INVESTIGATION OF THE SIMILARITY OF LAND SELECTED FOR AREA-YIELD CROP INSURANCE FOR THAI RICE

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Abstract

Thailand has the fifth biggest harvested area of rice of any of the countries in the world. Rice growing is principally dependent on weather-related factors and the number of natural disasters appears to have been rising year after year, exerting a highly significant impact on Thai farmers. This study aims to investigate a potential risk mitigation approach for major rice insurance to protect their interests, namely the area-yield index, in which the first vital step is the selection of the area in order to reduce basis risk. The similarity between the various areas of land chosen is investigated and historical data covering the years 1995-2011 for crop rice from six provinces in the northeast of Thailand - LOEI, NAKHONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI - are assessed. The results show that on the basis of the relevant variables examined, there are differences between the provinces in terms of both area and climate.

Keywords: Area-Yield Index Insurance, Thai Rice, Similarity of Areas

Introduction

In Thailand, the main use of land is agriculture. The US Central Intelligence Agency (CIA) (2011) reports that rice forms Thailand's primary harvested crop, coming out above other major crops. Rice represents 48.70% of arable land, meaning that Thailand has the fifth largest harvested area of rice of any country in the world (11,630,300 ha) (Food and Agriculture Organization of the United Nations (FAO), 2011). Furthermore, rice constitutes an essential part of the diet of Thai families, with some 4.4 million families (in other words, 76.36% of all agricultural families) cultivating crop rice (Department of Trade Negotiations (DTN), 2011).

However, based on figures in FAO (2011), Thailand has a lower yield than countries with a considerably smaller crop area, resulting in a significant impact on farmers' standard of living (for instance, their income). Furthermore, agriculture, industry and services account for, respectively, 8.6%, 39% and 52.4% shares of the overall GDP (CIA, 2011).

There are a number of reasons for the growing area / production dichotomy, with natural disasters emerging as one of the principal causes. Although the authorities and the relevant public and private organisations have been trying to set up insurance for major crops for many decades, as it is one of the key instruments for mitigating risks for rice farmers, the programmes for this purpose were not always a complete success. The Office of Insurance Commission (OIC) (2011) indicates that there is a particularly conspicuous development in the loss ratio calculated based on the earned premium and losses accrued after deductible for this kind of insurance, namely a consistent pattern of increases one year after the next (for instance 7.43%, 23.67%, 59.96%, 67.88% and 145.31% for 2007, 2008, 2009, 2010 and 2011, respectively).

In this study, we will focus on the mitigation risk methodology for protecting farmers' interests from losses, namely the area-yield index method, which has until now not been part of the Thai crop insurance landscape. The idea behind area-yield crop insurance is that claim payments depend mainly on the aggregate yields of rice in the respective set of areas. Therefore, the first crucial step is to investigate the similarity of the areas selected. If a group of similar characteristics is used for each area, farmers pay reasonable premiums and receive optimal coverage, as well as being guaranteed sufficient support to start another crop cycle in the event that losses destroy the rice plantation covered by the policy. For the government, in addition to contributing to insurance premiums, which costs less than subsidising losses, there is the advantage that it can manage the policy adopted to cover growers in the areas in question. Moreover, this approach leads to improved actuarial performance of crop insurance premiums, means of underwriting and related processes designed by insurance companies and causes the customer base to expand to include a number of other sectors. The next section will provide an introduction to rice growing in Thailand followed by a brief presentation of crop insurance in Thailand and an introductory description of the area-yield index method. Subsequently, the methodology used for the analysis will be discussed and we will describe the results before, in the last section, setting out our conclusions.

Rice growing in Thailand

Generally regarded as one of Asia's developing countries, Thailand has 11,630,300 hectares for cropping rice according to FAO (2011) - as shown in Table 1 - making it the nation with the fifth largest harvested area in the world. Rice occupies 46.54% of the country's total surface area of 51,311,502 ha (Office of Agricultural Economics (OAE), 2011) and 76.52% of its arable land of 15,200,000 ha (International Rice Research Institute (IRRI), 2011). In addition, rice is traditionally the main diet for Thais - with consumption standing at 10,700,000 tonnes in 2011 (USDA, 2012).

Table 1: Harvested area (ha): top 5 countries in 2011

Country	Harvested area (ha)
India	44,100,000
China	30,311,300
Indonesia	13,201,300
Bangladesh	12,000,000
Thailand	11,630,300

Source: Authors' construct based on Food and Agriculture Organization of the United Nations (2011)

However, although Thailand has a large area for growing rice, the yield (the production per area) is less than countries with a smaller area, as presented in Table 2.

Table 2: Yield (hg/ha): a selection of 5 countries in 2011

Country	Yield (hg/ha)
Vietnam	55,322
Myanmar	40,806
Philippines	36,776
Cambodia	30,003
Thailand	29,740

Source: Authors' construct based on Food and Agriculture Organization of the United Nations (2011)

There are many factors creating diversification between harvested area and yield. Natural risks arising from climate change play a crucial role. The shortage of rain, for example, influences farmers' rice dramatically, while at the end of the cropping season, so during the harvest period, floods can cause major losses for rice growers. The government has attempted to establish a sustainable approach for coping with natural risks for years, establishing crop insurance, which is considered as one of the important tools in risk management, for Thai farmers. This will be scrutinised in the next section.

Crop insurance in Thailand

Crop insurance was first introduced in Thailand in 1978. Jeerachaipaisarn (2012); Manuamorn (2009); Lorchirachoonkul and Chaisilaparungruang (2002) claim that an indemnity insurance contract for natural risks, such as floods, was drawn up for cotton in Pak Chong District of Nakorn Ratchasrima Province (located in the northeast of Thailand), and that programme was brought in again from 1982 to 1984. In 1990 to 1991, all risks insurance for maize, sorghum and soybean was launched. However, due to high indemnity payments the programme was not successful.

In 2005, the World Bank established a Weather Index Insurance pilot scheme for maize (focusing on drought risk) in Pak Chong District of Nakorn Ratchasrima Province (Manuamorn, 2009). Manuamorn reports that in the pilot the key players in this initiative were the Bank for Agriculture and Agricultural Cooperatives (BAAC), the Commodity Risk Management Group (CRMG) of the World Bank's Agricultural and Rural Development (ARD) Department, the General Insurance Association (GIA), the Department of Insurance (DOI) (now the Office of Insurance Commission (OIC)), the Ministry of Agriculture and Agricultural Cooperatives (MOAC) and the Thai Meteorological Department (TMD).

Jeerachaipaisarn (2012) mentions that Weather Index Insurance for Maize was traded on the market in 2006. After that, in 2008 a pilot programme for weather index insurance (covering drought risk) for rice was launched. In 2011, a weather index insurance scheme for rice started collecting premiums. The number of policyholders for those two insurance policies increased, leading to a better position than in the past. Moreover, as regards the weather index policy, insurers will pay for the additional loss after the government-controlled Disaster Relief Programme has been compensated (Jeerachaipaisarn, 2012).

Notwithstanding this, as catastrophic events can cause unexpected losses for rice growers and they seem to be increasing every year, the relevant organisations have made efforts to investigate new crop insurance policies or even improve the existing policies. A substantial variety of adaptation and mitigation methods to take care of Thai farmers' interests should be looked at. In the next part, a brief introduction to index-based crop insurance will be given.

A brief introduction to index-based crop insurance:

Based on transferring disaster risks affecting nation's commodities, index-based crop insurance has been widely studied. A number of articles examine the effectiveness of such policies. For example, Bokusheva and Breustedt (2012) consider how index-based crop insurance (weather-based index insurance and area-yield crop insurance) reduces the level of risk that is involved in traditional crop insurance in the case of wheat in Kazakhstan. Meanwhile, Miranda (1991) studies the effectiveness of area-yield crop insurance for soybean producers in Western Kentucky, drawing the conclusion that crop insurance using the area-yield approach provides better coverage for yield risk for producers overall than individual-yield crop insurance.

According to Skees (2008), the Katie School of Insurance (2011) and Bokusheva and Breustedt (2012), the basic thought underlying any index-based insurance (e.g. weather index and area-yield index) is to launch paid claims when there are major disaster losses resulting from a loss-event measure exceeding or not reaching the preset threshold. Two main types of index - weather index and area-yield index - will be outlined in this paper.

Skees (2008) reports that crop insurance applying the weather index has been rolled out in a number of developed and developing countries, including India, Mexico, Peru and the United States. Thailand has applied this type of insurance so far as mentioned previously. Under weather index insurance, a drought is indicated by the accumulated rainfall in the period in question falling below the predetermined range, leading to farmers being paid compensation. Agro-meteorological stations have monitors that provide readings showing the level of rainfall. Worthy of note is the fact that the location of the farm has a limiting effect on full application of the weather index, so for instance if a grower's land is a long way from the station or even in an area with no stations, insurers lack the information necessary to issue the policy or set up claim payments.

Several studies (Gordon, Williams, Barnaby & Black, 1990; Miranda, 1991; Skees, 1993; Smith, Chouinard & Baquet, 1994; Skees, Black & Barnett, 1997; Mahul, 1999; Smith & Watts, 2009; Awondo, Datta, Ramirez & Fonsah, 2012) point to Halcrow with his key 1949 article as the proponent of the area-yield crop insurance approach, and in recent times scholars starting with Miranda (1991) have built on Halcrow's work. Area-yield crop insurance, which was piloted in its early years by the US Group Risk Plan (GRP), entails indemnity payouts and premiums that take as their basis the area yield (known as county yield in the United States) instead of the individual yield of a farm. Under area-yield crop insurance, claims are only paid to policyholders - whether they are farmers or other insured parties - if and only if the actual area yield is under a critical yield level (or trigger or guarantee yield), determined using the expected area average yield, a scale level[1] (or a level of protection) and a coverage[2] (or the insurance deductible) (Halcrow, 1949; Gordon et al., 1990; Miranda, 1991; Skees, 1993; Smith et al., 1994; Skees et al., 1997; Skees, Hazell & Miranda, 1999; Smith & Watts, 2009; Binici & Zulauf, 2006; Deng, Barnett, Hoogenboom, Yu & Garcia, 2006; Skees, 2008; Dick, 2010; Awondo et al., 2012). Gordon et al. (1990)

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[1] 'Scale', 'protection' and 'coverage' are used interchangeably, with the third of these terms commonly used in the insurance sector.

[2] The following two terms are used interchangeably in this context: 'coverage' (which in an agricultural setting refers to (1-deductible)) and 'deductible' (widely used with reference to insurance).

allude to Miranda's 1989 paper, demonstrating that the area-yield approach can provide proper protection for loss of yield.

Hence, this programme involves the index and the basis risk (in other words, the difference between the yield of an individual and the yield of an area (Skees et al., 1997; Binici & Zulauf, 2006; Smith & Watts, 2009; Deng et al., 2006; Katie School of Insurance, 2011)), for example to cover yield losses still suffered by farmers whose yield exceeds the predetermined area yield or trigger yield without benefiting from any indemnities. This means that there is a possibility that those farmers with a yield that corresponds less closely to the critical yield will deem that this insurance is not fit for their purposes (Binici & Zulauf, 2006). Therefore, Skees et al. (1997), in a nutshell, put forward a number of major aspects which need to be considered when designing an insurance policy, with a particular focus on the area selected. In other words, as indicated above, choosing the area for application of area-yield crop insurance is the principal strategy for decreasing the basis risk (Skees et al., 1997; Binici & Zulauf, 2006).

The main factor that needs to be borne in mind when designating the area is that the insured areas should be alike with regard to e.g. the temperature, the precipitation and the type of crop, so framed in other terms, the homogeneity of the area (Katie School of Insurance, 2011). Generally speaking, the selected regions are likely to be adjacent to each other. Moreover, it is the optimum tool to reduce basis risk as much as possible. The level of similarity will be analysed, focusing in particular on implementing the area-yield approach in a Thai context.

Methodology

This paper will concentrate on rice yields in northeastern Thailand, i.e. the part of the country that had the largest harvested area in 2011 (5,702,538 hectares – in other words, 49.03% of the total harvested area of rice of 11,630,300 hectares) (OAE, 2011). The focus will be on six provinces (LOEI, NAKHONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI), which fall under the purview of the Office of Agricultural Economics (OAE) (Zone 3).

The investigation will examine six variables: harvested area for cropping rice (ha), amount of rainfall (ml), number of days when rain fell in a year (days), the minimum temperature during a year (degrees Celsius), the maximum temperature during a year (degrees Celsius) and the harvested yield (hg/ha). Mathematical statistical methods, in the form of the Analysis of Variance (ANOVA), are often deployed to examine the differences between variables from one province to another (and from the grand mean). Such methods are also applied in this study, which modifies the general ANOVA model of Kutner, Nachtsheim, Neter & Li (2005):

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}, \qquad (1)$$

where

Y_{ij} are the values of the dependent variable in the jth year for the ith provinces;

μ is the grand mean of the observations;

τ_i is the effect of the ith provinces (a deviation from the grand mean);

$\sum \tau_i = 0$;

ε_{ij} are normally distributed zero-mean random error terms;

i stands for 1,…,6 (corresponding to the six provinces in the study);

j stands for 1,…,17 (corresponding to 17 observations for each province in the study).

If provinces in the study differ with respect to independent variables, we perform Tukey's HSD post-hoc test (Tukey's Honest Significant Difference) to further investigate which of the discrepancies are significant. Results of interest will be presented in the next section.

Results

Once the data had been compiled, an evaluation was made of the results. The findings are presented below. The first section will describe the general characteristics of the Thai provinces that were selected for this study and then the second section details the results of our application of ANOVA.

For the Harvested_Yield variable, the Analysis of Variance section of Figure 1 shows that yields are indeed different in these provinces. Furthermore, a dummy coefficient of 20,090 represents the expected average yield of all provinces. The estimate for LOEI seems to be the highest and differs significantly (Pr < .0001, at α = 0.05) from the average yield for the group of provinces, as its dummy coefficient is 24,529.25 hg/ha = 20,090 + 4439.25. An actual parameter estimate of the dummy variable NONGBUALAMPHU is 19,461.36 hg/ha = 20,090 + (-628.64), while the estimates for UDONTHANI, NONGKHAI, SAKONNAKHON and NAKHONPHANOM are 19,386.01 hg/ha, 19,551.66 hg/ha, 18,920.54 hg/ha and 18,691.19 hg/ha, respectively.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	411600867	82320173	17.50	<.0001
Error	96	451462784	4702737		
Corrected Total	101	863063651			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	20090	214.72137	93.56	<.0001
LOEI	1	4439.24510	480.13159	9.25	<.0001
NONGBUALAMPHU	1	-628.63725	480.13159	-1.31	0.1936
UDONTHANI	1	-703.99020	480.13159	-1.47	0.1458
NONGKHAI	1	-538.34314	480.13159	-1.12	0.2650
SAKONNAKHON	1	-1169.46078	480.13159	-2.44	0.0167
NAKHONPHANOM	1	-1398.81373	480.13159	-2.91	0.0044
RESTRICT	-1	2.09184E-11	0.00005109	0.00	1.0000*

* Probability computed using beta distribution.

Figure 1: The selected output for Harvested_Yield and Province

Figure 2 presents the Tukey HSD Test for a number of pairwise comparisons. Unsurprisingly, the mean Harvested_Yield in LOEI is strikingly high, differing significantly from all the other provinces, whereas the other provinces do not differ from one another in terms of the mean yield (p < .05). In other words, as their confidence intervals include zero, there is no evidence not to accept the null hypothesis that the mean difference is zero.

Tukey multiple comparisons of means
95% family-wise confidence level
$Province

	diff	lwr	upr	p adj
NAKHONPHANOM-LOEI	-5838.05882	-8001.144	-3674.974	0.0000000
NONGBUALAMPHU-LOEI	-5067.88235	-7230.967	-2904.797	0.0000000
NONGKHAI-LOEI	-4977.58824	-7140.673	-2814.503	0.0000000
SAKONNAKHON-LOEI	-5608.70588	-7771.791	-3445.621	0.0000000
UDONTHANI-LOEI	-5143.23529	-7306.320	-2980.150	0.0000000
NONGBUALAMPHU-NAKHONPHANOM	770.17647	-1392.908	2933.261	0.9047921
NONGKHAI-NAKHONPHANOM	860.47059	-1302.614	3023.555	0.8559264
SAKONNAKHON-NAKHONPHANOM	229.35294	-1933.732	2392.438	0.9996162
UDONTHANI-NAKHONPHANOM	694.82353	-1468.261	2857.908	0.9366660
NONGKHAI-NONGBUALAMPHU	90.29412	-2072.791	2253.379	0.9999962
SAKONNAKHON-NONGBUALAMPHU	-540.82353	-2703.908	1622.261	0.9781373
UDONTHANI-NONGBUALAMPHU	-75.35294	-2238.438	2087.732	0.9999985
SAKONNAKHON-NONGKHAI	-631.11765	-2794.203	1531.967	0.9574418
UDONTHANI-NONGKHAI	-165.64706	-2328.732	1997.438	0.9999226
UDONTHANI-SAKONNAKHON	465.47059	-1697.614	2628.555	0.9888488

Figure 2: The Tukey HSD Test for Harvested_Yield

Parallel to what was reported above, for the ANOVA model of Harvested_Area and Province (Figure 3), the mean harvested areas generally speaking differ between provinces. The expected average area for all provinces is 176,954 ha. The actual intercepts of LOEI, NONGBUALAMPHU, UDONTHANI, NONGKHAI, SAKONNAKHON and NAKHONPHANOM are 64,795 ha, 131,668 ha, 290,652 ha, 157,824 ha, 264,865 ha and 151,920 ha, respectively. These parameter estimates are statistically significantly different (Pr < .0001, at α = 0.05) from the estimated harvested area of all these provinces.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	6.167337E11	1.233467E11	414.56	<.0001
Error	96	28563604520	297537547		
Corrected Total	101	6.452973E11			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	176954	1707.93290	103.61	<.0001
LOEI	1	-112159	3819.05406	-29.37	<.0001
NONGBUALAMPHU	1	-45286	3819.05406	-11.86	<.0001
UDONTHANI	1	113698	3819.05406	29.77	<.0001
NONGKHAI	1	-19130	3819.05406	-5.01	<.0001
SAKONNAKHON	1	87911	3819.05406	23.02	<.0001
NAKHONPHANOM	1	-25034	3819.05406	-6.56	<.0001
RESTRICT	-1	4.94765E-10	0.00040641	0.00	1.0000*

* Probability computed using beta distribution.

Figure 3: The selected output for Harvested_Area and Province

In the same way, the pairwise comparisons using the Tukey HSD Test in Figure 4 tell us that there is no significant difference between the average harvested area of on the one hand NONGKHAI and NAKHONPHANOM on the other ($p < .05$). The areal means of the other provinces differ significantly from one another as their confidence intervals overlap zero.

Tukey multiple comparisons of means
95% family-wise confidence level
$Province

	diff	lwr	upr	p adj
NAKHONPHANOM-LOEI	87124.471	69918.900	104330.04	0.0000000
NONGBUALAMPHU-LOEI	66873.000	49667.429	84078.57	0.0000000
NONGKHAI-LOEI	93029.118	75823.547	110234.69	0.0000000
SAKONNAKHON-LOEI	200069.235	182863.664	217274.81	0.0000000
UDONTHANI-LOEI	225856.412	208650.841	243061.98	0.0000000
NONGBUALAMPHU-NAKHONPHANOM	-20251.471	-37457.041	-3045.90	0.0114312
NONGKHAI-NAKHONPHANOM	5904.647	-11300.924	23110.22	0.9175153
SAKONNAKHON-NAKHONPHANOM	112944.765	95739.194	130150.34	0.0000000
UDONTHANI-NAKHONPHANOM	138731.941	121526.370	155937.51	0.0000000
NONGKHAI-NONGBUALAMPHU	26156.118	8950.547	43361.69	0.0003646
SAKONNAKHON-NONGBUALAMPHU	133196.235	115990.664	150401.81	0.0000000
UDONTHANI-NONGBUALAMPHU	158983.412	141777.841	176188.98	0.0000000
SAKONNAKHON-NONGKHAI	107040.118	89834.547	124245.69	0.0000000
UDONTHANI-NONGKHAI	132827.294	115621.723	150032.86	0.0000000
UDONTHANI-SAKONNAKHON	25787.176	8581.606	42992.75	0.0004609

Figure 4: The Tukey HSD Test for Harvested_Area

In Figure 5, the expected average amount of rainfall is 1,517.82 ml. The expected rainfalls for LOEI, NONGBUALAMPHU, UDONTHANI, NONGKHAI, SAKONNAKHON and NAKHONPHANOM are 1,265.06 ml, 1,356.94 ml, 1,544.47 ml, 1,767.29 ml, 1,386.06 ml and 1,787.12 ml, respectively. Apparently, the parameter estimates for each province are not statistically different from the parameter estimate for the group as a whole (examined at $\alpha = 0.05$). In other words, the expected average rainfall values in each province do not differ significantly from those for all provinces.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	4124200	824840	4.07	0.0021
Error	96	19446090	202563		
Corrected Total	101	23570291			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1517.82353	44.56362	34.06	<.0001
LOEI	1	-252.76471	99.64728	-2.54	0.0128
NONGBUALAMPHU	1	-160.88235	99.64728	-1.61	0.1097
UDONTHANI	1	26.64706	99.64728	0.27	0.7897
NONGKHAI	1	249.47059	99.64728	2.50	0.0140
SAKONNAKHON	1	-131.76471	99.64728	-1.32	0.1892
NAKHONPHANOM	1	269.29412	99.64728	2.70	0.0081
RESTRICT	-1	1.13687E-13	0.00001060	0.00	1.0000*

* Probability computed using beta distribution.

Figure 5: The selected output for Rainfall and Province

Notwithstanding this, we found that the average amount of rainfall in LOEI differs from NAKHONPHANOM and NONGKHAI (p < .05), as shown in Figure 6. In the case of the other provinces, there is no evidence to indicate a significant distinction between them with regard to rainfall.

Tukey multiple comparisons of means
95% family-wise confidence level
$Province

	diff	lwr	upr	p adj
NAKHONPHANOM-LOEI	522.05882	73.12872	970.98893	0.0129698
NONGBUALAMPHU-LOEI	91.88235	-357.04775	540.81246	0.9911351
NONGKHAI-LOEI	502.23529	53.30519	951.16540	0.0190686
SAKONNAKHON-LOEI	121.00000	-327.93010	569.93010	0.9696525
UDONTHANI-LOEI	279.41176	-169.51834	728.34187	0.4643242
NONGBUALAMPHU-NAKHONPHANOM	-430.17647	-879.10658	18.75363	0.0683268
NONGKHAI-NAKHONPHANOM	-19.82353	-468.75363	429.10658	0.9999950
SAKONNAKHON-NAKHONPHANOM	-401.05882	-849.98893	47.87128	0.1076999
UDONTHANI-NAKHONPHANOM	-242.64706	-691.57716	206.28305	0.6189241
NONGKHAI-NONGBUALAMPHU	410.35294	-38.57716	859.28305	0.0935178
SAKONNAKHON-NONGBUALAMPHU	29.11765	-419.81246	478.04775	0.9999660
UDONTHANI-NONGBUALAMPHU	187.52941	-261.40069	636.45952	0.8286540
SAKONNAKHON-NONGKHAI	-381.23529	-830.16540	67.69481	0.1436505
UDONTHANI-NONGKHAI	-222.82353	-671.75363	226.10658	0.7005334
UDONTHANI-SAKONNAKHON	158.41176	-290.51834	607.34187	0.9080486

Figure 6: The Tukey HSD Test for Rainfall

Similarly, the parameter estimate of Rainy_Days for all provinces is 166.56 days (see Figure 7). The expected numbers of rainy days for LOEI, NONGBUALAMPHU, UDONTHANI, NONGKHAI, SAKONNAKHON and NAKHONPHANOM are 194.12 days, 144.12 days, 158.06 days, 149.59 days, 173.09 days and 180.41 days, respectively. The mean number of rainy days is not the same in these provinces and only the parameter estimate for LOEI is statistically different from the parameter estimate for the group.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	31578	6315.50000	9.42	<.0001
Error	96	64328	670.07966		
Corrected Total	101	95905			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	166.55882	2.56309	64.98	<.0001
LOEI	1	27.55882	5.73123	4.81	<.0001
NONGBUALAMPHU	1	-22.44118	5.73123	-3.92	0.0002
UDONTHANI	1	-8.50000	5.73123	-1.48	0.1413
NONGKHAI	1	-16.97059	5.73123	-2.96	0.0039
SAKONNAKHON	1	6.50000	5.73123	1.13	0.2596
NAKHONPHANOM	1	13.85294	5.73123	2.42	0.0175
RESTRICT	-1	7.10543E-15	6.098926E-7	0.00	1.0000*

* Probability computed using beta distribution.

Figure 7: The selected output for Rainy_Days and Province

As for all the pairs of comparisons between provinces, the average number of rainy days in LOEI differs significantly from NONGBUALAMPHU, NONGKHAI and UDONTHANI. The same applies to NONGBUALAMPHU and NAKHONPHANOM, to NONGKHAI and NAKHONPHANOM, and to SAKONNAKHON and NONGBUALAMPHU ($p < .05$) (see Figure 8).

Tukey multiple comparisons of means
95% family-wise confidence level
$Province

	diff	lwr	upr	p adj
NAKHONPHANOM-LOEI	-13.705882	-39.526190	12.114425	0.6371476
NONGBUALAMPHU-LOEI	-50.000000	-75.820308	-24.179692	0.0000026
NONGKHAI-LOEI	-44.529412	-70.349719	-18.709104	0.0000352
SAKONNAKHON-LOEI	-21.058824	-46.879131	4.761484	0.1766759
UDONTHANI-LOEI	-36.058824	-61.879131	-10.238516	0.0013639
NONGBUALAMPHU-NAKHONPHANOM	-36.294118	-62.114425	-10.473810	0.0012410
NONGKHAI-NAKHONPHANOM	-30.823529	-56.643837	-5.003222	0.0098257
SAKONNAKHON-NAKHONPHANOM	-7.352941	-33.173249	18.467366	0.9615902
UDONTHANI-NAKHONPHANOM	-22.352941	-48.173249	3.467366	0.1292642
NONGKHAI-NONGBUALAMPHU	5.470588	-20.349719	31.290896	0.9896120
SAKONNAKHON-NONGBUALAMPHU	28.941176	3.120869	54.761484	0.0187233
UDONTHANI-NONGBUALAMPHU	13.941176	-11.879131	39.761484	0.6200005
SAKONNAKHON-NONGKHAI	23.470588	-2.349719	49.290896	0.0968435
UDONTHANI-NONGKHAI	8.470588	-17.349719	34.290896	0.9310445
UDONTHANI-SAKONNAKHON	-15.000000	-40.820308	10.820308	0.5420981

Figure 8: The Tukey HSD Test for Rainy_Days

As regards Min_Temp and Max_Temp, we interpret the results in the same way as the previous variables; and for these two variables as well, the parameter estimates for each province are not statistically different from the parameter estimate for the group (see Figures 9 and 11) but they do nevertheless differ from each other. The expected Min_Temp value for the whole region is 18.01 degrees Celsius and for LOEI, NONGBUALAMPHU, UDONTHANI, NONGKHAI, SAKONNAKHON and NAKHONPHANOM it is 17.52 degrees Celsius, 17.93 degrees Celsius, 18.36 degrees Celsius, 18.58 degrees Celsius, 17.99 degrees Celsius and 17.67 degrees Celsius, respectively. While the expected Max_Temp value for the whole region is 35.90 degrees Celsius, for LOEI, NONGBUALAMPHU, UDONTHANI, NONGKHAI, SAKONNAKHON and NAKHONPHANOM it is 35.84 degrees Celsius, 36.20 degrees Celsius, 36.29 degrees Celsius, 36.03 degrees Celsius, 35.38 degrees Celsius and 35.64 degrees Celsius, respectively.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	13.83490	2.76698	6.11	<.0001
Error	96	43.45882	0.45270		
Corrected Total	101	57.29373			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	18.00784	0.06662	270.31	<.0001
LOEI	1	-0.49020	0.14897	-3.29	0.0014
NONGBUALAMPHU	1	-0.07843	0.14897	-0.53	0.5998
UDONTHANI	1	0.35098	0.14897	2.36	0.0205
NONGKHAI	1	0.57451	0.14897	3.86	0.0002
SAKONNAKHON	1	-0.01961	0.14897	-0.13	0.8956
NAKHONPHANOM	1	-0.33725	0.14897	-2.26	0.0258
RESTRICT	-1	8.52651E-14	1.585234E-8	0.00	1.0000*

* Probability computed using beta distribution.

Figure 9: The selected output for Min_Temp and Province

Figure 10 illustrates the minimum temperatures on average for NONGKHAI, which differ from LOEI and NAKHONPHANOM; and there is also a difference between UDONTHANI and NAKHONPHANOM ($p < .05$). The following four pairs of provinces are not homogeneous in terms of their mean maximum temperature ($p < .05$): UDONTHANI and NAKHONPHANOM; SAKONNAKHON and NONGBUALAMPHU; SAKONNAKHON and NONGKHAI; and UDONTHANI and SAKONNAKHON (see Figure 12).

Tukey multiple comparisons of means
95% family-wise confidence level
$Province

	diff	lwr	upr	p adj
NAKHONPHANOM-LOEI	0.15294118	-0.51818096	0.82406331	0.9855394
NONGBUALAMPHU-LOEI	0.41176471	-0.25935743	1.08288684	0.4806998
NONGKHAI-LOEI	1.06470588	0.39358375	1.73582802	0.0001744
SAKONNAKHON-LOEI	0.47058824	-0.20053390	1.14171037	0.3283279
UDONTHANI-LOEI	0.84117647	0.17005434	1.51229860	0.0056455
NONGBUALAMPHU-NAKHONPHANOM	0.25882353	-0.41229860	0.92994566	0.8713190
NONGKHAI-NAKHONPHANOM	0.91176471	0.24064257	1.58288684	0.0020113
SAKONNAKHON-NAKHONPHANOM	0.31764706	-0.35347508	0.98876919	0.7409334
UDONTHANI-NAKHONPHANOM	0.68823529	0.01711316	1.35935743	0.0410307
NONGKHAI-NONGBUALAMPHU	0.65294118	-0.01818096	1.32406331	0.0613262
SAKONNAKHON-NONGBUALAMPHU	0.05882353	-0.61229860	0.72994566	0.9998492
UDONTHANI-NONGBUALAMPHU	0.42941176	-0.24171037	1.10053390	0.4325518
SAKONNAKHON-NONGKHAI	-0.59411765	-1.26523978	0.07700449	0.1137011
UDONTHANI-NONGKHAI	-0.22352941	-0.89465155	0.44759272	0.9267322
UDONTHANI-SAKONNAKHON	0.37058824	-0.30053390	1.04171037	0.5967791

Figure 10: The Tukey HSD Test for Min_Temp

```
                       Analysis of Variance
                            Sum of          Mean
Source              DF       Squares        Square    F Value    Pr > F
Model                5      10.19225       2.03845       5.82    <.0001
Error               96      33.59529       0.34995
Corrected Total    101      43.78755
                       Parameter Estimates
                      Parameter      Standard
  Variable       DF       Estimate          Error    t Value    Pr > |t|
  Intercept       1       35.89510        0.05857     612.82     <.0001
  LOEI            1       -0.05980        0.13098      -0.46     0.6490
  NONGBUALAMPHU   1        0.30490        0.13098       2.33     0.0220
  UDONTHANI       1        0.39314        0.13098       3.00     0.0034
  NONGKHAI        1        0.13431        0.13098       1.03     0.3077
  SAKONNAKHON     1       -0.51275        0.13098      -3.91     0.0002
  NAKHONPHANOM    1       -0.25980        0.13098      -1.98     0.0502
  RESTRICT       -1    -1.8985E-14    1.393778E-8      -0.00     1.0000*
             * Probability computed using beta distribution.
```

Figure 11: The selected output for Max_Temp and Province

```
  Tukey multiple comparisons of means
    95% family-wise confidence level
$Province
                                   diff         lwr         upr     p adj
NAKHONPHANOM-LOEI           -0.20000000 -0.79006765  0.39006765 0.9214607
NONGBUALAMPHU-LOEI           0.36470588 -0.22536177  0.95477353 0.4722999
NONGKHAI-LOEI                0.19411765 -0.39595000  0.78418529 0.9302682
SAKONNAKHON-LOEI            -0.45294118 -1.04300882  0.13712647 0.2328736
UDONTHANI-LOEI               0.45294118 -0.13712647  1.04300882 0.2328736
NONGBUALAMPHU-NAKHONPHANOM   0.56470588 -0.02536177  1.15477353 0.0689311
NONGKHAI-NAKHONPHANOM        0.39411765 -0.19595000  0.98418529 0.3832184
SAKONNAKHON-NAKHONPHANOM    -0.25294118 -0.84300882  0.33712647 0.8126735
UDONTHANI-NAKHONPHANOM       0.65294118  0.06287353  1.24300882 0.0211560
NONGKHAI-NONGBUALAMPHU      -0.17058824 -0.76065588  0.41947941 0.9590585
SAKONNAKHON-NONGBUALAMPHU   -0.81764706 -1.40771471 -0.22757941 0.0015252
UDONTHANI-NONGBUALAMPHU      0.08823529 -0.50183235  0.67830294 0.9979720
SAKONNAKHON-NONGKHAI        -0.64705882 -1.23712647 -0.05699118 0.0230137
UDONTHANI-NONGKHAI           0.25882353 -0.33124412  0.84889118 0.7975246
UDONTHANI-SAKONNAKHON        0.90588235  0.31581471  1.49595000 0.0003091
```

Figure 12: The Tukey HSD Test for Max_Temp

Conclusion

This study investigated the issue of a new crop insurance approach called area-based insurance for rice growing in Thailand, where the first step in policy design is the selection of the land. We chose and examined a number of factors in six provinces in the northeast of Thailand (LOEI, NAKHONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI) that are supervised by the Office of Agricultural Economics (OAE) (Zone 3). The analysis determined whether factors of interest differ significantly between individual provinces, thereby allowing a decision to be made on whether the areas chosen were of a homogeneous or a heterogeneous nature.

The six specific variables that were considered (Harvested_Yield, Harvested_Area, Rainfall, Rainy_Days, Min_Temp and Max_Temp) allowed conclusions to be drawn for area selection. Provinces in the study were dissimilar with respect to five of the variables investigated. However, for rainfall the results were generally not heterogeneous at a significance level of 0.05. It emerged that LOEI was different from the other provinces, with the highest harvested yield of all the areas studied. However, the provinces apart from NONGKHAI and NAKHONPHANOM had different harvested areas and for NAKHONPHANOM and NONGKHAI the mean amount of rainfall differed remarkably from LOEI. The average number of rainy days in the six pairs of provinces differed significantly, and the minimum average temperature for NONGKHAI was unlike that of LOEI and NAKHONPHANOM. UDONTHANI and NAKHONPHANOM differed in terms of their mean minimum and maximum temperatures, while UDONTHANI and SAKONNAKHON did not appear to have the same mean maximum temperature, and the same applied to SAKONNAKHON with respect to NONGBUALAMPHU and NONGKHAI.

Therefore, on the basis of an investigation of six factors, no provinces were similar to each other with regard to area and weather (as rainfall will differ from one province to another if a more restricted choice of significance levels is embraced). Therefore, attention should be focused by the relevant parties on area-yield crop insurance policy design, i.e. the premiums collected should be tailored to the character of the area and should reduce basis risk, since as indicated by Skees et al. (1999), government policy and public cooperation are absolutely central to implementing this kind of insurance in many emerging economies (for instance, establishing an appropriate legal and regulatory framework, grouping together provinces which are similar to each other, underwriting the insurance in some way and educating farmers).

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