1,200/MT) set by the government for Peninsular Malaysia.

$$Pure\ Premium = Actuarially\ Fair\ Premium = Expected\ loss \times Sum\ Insured \qquad (3)$$

3. RESULT AND DISCUSSION

Based on the correlation analysis, there is a negative relationship ($p < 0.001\%$) between yield of MADA off season with the precipitation on the month of August (-0.55) during the harvesting period and negative relationship ($p < 0.05\%$) with the average temperature on the month of April (-0.35) during the planting period. Analysis for the BLS main season, shows that significantly positive relationship ($p < 0.01\%$) between yield with the precipitation on the harvesting month of December (0.45) and significantly negative ($p < 0.01\%$) relationship in January (-0.45). The relationship between yield and temperature in MADA and BLS are not strong which indicates that during the study period, the temperature increase is still favourable for paddy planting and as a whole climate change does not have any impact on the overall crop growth.

The result of regression analysis shows that only 3 models are significant which is Model 2, 8 and 10. Analysis of regression between MADA off-season yield and precipitation and temperature Model 2 shows that the increase in precipitation in August reduced the yield by 0.66 ($p < 5\%$). However, the rising temperature in June increases the yield by 1.04 ($p < 5\%$), which means that the temperature increase is optimal for paddy plant growth. For BLS off-season (Model 8), an increase in rainfall in March and May reduced the yield by 0.46 ($p < 5\%$) and 0.63 ($p < 5\%$), respectively. The temperature in May reduces the yield by 0.65 ($p < 10\%$), while the temperature in February and June increases the yield by 1.21 ($p < 5\%$) and 1.44 ($p < 1\%$), respectively. Regression analysis between BLS main season yield and SPI 6 (Model 10) shows a reduced yield by 0.88 ($p < 1\%$) in the second month of the planting period, which indicates the negative effects of higher-than-normal precipitation during the early stages of paddy planting.

Table 1: Average loss rate and pure premium of MADA and BLS for main and off-season (per hectare)

Granary	Planting Season	Average loss rate	Pure Premium (RM/USD)
MADA	Main	0.035	41.41 / 8.86
	Off	0.011	13.11 / 2.81
BLS	Main	0.041	49.31 / 10.56
	Off	0.033	39.53 / 8.46

Notes: USD1=RM4.67 (June 29, 2023)

The highest yearly yield loss for MADA main season happened during 2006 (0.298 kilogram/hectares) caused by floods (Alam, 2020) and followed by 1997 (0.151 kilogram/hectares) due to EL-Nino affecting the whole of Malaysia in 1997/1998 (ASM, 2018). MADA off-season also experiences loss during the 1997/1998 El-Nino, but the loss (0.055 kilogram/hectares) is lesser than the main season. BLS's higher yield loss during the primary season occurred in 1999 (0.143 kilogram/hectares) because of EL-Nino and 1994 (0.162 kilogram/hectares) during the off-season for unknown causes. As shown in Table 1, MADA pure premium in the off-season is the lowest under fewer anomalies in the historical data compared to the main season. For BLS, the pure premium is almost similar in both main and off-season but slightly higher if compared to MADA. Based on the relationship analysis of crop yield and weather, the pure premium for the off-season in MADA and BLS are representations of pure premiums affected by weather conditions.

4. CONCLUSIONS

Overall, BLS have a higher pure premium than MADA as it is more affected by temperature and monthly rainfall increase. Both premium amounts are lower than the previous study, suggesting that farmers are willing to pay RM48-76 for RM 1,000/hectares coverage, totalling RM230 - 365/hectares (i.e., an average yield of 4 tons/ha is RM4,800/ha) (Abdullah A. et. al. 2014, Afroz, R. et al.,2017). The total premium amount to provide coverage for both planting seasons for the MADA area is RM8.95 million/USD1.91 million and for the BLS area is RM 1.64 million/USD 0.35 million. However, the premium value does not include the administration cost and the risk loading of different risk areas, which might increase the final premium rate calculated in this study to more than the farmer's WTP and the total amount. As discussed in the literature, premium pricing of crop insurance is one of the stumbling blocks when a government tries to expand or upscale their crop insurance program. It is essential that the participation of farmers be the government's main priority, and voluntary farmers' participation only happens when farmers can pay for the premium themselves based on their affordability.

5. REFERENCES:

Abdullah A. et. al (2014). Farmers' willingness to pay for crop insurance in North West Selangor Integrated Agricultural Development Area (IADA), Malaysia. Journal of the International Society for Southeast Asian Agricultural Sciences. 20. 19-30.

Academy of Sciences Malaysia (ASM). (2018). El Niño: A Review of Scientific Understanding and the Impacts of 1997/98 Event in Malaysia.

Afroz, R. et al. (2017). Willingness to Pay for Crop Insurance to Adapt Flood Risk by Malaysian Farmers: An Empirical Investigation of Kedah. IJEFI, 7, 1–9.

Alam, A. S. et. al (2020). Agriculture Insurance for Disaster Risk Reduction: A case study of Malaysia. https://doi.org/10.1016/j.ijdrr.2020.101626

Bernama. (2023). Takaful scheme for PADI crops to be launched soon. BERNAMA.https://www.bernama.com/en/general/news_disaster.php?id=2168513

Centre for Research on the Epidemiology of Disasters (CRED) / UCLouvain, Brussels, Belgium. The emergency event database (EM-DAT) – www.emdat.be. Accessed in May 2023

Dick, W. J. A., & Wang, W. (2010). Government interventions in agricultural insurance. https://doi.org/10.1016/j.aaspro.2010.09.002

Ministry of Agriculture and Food Industries (MAFI), Malaysia, 2021. Perangkaan Agromakanan Malaysia 2021

New Straits Times Press (NSTP). (2023). Farmers incur RM5.4 million in losses due to floods. https://www.nst.com.my/news/nation/2023/01/869512/farmers-incur-rm54-million-losses-due-floods

Sinha, S. et. al (2016). Assessing the challenges in successful implementation and adoption of crop insurance in Thailand. Sustainability, 8(12), 1306.

Wang, W. et. al. (2023) Remote Sensing Application in Pure Premium Rate- Making of Winter Wheat Crop Insurance. https://doi.org/10.3390/ su15097133