DETERMINATION OF CRITICAL PRODUCTIVITY LEVEL ON CLUSTER-BASED AREA OF RICE CROP INSURANCE IN JAVA

Penentuan Tingkat Produktivitas Kritis pada Wilayah Asuransi Usaha Tani Padi Berbasis Klaster di Jawa

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ABSTRAK

Kesenjangan tingkat produktivitas padi di Indonesia cukup besar yang di antaranya dipengaruhi oleh luasnya wilayah pertanaman. Hal ini berdampak pada desain dan penerapan model Asuransi Usaha Tani Padi (AUTP) berbasis produktivitas. Perluasan klaster pada tingkat provinsi diperkirakan dapat mengurangi keragaman produktivitas di tingkat wilayah kota/kabupaten sebagai risiko dasar pemanfaatan skema AUTP berbasis klaster. Klaster, sebagai wilayah atau zona, diperlukan untuk menentukan indeks kritis produktivitas yang akurat dalam rangka penghitungan tingkat premi yang tepat. Kajian ini bertujuan untuk menentukan tingkat produktivitas kritis pada lahan padi yang menerapkan skema AUTP. Kajian ini menggunakan analisis statistik dengan pendekatan batas bawah *Two Sigma* yang dapat dianggap sebagai batas produktivitas kritis untuk setiap klaster. Teknik ini memberikan persentase yang rendah atas klaim yang terjadi, serta ekspektasi dan simpangan baku dari risiko dasar kerugian. Tarif premi murni yang diperoleh adalah Rp85.191,18, hampir 2,5 kali lipat lebih kecil dibandingkan dengan menggunakan teknik lain sebagai batas poduktivitas. Hasil kajian ini mengungkapkan bahwa penggunaan skema berbasis klaster lebih baik dari skema berbasis provinsi, sebagaimana ditunjukkan oleh nilai TVaR. Kajian ini menyarankan agar Kementerian Pertanian dapat merancang model AUTP berbasis produktivitas berdasarkan klaster dengan setiap klaster memiliki nilai indeks produktivitas kritis yang berbeda untuk menetapkan tingkat premi yang dikenakan.

Kata kunci: *asuransi usaha tani padi, indeks produktivitas berbasis klaster, produktivitas*

ABSTRACT

There is a large gap in productivity of paddy in Indonesia which is, among others affected by the area size of crop planting. This condition should influence the design and application model of the rice crop insurance scheme. Developing clusters under the province level is recommended to reduce the heterogeneous productivity as basis risk within regencies/municipalities in improving the area yield index of crop insurance policy in Indonesia. Clusters, as the zone, are necessary to determine accurate critical yield index leading to a more precise premium rate making. This study aims to determine critical productivity level on rice crop insurance area. This study applied statistical analysis using the lower bound of Two Sigma as a critical yield for each cluster. This technique provides a small percentage of claim, and the expectation and standard deviation of basis risk loss. The pure premium rate obtained from the analysis is IDR85,191.18, that is almost 2.5 times less than using other methods as trigger productivity. The analysis result emphasized that the use of the cluster-based scheme is better than the province-based as shown by TVaR value. The study suggests that the Ministry of Agriculture could design the area yield index based on clusters as each cluster will have a different critical productivity index with adjusted premium rate value.

Keywords: *cluster-based area yield index, productivity, rice crop insurance*

INTRODUCTION

Rice is staple food for Indonesian. The availability, accessibility, and affordability of rice at all times have been the concern of the government to feed Indonesians. Rice production steadily increase following the application of a more intensive technology while keeping the cultivation adjusted to local farm recommendation. Meanwhile, adaptation to the impact of global climate change is constantly the primary attention. With improvement of agricultural infrastructures, along with improved irrigation and adoption of high-yield varieties, the farmers could continue to work in their respective farms. As a main crop, rice has been treated intensively with various facilities to ensure its production. Fertilizer subsidy and financial support through low rate interest of credit are among the facilities at which farmers are eligible to, although with certain terms and conditions. Nonetheless, farmers always face farm risks that would end up with great loss, due to, for instance, uncontrolled natural calamities or man-made disasters. Uncertainty leading to farm damage or harvest failure mainly caused by flood, drought, and or pests and diseases infestations. In many developing countries, including Indonesia, 83% of losses in agricultural sector is caused by flood and drought (Pasaribu et al. 2020; FAO 2015).

During the era of Covid-19 pandemic, farm protection through agricultural insurance is highly required to secure the farmers and their farm activities. Farmers are requested to continue their activities in their respective farm fields to ensure the production of, especially food for all people. It is understood that farmers are struggling to work in their farms amid the threat of the deadly coronavirus. Therefore, extra protection should be addressed to the farmers who are preparing food and trying hard to meet the increasing trend of food demand. Agricultural insurance obviously plays its significant role to support optimism and keep the farmer’s safe, secure, and peaceful. The farmers deserve to have close guard, not only from technical point of view, but also from the farm risks they may experience through the planting season/raising the livestock. This situation is relevant with the current situation. While keeping and applying the recommended health protocols, the farmers are entitled to have special attention as they may experience double burden caused by the impact of Covid-19 pandemic. For this condition, the Ministry of Agriculture has been alerted and immediately took an action by the issuance of policy support through the close guard to make the availability of agricultural inputs at all times and speeding the payment of claim to allow farmers to immediately continue their work at farm level.

One of the problems encountered in farm and agricultural development is the smallholding farmer’s inability to provide sufficient capital to cover cost of production. Therefore, if the farmers are confronted with risk that cause severe damage of the farm with great loss, they would be unable to continue their activity. Lack of money to fund their farm would only be allow them to depend on the local money lenders since most of them are not eligible to access to formal credit. This description trying to state that the small farmers need protection, and agricultural insurance is one of the positive responses to encounter such constraint.

Following the insurance of Law No. 19/2013 on Farmer’s Protection and Empowerment, agricultural insurance has been introduced to protect the farmer’s interest. This mandate has been recognized as a key success of agricultural growth that would stabilize farmers’ income when facing natural disasters (Wang et al. 2015). However, agricultural insurance is not always available according to the farmer’s need. The offered insurance scheme may not suitable with the farmers’ interest as it is come with unexpected terms and conditions along with the estimation of the amount of losses/size of farm damage (Lyu and Barre 2017). Therefore, protection on farmer’s farm should thoroughly consider the amount of premium rate with requirements the farmers could afford. Detail information should be available and well communicate with the farmers at which the insurance company should not be allowed to take any advantage other that the stipulated and agreed terms and conditions (Liesivaara dan Myyra 2014). Comprehensive and clear information should be the basis of agricultural insurance (rice crop insurance scheme) application.

Ministry of Agriculture (MoA) has conducted farm/livestock protection to rescue farmers from great loss due to farm risks causing farm damage or loss of cows. The schemes, called rice crop insurance (AUTP, since 2015) and livestock insurance (AUTS/K, since 2016), were designed following the principal of public-private partnership business model by involving the government (regulator), the private sector (implementor/insurer), and the farmers (recipient/insured). The AUTP and AUTS/K schemes so far have been accepted by the farmers with subsidized premium rate and other advantages in favor of the farmers. MoA requested PT Jasindo, a state-owned insurance company to conduct this indemnity-based crop insurance scheme or also known as Multi-Peril Crop Insurance (MPCI).

To have a picture of the implementation of AUTP and AUTS/K schemes, the following Table 1 could illustrate the schemes performance since this insurance was introduced. The AUTP scheme indicated some fluctuations as shown by the figures of claim filled by the farmers. Similar condition also shown by the AUTS/K scheme indicated the dynamic of these schemes at the implementation stage. However, farmers who

Table 1. Performance of AUTP and AUTS/K insurance scheme, 2015-2020

Year	AUTP scheme				AUTS/K scheme			
	Target (000 ha)	Actual (ha)	%	Claim (IDR000)	Target (000 head)	Actual (head)	%	Claim (IDR000)
2015	1,000	233,499.55	23.34	23,148,389	-	-	-	-
2016	1,000	499,962.25	49.99	78,393,661	120	20,000	16.67	9,942,587
2017	1,000	997,960.54	99.79	96,115,945	120	92,176	76.81	7,571,035
2018	1,000	588,506.26	58.85	102,452,187	120	88,673	73.89	32,281,508
2019	1,000	971,218.76	97.12	126,964,863	150	140,19	93.46	42,333,245
2020*	1,000	681,950.57	68.19	NA	120	55,821	46.54	4,600,000

Source: Direktorat Pembiayaan Pertanian (2020)
Note: *Estimated as of 14 September 2020

suffered from farm damage or livestock losses have had benefits obtained from such schemes. This model works and attracts farmers as the figures indicate the incerasing trend of the insured party. Nonetheless, an alternative insurance could be an advantage in enhancing the imporatnce of farmer's protection.

Over the year of 2015 to 2020, the area of damaged land (ha) and total claims (IDR) continued to increase (as shown in Table 1). This is obvious as the number of farmers or Poktan joining insurance did also increase. However, the total of claims (IDR), which is triple from 2015 to 2017, even more so in 2019, could of course be detrimental to the insurance company. In addition, the possibility of moral hazard occuring at the individual farmer and/or Poktan level is also increasing.

The indemnity-based insurance model, to some extent has also carried out some disadvantages, especially when it comes to claim mechanism at which complex producers should be folowed. Therefore, other insurance models would be welcome as long as it meets farmer's preference. The area yield index (AYI) could be an alternative scheme to be applied in Indonesia as this model has more accurate with fairness in treating both the insured and insurer parties (Handoko 2016; Sutomo et al. 2019; Kusumaningrum et al. Forthcoming).

How AYI insurance model fit with the interest of both insurer and insured parties? First, farmers need to look at the premium rate and the claim amount along with the terms and conditions. This is why the calculation of this premium rate is necessary and this paper is prepared in response to such request. Second, how to apply it if this is suitable to the farmer's expectation. Normally, farmers need very simple requirements, less paper work, and fast process. If this AYI model is affordable, all information regarding the new applied model should be well prepared with dissemination procedures (socialization, promotion, and advocation activities). The insurer, on the other hand, need all requirements to be well understood by the insured farmers. In this regard, cooperation among the stakeholders, specifically between the insurer and the local government to launch the AYI model is essential. When no gap in communication between these parties, the AYI model could be smoothly implemented.

The application of the AYI scheme in several countries apart from Indonesia has been considered (Bunyasiri and Sirisupluxana 2018; Ye et al. 2019). The indemnity of AYI product is based on the actual (harvested) average yield of an area such as a county or district, not the individual yield. The losses are measured as the difference between the actual yields and the insured average yields in the indexed municipality (Boshkovska 2018). The trigger yield used requires historical "region" yield data on which the normal average yield and insured yield can be established. Hence, it can minimize problems, like adverse selection and moral hazard, and works efficiently when the insurance unit is homogeneous (Rao 2010). Presently, the rice yield gap is being made to reduce the heterogeneous area as the 'basis risk' in Indonesia, especially in Java.

Although it has been stated that a reduction in area size will improve the risk-reducing effectiveness in Indonesia, no alternative has been found to the area or zone boundaries for implementing area yield scheme. Haryastuti et al. (2021) have found the area or zone boundaries for the area yield scheme to improve the risk-reducing effectiveness. It is referred to as clusters or "sub province" level, lower disaggregate of province, that contains regencies/municipalities. The 12 clusters in Java is conducted by the average of paddy productivity from 2007 to 2018, which becomes a new potential to obtain the critical index of the zone, and the Queen contiguity matrix by regency/ municipality to cluster similar characteristics of farmers (Wang 2000). Thus, the area yield index scheme based on these clusters would be designed and each cluster will have different critical productivity index and adjusted premium.

Accordingly, obtaining the estimation of triggered or critical yield index is the thrust of this paper, which is an important step after developing zone for area yield scheme to calculate a more precise premium and compensation. There are two essential lines to be conveyed: (1) earning the expected critical yield index, and (2) emphasizing the application of selected zone. To these lines, first, after classifying/ assigning each region into an appropriate zone on previous study, a method for critical productivity index based on the clusters is proposed. The method that produces the minimum expectation and standard deviation of indemnity in the selected zone indicates the best critical yield index. There are mean, median, average of Winsor, and lower bound of Two Sigma approach. The proposed methods are very simple, so that it can be applied easily and practically by insurance company or relevant industries. Second, this research also extends the previous study to compare the risk concepts, i.e. *Value-at-Risk* ($VaR(X)$) and *Tail-Value-at-Risk* ($TVaR(X)$), between province-based and cluster-based. This is due to the use of standard deviation ratios, within and between clusters (Munthe et al. 2018), in the zone selection that is too simple. Maximum Likelihood Estimation (MLE) is prominent method to estimate the parameter distribution of loss according to the data in this study.

METHODOLOGY

Theoretical Framework

GRP or commonly known as AYI insurance scheme is a type of insurance which pays a farmer indemnity only when the realized average yield of its county falls below pre-selected coverage level (Wang and Zhang 2003). This scheme had been applied into several agrarian countries using county as the triggered yields, but the effectiveness still needs to be evaluated. Whereas, the concept of zone based area yield scheme to mitigate the risk of implementing crop insurance in this study refers to Wang (2000). It is a more effective risk-reducing tools than AYI in general. The zone is referred to as a geographical region covering regencies/ municipalities, each of which can be considered as triggered or critical yield and consist of all farms with similar yields. Haryastuti et al. (2021) have estimated using Ward-like hierarchical clustering that the area or zone boundaries for the area yield scheme is referred to as clusters or "sub province" level, lower dissaggregate of province. The variables used to establish the zone are average paddy productivity over time and geographical constraint or spatial dependency (that is the latitude and longitude), both are among at regency/ municipality level.

The next important part in developing area yield scheme is determining the estimation of triggered or critical yield index y_{c_k}. Without the y_{c_k}, we could not adjust appropriate both premium and compensation for farmers. Assuming that the paddy productivities in each cluster are homogeneous and normal distributed, the central tendency of statistics for y_{c_k} as parameter estimation is conducted, that is mean and median. Moreover, to cope with developed clusters that is not ideal, average of Winsor and lower bound of Two Sigma approach are used to alleviate the variation between cluster index and actual productivity or reference index. Besides the goodness of fit assumption, those methods are also offered due to the simple calculation for the insurance practitioners. The method that produces the minimum expectation ($E(X)$) and standard deviation ($Std(X)$) of indemnity in the selected zone indicates the best critical yield index (Binswanger-Mkhize 2012; Garcia and Tsur 2020). If the expected value of indemnity is assumed to be the pure premium, it should cover basis risk loss and catastrophic risk loss (Wang et al. 2010) and be as minimum as possible, so it is affordable by the farmers. While the standard deviation, that is a measure of how much the probability is spread out over the random variable's possible value, may capture the fluctuation of adjusted premium rate.

To adjust the premium, the average productivity of district $\bar{y}_d$ within its cluster will be compared to the critical productivity index y_{c_k}. The $\bar{y}_d$ is the reference index that determines indemnity, not individually (Kusumaningrum et al. Forthcoming). If the actual productivity of the entire village of the district $\bar{y}_d$ is under the critical productivity index y_{c_k}, then the indemnity will be triggered and all farmers of the district will be compensated proportionally, subjected to the insured farming land size. Bootstrap method is conducted to resample the individual level of paddy productivity and harvested land area due to the lack of sample size. The individual yield rates are used to estimate the robust mean of productivity farmers within the district. Whereas harvested land area of the household under 2 ha is assumed to be insured farming land. Further, both generated data are provided to acquire indemnity amount for first quarter of harvesting period.

Maximum Likelihood Estimation (MLE) is not only used to estimate ($E(X)$) and ($Std(X)$) of indemnity, but also to describe the upper tail distribution, that is $VaR(X)$ and $TVaR(X)$. It is applied to accentuate the zone that is better based on each estimated critical yield. The excess of $TVaR(X)$ over $VaR(X)$ is linear increasing function in the $VaR(X)$. In other words, a larger $VaR(X)$ results in a larger mean excess loss indicating a dangerous distribution (Klugman et al. 2012).

Data

The research has been carried out from 2018 to 2020 at DI Yogyakarta, West Java, Central Java, East Java, West Nusa Tenggara, and North Sumatera. The selected location is based on consideration of rice production center provinces in Indonesia. The survey used non-probability sampling method by interviewing 488 farmers. The data taken is rice farming data, including planting area (ha), productivity (ton per ha), estimated production cost and total revenue (IDR), and so on, and recorded into three planting seasons. First term starts from November 2017 to February 2018, second term starts from March to June 2018, and third term starts from July to October 2018. In this study, determination of cluster based area yield and its critical index, was only conducted in Java. Table 2 shows the information about our samples surveyed, combined with the actual number of farmer's groups (called as Kelompok Tani (Poktan) in Indonesia) provided by PT Jasindo.

The use of primary data did not deliver the estimation of critical yield index for each cluster directly (see Figure 1). In this study, paddy productivity and harvested area at the household level of first planting season (November 2017 to February 2018) is applied to obtain the loss distribution, predicated on its expectation and standard deviation of the indemnity. The proposed methods, namely mean, median, average of Winsor, and lower bound of Two Sigma, should produce different distribution of losses. Whereas, the four estimation of critical yield indexes on each cluster have received from secondary data. That was paddy productivity at regency/municipality level, taken from Agricultural Statistics Database of MoA since the year of 2007 to 2018 (Haryastuti et al. 2021).

In order to calculate a more accurate indemnity and generate its distribution, resampling will be carried out to the surveyed samples using Bootstrap method. It is because of the insufficient number of farmers statistically on each district. The replication is as much as the number of Poktan in each district multiplied by 25. The number of Poktan members is around 20 to 25 farmers (MoA 2007).

According to Sahinler and Topuz (2007), the steps for our Bootstrap studies are summarized as follows:

a. Consider the sample from population with sample size *n* of each surveyed district.

b. For each district, draw a sample from the original sample data with replacement with size *n*, and replicate *B* times. Take into account the number of Poktan, then multiplied by 25, for the size of *B* bootstrap samples.

c. Evaluate the average of θ for each bootstrap sample, and there will be totally *B* estimates of θ.

Table 2. Number of districts and farmers surveyed in each province

Province	Regency/municipality	Number of district	Number of farmers	Number of poktan*
D.I Yogyakarta	Kulon Progo	1	20	10
	Sleman	4	60	11
Jawa Barat	Bandung	14	37	141
	Bogor	5	41	26
	Cirebon	6	30	396
	Karawang	6	123	498
	Kota Bogor	1	25	4
Jawa Tengah	Klaten	1	49	2
	Sukoharjo	1	21	15
Jawa Timur	Lamongan	9	35	859
	Malang	9	34	109

Note: *Number of Poktan is provided by PT Jasindo that can be used to estimate the number of farmer

d. Run step (a) through (c) for both actual paddy productivity (ton per ha) and harvested land, that is assumed as total insured farming land, at household level.

Analysis Procedure

The following are the carried out stages of analysis (see Figure 1):

1. Earn the expected area yield of yield rate for each cluster μ_k of selected zone. Based on Rao (2010) y_c, which is also called threshold yield, is the μ itself. Here we use the average, median, average of Winsor, and lower bound of Two Sigma approach.

   a. Based on average

   $$\mu_k = \frac{1}{N_k}\sum_{i=1}^{N_k} x_i \qquad (1)$$

   b. Based on median

   $$\mu_k = \begin{cases} x_{\frac{N_k+1}{2}}, \; if\ N_k\ is\ odd \\ \dfrac{x_{\frac{N_k}{2}} + x_{\frac{N_k+2}{2}}}{2}, \; if\ N_k\ is\ even \end{cases} \qquad (2)$$

   c. Based on average of Winsor approach

   $$\mu_k = \frac{1}{N_k}\left((w+1)x_{(w+1)} + \sum_{i=w+2}^{N_k-w-1} x_i + (w+1)x_{(N_k-w)}\right) \qquad (3)$$

   The *w*-times Winsorized mean is the mean computed after replacing the *w* smallest observations with the (*w+1*) smallest observation, and the *w* largest observations with the (*w+1*) largest observation.

   d. Based on lower bound of two-sigma approach (Shewhart control chart)

   $$\mu_k^* = \mu_k - 2\sigma_k \qquad (4)$$

   It allows 95% of the population lies within two standard deviations of mean, for which data has unimodal symmetrical distribution (Montgomery 2009; Klugman et al. 2012).

   Repeat (a.), (b.), (c.), and (d.) for all clusters, $k = 1,2,\dots,c$. For (b.), (c.), and (d.), x_i is the *i*th order statistic when the observations are arranged in increasing order.

2. Using the Bootstrap generated data y_{dj}, calculate the average yield rate of each district $\bar{y}_d$. The y_{dj} denotes the actual paddy productivity for farmer *j* in the *d*-th district, and $\bar{y}_d$ is the average ton per ha that defines the indemnity.

3. Calculate the indemnity using equation below

   $$indemnity = \max\left(\frac{y_{ck} - \bar{y}_d}{4.4\ \text{ton per ha}}, 0\right) \cdot SI \cdot L_{dj}, i = 1,2,\dots,m \qquad (5)$$

   where SI is sum of insured in Rupiahs (6,000,000.00 IDR), and L_{dj} is the total insured farming land for farmer *j* in the *d*-th district.

   The $\bar{y}_d$ is linked to a well-defined triggered yield of cluster y_{c_k}, then L_{dj} weights the amount of compensation that can be obtained

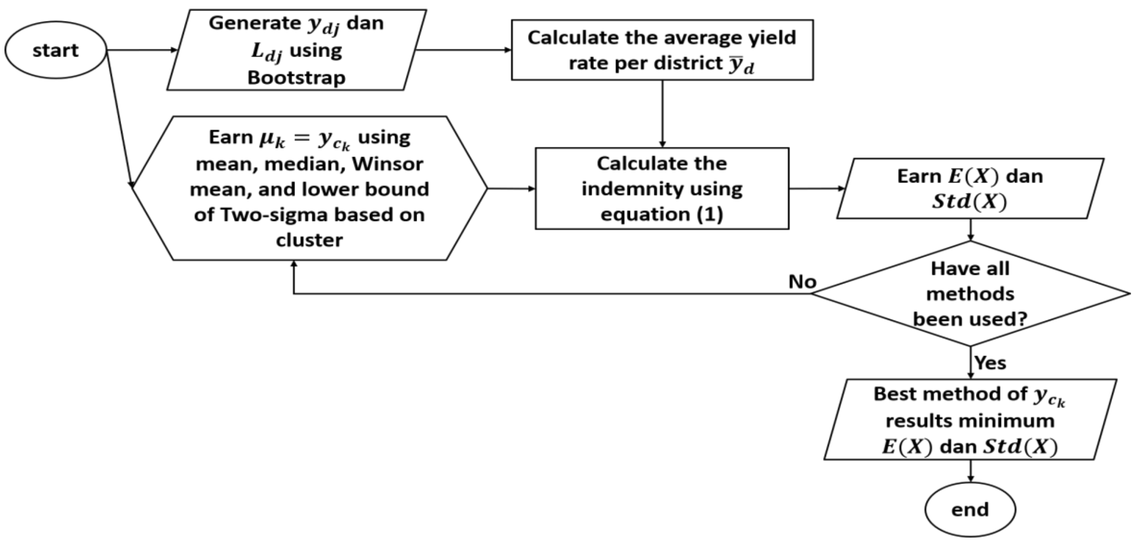

Figure 1. Research workflow

by farmers. The equation (5) is taken from Kusumaningrum et al. (Forthcoming), and the minimum average of yield rate over the years 2005 to 2015 that can be obtained nationally is 4.4 ton per ha.

4. Earn the expectation ($E(X)$) and standard deviation ($Std(X)$) of indemnity for all clusters based on each method in step (1).
5. Calculate the Value-at-Risk ($VaR(X)$) and Tail-*VaR* ($TVaR(X)$) of the indemnity. In this study, we use the probability of 75%. It can be written as

$$Pr\left(X > VaR_p(X)\right) = 1 - p,$$

$$TVaR_p(X) = E\left(X \middle| X > VaR_p(X)\right) = \frac{\int_{\pi_p}^{\infty} xf(x)dx}{1-F(\pi_p)}.$$

RESULTS AND DISCUSSIONS

Maintaining the production level of rice is crucial for farmers and consumers because rice farm activities are subject to uncertainty and are constantly exposed to high risks. With many problems faced by the farmers, adoption of technology, adaptation to climate change, and protection of farm are among the policies to improve farmer's welfare (Pasaribu and Sudiyanto 2016). Agriculture insurance is specifically designed to address such risks by MoA since the year 2012, when the pilot study of crop insurance scheme was carried out in severallocations.

When formally introduced in 2015, AUTP scheme should make some adjustments to its procedures to improve the scheme performance and meet the insured and the insurer's requirements. Table 3 illustrates the general performance of AUTP scheme during the past three years (2018-2020). The figures in this table should provide general description of AUTP scheme in the study locations.

In this study, the discussion will focus on improving the AUTP sheme, especially on the rice commodity, which implements MPCI. We proposed the AYI scheme to mitigate the risk by developing a zone, which groups regencies/ municipalities within each province based on similarities of productivity between spatial neighbors. Refers to Haryastuti et al. (2021), cluster labeling in the area yield scheme is denoted by the province itself (see Table 4). JTG stands for Central Java, JTM stands for East Java, BNT stands for Banten, JBR stands for West Java, and DIY stands for DI Yogyakarta. Each province has a maximum of three clusters. The first order, labeled 1, means that regencies/

Table 3. Area insured and claimed of AUTP scheme, 2018, 2019, and 2020

Year	Province	Insured areas	Flood	Drought	Pest and disease	Total claimed
2018	Banten	4,968.84	103.9	143.98	121.69	369.57
	West Java	131,376.55	191.38	648.08	590.37	1,429.82
	Central Java	85,639.69	464.16	345.34	206.96	1,016.46
	DI Yogyakarta	1,504.53	0	0	3.16	3.16
	East Java	390,696.27	565.78	963.76	390.92	1,920.45
	Total	614,185.88	1,325.21	2,101.16	1,313.08	4,739.45
	Percentage (%)		27.96	44.33	27.71	100
2019	Banten	13,715.34	24.7	579.45	63.6	667.75
	West Java	127,174.84	9.42	4,638.82	1,225.30	5,873.55
	Central Java	59,847.97	673.79	1,353.60	163.94	2,191.33
	DI Yogyakarta	2,532.42	599.18	0	0	599.18
	East Java	488,000.06	480.87	1,031.34	614.11	2,126.32
	Total	691,270.63	1,787.96	7,603.22	2,066.95	11.458.12
	Percentage (%)		15.6	66.36	18.04	100
2020	Banten	2,252.80	20.95	0	74.85	95.8
	West Java	66,855.85	600.28	58.37	606.33	1,264.98
	Central Java	95,826.29	73.52	40.52	169.87	283.9
	DI Yogyakarta	1,641.88	9.14	0	9.76	18.9
	East Java	329,498.33	71.57	49.58	825.49	946.64
	Total	496,075.15	775.45	148.47	1,686.30	2,610.22
	Percentage (%)		29.71	5.69	64.6	100

Source: Direktorat Pembiayaan Pertanian (2021)

Table 4. Critical productivity index based on clusters in Java

Level	Cluster	Method			
		Mean	Median	Winsor mean	Lower bound of Two Sigma
Low	JTG3	4.975	5.081	5.103	4.486
Middle	BNT1	5.343	5.373	5.343	5.156
	BNT2	5.206	5.206	5.206	4.850
	JBR3	5.480	5.495	5.480	5.309
	JTG2	5.599	5.606	5.599	5.344
	JTM2	5.782	5.749	5.782	5.479
	JTM3	5.252	5.313	5.306	4.648
High	DIY	5.922	6.095	5.935	4.920
	JBR1	6.070	6.077	6.070	5.996
	JBR2	5.879	5.856	5.879	5.709
	JTG1	5.997	5.926	5.969	5.463
	JTM1	6.206	6.167	6.177	5.909

Note: JTG is Central Java, JTM is East Java, BNT is Banten, JBR is West Java, DIY is DI Yogyakarta. The unit of measurement of critical productivity index is ton per ha.

municipalities within the cluster have highest paddy productivity, and up to order 3 is the cluster that consist of lowest yield. Apart from the clusters on each province that is defined as the zone area yield scheme, we also generalized those 12 clusters into three cover level based on target of rice productivity of Indonesia. It is done to maintain the effectiveness and efficiency of the cluster and its yield index, as well as an overview of the diversity of rice productivity to the agricultural insurance industry.

Apparently, the critical index resulted by mean, median, and Winsor mean in each cluster are similar (Table 4). It shows that the estimated yield rate between regencies/municipalities on each cluster are homogeneous or tend to follow normal distribution (Nicholson et al. 2019). The lower bound of Two Sigma certainly gives the lower value because it involves the standard deviation of the yield rate. This technique is chosen to overcome crop failures at the district level that may vary (Eichner and Wagener 2014).

To say that the cluster-based area yield scheme that is formed is good and can be applied, it is not enough for us to just see that paddy productivity at regency/ municipality level within the cluster is homogeneous and/ or following normal distribution. We need to look at distribution of losses, which can be explained by the expectation and standard deviation of indemnity, when implementing these clusters. The appropriate estimation of limit or critical productivity index for all farmers to be applied in area yield crop insurance is obtained from historical productivity data since 2007 to 2018 at regency/ municipality level within each cluster. The method is expected to be able to produce minimum claim occurrence, expectation, and standard deviation. Four statistical measures are used as the trigger yield y_{c_k} to be implemented in the calculation of indemnity according to equation (5), namely mean, median, Winsor mean, and lower bound of Two Sigma.

On the previous study (Sutomo et al.2019), we have obtained only seven clusters, which is coming from two levels, of paddy productivity. Those are DIY, JBR2, JTG1, and JTM1 which consist 5, 31, 1, and 9 districts respectively of high level productivity. Furthermore, JBR3, JTG2, and JTM2 which consist 1, 1, and 9 districts respectively of Medium level productivity. Since the lack of experimental data is a crucial issue to derive the strong estimate of actual yield rate of farmers in a district, generating more sample y_{dj} is necessary. After bootstrapping method is applied to resample the yield rate and harvested land area at household level, the average yield rate of surveyed district $\bar{y}_d$ is compared to its critical yield index y_{c_k}. If the actual productivity of the entire farmers on district drops below y_{c_k}, then the individual farmers or group farmers within the district will be compensated. It is called claim occurrence.

Figure 2 shows the claims that occur in high productivity level area are higher. The average rice productivity during the rainy season in 2018, the first quarter of planting, was 5.68 and 6.04 tons per ha at the high and middle level,

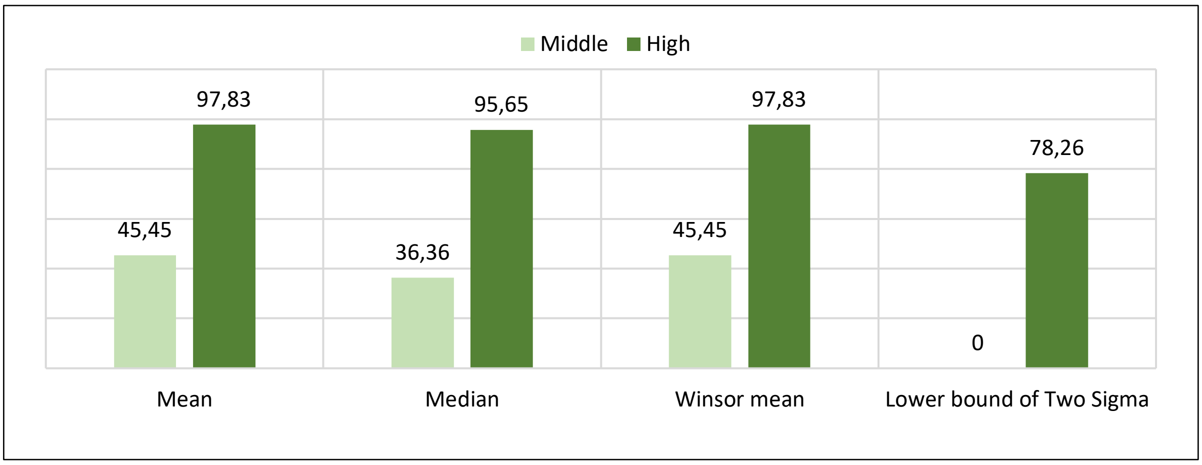

Figure 2. Percentage (%) of claim occurrence

respectively. The percentage of claims that occur when using the mean, median, and Winsor mean techniques as a trigger yield at the high productivity level area is twice the middle level. Meanwhile, when using the lower bound of Two Sigma approach, there are no claims at the middle level, and the high level is only 78.28%. That is lower than other methods. Even so, the high percentage of claim occurrence based on each estimation is still undesirable. Let say we use the lower bound of Two Sigma approach as the estimated yield index, so 78.26% of districts in high level areas should experience losses. Of course this figure is still relatively high and risky. The compensation should be shared by the insurance company, either those farmers actually have an average prductivity below its cluster (experiencing a loss) or not. Further description of the indemnity statistics would be continued with the following table.

The amount of indemnity or compensation is denoted by X, and the expected value of indemnity $E(X)$ is assumed to be the pure premium in this study. Ideally, a pure crop insurance premium rate should cover both basis risk loss and catastrophic risk loss (Wang et al. 2010). The basis risk loss is the compensation given to farmers or farmer groups proportionally, subject to the land area insured. Based on Table 5, loss distribution from applying cluster based area yield scheme with four estimation methods is impermissible. The value of standard deviation is overall bigger than the expectation of compensation. It means the possibility of greater losses by farmers that can affect premium rate. Moreover, the insurance company also has to provide even greater compensation.

Not only the percentage of claim occurrence is that is smallest than using the other methods (as shown in Figure 2), but lower bound of Two Sigma approach also gives the lowest, both expectation and standard deviation of indemnity (Table 5). While other methods provide statistics that are slightly different from one to another, it is difficult to draw conclusions. Among them are: Mean provides a minimum difference between $E(X)$ and $Std(X)$; Median provides lower percentage of claim occurrence and $E(X)$; Winsor Mean provides lower $Std(X)$.

Tabel 6 shows more detailed summary of the average loss experienced per cluster that built upon trial techniques y_{c_k}. Based on figures in this table, the highest average loss is experienced by farmers in JBR2. Contrarily, there are no claims in JBR3 and JTG2, based on the four methods; then JTG1 and JTM2 are in addition as applying the lower bound of Two Sigma approach. However, this comparison of average losses becomes less relevant because the number of

Table 5. Summary statistics of indemnity

Method	$E(X)$	$Std(X)$	$\lvert E(X) - Std(X)\rvert$
Mean	215,848.00	233,410.70	17,562.70
Median	211,103.50	233,258.80	22,155.30
Winsor mean	211,225.40	231,582.10	20,356.70
Lower bound of Two Sigma	85,191.00	159,900.60	74,709.42

Note: All columns are in IDR.

Table 6. Summary of indemnity per cluster

Cluster	Number of surveyed district	Mean	Median	Winsor mean	Lower bound of Two Sigma
DIY	5	305,387.84	380,260.17	311,154.98	12,289.64
JBR2	31	591,774.42	565,260.36	591,774.42	416,601.65
JBR3	1	0	0	0	0
JTG1	1	138,722.75	100,502.08	123,647.83	0
JTG2	1	0	0	0	0
JTM1	9	401,176.02	369,909.06	378,111.87	162,813.34
JTM2	9	46,082.95	33,492.07	46,082.95	0
$E(X)$	57	211,877.71	207,060.54	207,253.15	84,529.23

Note: All columns are in IDR.

districts involved per cluster is too varied. JTG1, JBR3, and JTG2 only consist of one surveyed district, while JBR2 has 31 districts to analyze. So that, there are large gap in the probabilites for claims between clusters. Broadly speaking, we want to say that the lower bound of Two Sigma suppress both claim occurrence and average compensation per cluster, that the insurance company must provide during the first planting period of 2018.

Table 6 is expected to provide an overview of the high claim occurrences (Figure 2), as well as the magnitude of standard deviation of indemnity (Table 5), which can be caused by several things. First, the difference in average productivity of district $\bar{y}_d$ as the reference index of actual productivity within cluster to its estimated critical yield is too large. This may be because productivity at the farm level is too diverse when aggregated at the district level. It may be that the scope of reference index is modified into farmer group, Poktan, or individual farmer itself, smaller level. It is called a geographical basis risk or spatial basis risk (Gaurav and Chaudhary 2020; Boyd et al. 2019). Second, the lack of district samples taken to calculate the average productivity and then it still compared to the cluster index level (see Table 5). Large variance and the form of loss distribution that is unfit can be caused by the small number of samples. In contrast to Sutomo et al. 2019, simulation of indemnity calculation carried out on the individual farmer itself. Therefore, the more replication of farmer samples is generated, the more fit the loss distribution will be, and it minimizes variance.

To capture the risk overview, the Value-at-Risk ($VaR(X)$) and Tail-*VaR* ($TVaR(X)$) of the basis risk loss are also used. MLE is prominent method to estimate the parameter of loss distribution according to the data, both $VaR(X)$ and $TVaR(X)$. $VaR(X)$ and $TVaR(X)$ at probability *p* are used to describe the upper tail of certain distribution, because parameter $E(X)$ which is not sufficiently representative. In addition, the high $Std(X)$ indicates that the indemnity does not follow the goodness of fit of normal distribution and tend to have heavier right tail (Klugman et al. 2012), in terms of loss distribution.

Based on Table 7, $VaR_{0.75}(X)$ of province based are consistantly above the cluster based values. Contrary, the $TVaR_{0.75}(X)$ of province based are higher than the cluster based values, 20% on average. It means that province based has a more right skewed or heavier upper tail of loss distribution of each methods applied than the indemnity of cluster-based. As we have mentioned before, the larger mean excess loss or $TVaR(X)$ indicating a dangerous distribution. If we apply the province based as the zone of area yield scheme, the premium rate may be smaller than cluster based, but it also riskier. The premium rate borne by farmers can soar up to IDR1,184,847.85

Table 7. *VaR* and *TVaR* of each method and zones

Method	Cluster based		Province based	
	$VaR_{0.75}(X)$	$TVaR_{0.75}(X)$	$VaR_{0.75}(X)$	$TVaR_{0.75}(X)$
Mean	643,494.80	981,333.70	373,069.44	1,312,703.5
Median	620,176.60	952,142.90	412,062.50	1,329,696.3
Winsor mean	640,706.90	977,286.60	373,069.44	1,313,206.5
Lower bound of Two Sigma	468,858.60	755,028.50	66,597.78	783,785.10

Note: All columns are in IDR

from IDR306,199.79 on average. It is almost 4 times greater. While we conduct the cluster based, it fluctuates 1.5 times. Hence, this confirms that cluster level is better to be applied than province based as a zone in the alternative area yield scheme in Java. Moreover, based on four parameter estimation method, the lower bound of Two Sigma approach provides smallest estimated maximum loss. At the 75% confidence level, the losses suffered by insurance companies in the 2018 rainy season were IDR755,028.5. It is about 20% lower than when using the mean, median, or Winsor mean as the trigger yield. This lower tail risk means that the risk for the insurance company can be smaller (Zhou et al. 2015).

CONCLUSION AND RECOMMENDATION

Conclusion

Agricultural insurance has increasingly important following the acceptance of its schemes to protect the farmer's interest. The AUTP and AUTS/K schemes were designed in favor of the farmers at which they could work peacefully amid various farm risks they may exposed to. As experienced by the farmers, the indemnity-based insurance model applied in these schemes have provided benefits through claim mechanism. Farmers have enjoyed the cash obtained from the insurance scheme and enable to purchase production input or buy young cattle.

The pure premium rate obtained from the analysis is IDR85,191.18. This figure much less than that of the current applied premium rate, IDR180,000. The analysis indicates that the use of the cluster-based scheme is better than the province-based as shown by the TVaR value in favor of the insurer. This method indicates the fairness of the scheme as the farmers also obtain benefits.

As revealed by the analysis, the cluster-based area yield scheme in rice crop insurance is proposed to be an alternative model to improve crop insurance in Indonesia. Developing clusters in order to group similar farmers or farmer groups can minimize heterogeneity yield as the basis of risk and increase risk-management effectiveness. In this study, using Bootstrap generated data of surveyed area in Java, the standard risk measure of extreme event in the crop loss (*TVaR*) also shows that insurance company should retain smaller amount of indemnity as cluster scheme is applied. On top of that, lower bound of Two Sigma could be considered as an alternative of critical yield index. This technique provides lowest pure premium and standard deviation, which are obtained from its indemnity, among other methods.

Recommendation

As the current indemnity-based insurance model is acceptable, the development of similar protection scheme could be expanded to cover other strategic but have high risks commodities, such as shallot and goat/sheep. Corn, chili, and coffee are among the important agricultural commodities to be included in this protection program as it is mandated by the Law No. 19/2013 on farmer's protection and empowerment.

The model is not only capable of selecting the area or zone boundaries for an area yield using productivity, but also determining critical yield index has never done before. Therefore, we suggest that the Ministry of Agriculture could design the area yield index policy based on these clusters. Each cluster will have different critical productivity index using its lower bound of Two Sigma and adjusted premium.

As data permit, the cluster that have been generated in this study can only be applied to provinces in Java. It is suggested that it is necessary to model other clusters for other provinces in Indonesia. It is also possible to consider the volatility of yield rate over the years and auxiliary variable, such as monthly rainfall, depends on the characteristics of region.

Meanwhile, on the technique to provide pure premium, further reviewed of basis risk should be done actuarially, both shortfall and overpayment. This is required to ensure that the method does not result arbitrary premium rate, not only for insurance companies (subject to overpayment), but also farmers (subject to shortfall). Other than that, the other method for generating sample data also can be done technically. Extensive Monte Carlo studies can be simulated by calibrating the risk model to the empirical data in order to overcome insufficient primary data.

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