# Adaptation of Thai Insurance in Light of Natural Disasters: an Investigation of Developments in Major Rice Crop Insurance Applying the Area-Yield Approach

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**Abstract**
Thailand has the fifth largest harvested area of rice of any country in the world. Growing rice depends mainly on weather-related factors and it appears that the number of natural disasters has been increasing every year, having a key impact on Thai farmers. In this study, we investigate a potential risk mitigation approach for major rice insurance to protect their interests, namely the area-yield index, specifically applying a weather variable, and culminating in a rate-making process. Historical data covering the years 1995-2011 for crop rice from six provinces - LOEI, NAKHONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI - in the northeast of Thailand are assessed. The results show the function of the expected yields for the provinces in question. On the basis of trigger yields generated at four distinct levels of coverage (80%, 85%, 90% and 95%) and two protection scales (100% and 150%), we found that there was a remarkably wide range of different premium rates for the provinces being examined.
**Keywords:** Area-Yield Index Insurance, Thai Rice, Weather-related Factors

## 1. Introduction

In Thailand, the main use of land is agriculture (23,906,669 ha, i.e. 46.54% of the total area of 51,311,502 ha) (Office of Agricultural Economics (OAE), 2011). According to the United States' Central Intelligence Agency (CIA) (2011), rice represents Thailand's primary harvested crop, outstripping other major Thai crops such as cassava and rubber. Indeed, Thailand is the country with the fifth largest harvested area of rice worldwide (11,630,300 ha), with rice accounting for 48.70% of arable land (Food and Agriculture Organization of the United Nations (FAO), 2011). Furthermore, as rice is the most common main course for Thai families, some 4.4 million families (in other words, 76.36% of all agricultural families) cultivate crop rice (Department of Trade Negotiations (DTN), 2011). However, with 29,740 hectograms per hectare (FAO, 2011), Thailand has a lower yield than countries with a substantially smaller crop area, including a number of neighbouring countries, resulting in a significant impact on farmers' standard of living (for example their income). Moreover, the percentage contributions of agriculture, industry and services to total GDP are 8.6%, 39% and 52.4%, respectively (CIA, 2011).

The contrast between growing area and production is a result of various factors, with natural disasters featuring especially prominently among them. Despite the fact that for many decades the government and the relevant public and private organisations have been making attempts to establish insurance for major crops, given that it is one of the crucial tools to mitigate risks faced by rice growers, the programmes to this end were not a resounding success. According to the Office of Insurance Commission (OIC) (2011), the loss ratio calculated on the basis of the earned premium and losses incurred after deductible for this type of insurance is particularly noteworthy, with a steady upward trend year after year (for instance 7.43%, 23.67%, 59.96%, 67.88% and 145.31% for 2007, 2008, 2009, 2010 and 2011, respectively). Furthermore, as natural disasters have hit many parts of Thailand and the country's agricultural products, recently there has been a sharp increase in applications for existing and new crop insurance policies.

In this investigation, a wide range of adaptation and mitigation methods that aim to specifically protect Thai farmers' interests will be studied by taking a look at another potential approach for major rice insurance, namely the area-yield index method, under which farmers are guaranteed sufficient support to start another crop cycle if losses destroy their rice plantation, thereby leading to increased stability in their status and their quality of life. An advantage for the government is that the cost of subsidising losses will be less than its contribution to insurance premiums. Moreover, this insurance has the potential to lead to an expansion in the customer base to encompass various other business sectors and policies.

Of key importance to our study is that area-yield index crop insurance involving the application of a weather variable does not exist in the context of Thai crop insurance, hence the interest of examining it further. The next section will provide an introduction to crop insurance in Thailand, and then the area-yield index method will be described. Subsequently, we will discuss the statistics used for the analysis and we will then set out the results and, finally, present our conclusions.

## 2. Introduction to crop insurance in Thailand

Thailand figures among those Asian countries where the commonest use of land is for agriculture, accounting for 46.54% of the total area of 51,311,502 ha (OAE, 2011). Rice is the country's leading harvested crop and its main source of income, outstripping the other main typical Thai agricultural products, such as natural rubber, sugar cane and cassava (also known as tapioca).

Indeed, as shown in Table 1, with rice representing around 48.70% of arable land use, Thailand has the fifth largest harvested area of rice of any country worldwide (11,630,300 hectares) according to FAO (2011).

Table 1. Harvested area (ha): top 10 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 |
| Myanmar | 8,038,000 |
| Vietnam | 7,651,900 |
| Philippines | 4,536,640 |
| Cambodia | 2,926,000 |
| Brazil | 2,752,890 |

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

Furthermore, around 4.4 million families (i.e. 76.36% of the total of approximately 5.8 million agricultural families) grow crop rice (DTN, 2011). Yet in terms of yield (29,740 hectograms per hectare), it features below countries with a much smaller crop area (e.g. Vietnam, which has a crop area of 7,651,900 ha but a yield of 55,322 hg/ha) (FAO, 2011) - see Table 2 - affecting farmers' standard of living (for example their income).

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

| Country | Yield (hg/ha) |
|---|---|
| Australia | 95,441 |
| United States of America | 79,207 |
| China | 66,862 |
| Vietnam | 55,322 |
| Indonesia | 49,799 |
| Brazil | 48,956 |
| Bangladesh | 42,189 |
| Myanmar | 40,806 |
| Philippines | 36,776 |
| India | 35,306 |
| Cambodia | 30,003 |
| Thailand | 29,740 |

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

The divergence between growing area and production is due to a number of factors, with natural disasters in particular featuring prominently among them, as rice yield in many parts of Thailand mainly depends on rainfall. Therefore, for many decades the government and the relevant public and private organisations have been making efforts to establish insurance for major crops. Skees (2008) points out that for the most extreme risks such as disaster risk, a mix between government funding (whereby the government acts as a reinsurer before the events occur) and insurance is a suitable tool in such incomplete markets. The first type of crop insurance was an indemnity insurance policy for all natural risks (e.g. floods and drought) for cotton launched in 1978 in Pak Chong District of Nakorn Ratchasrima Province (Jeerachaipaisarn, 2012; Manuamorn, 2009; Lorchirachoonkul & Chaisilaparungruang, 2002) - a programme that was resumed from 1982 to 1984. Subsequently, all risks insurance for maize, sorghum and soybean was provided from 1990 to 1991. However, the programme was not a complete success as the collected premiums were less than the indemnity payments.

Manuamorn (2009) reports that in 2005 the World Bank established a Weather Index Insurance pilot scheme in Thailand supplying technical assistance, advice regarding administrative procedures, pilot programme monitoring and feedback on international experiences. Four main organisations were involved in the pilot. 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) and the Department of Insurance (DOI) (now the Office of Insurance Commission (OIC)) dealt respectively with the operational, technical, financial and legal aspects. In addition, the Ministry of

 

Agriculture and Agricultural Cooperatives (MOAC) and the Thai Meteorological Department (TMD) played a role. Besides, maize - the main crop in Pak Chong District of Nakorn Ratchasrima Province - formed the focus of the pilot test and concentrated on drought risk. Two of the most important lessons that arose from this work were that the contract design should be made more suited to Asia, and that Thai farmers should pay attention to the trustworthiness of the institution promoting the product. These findings mean that this scheme will be useful for the relevant parties to optimise the design of future insurance products.

Subsequently, weather index insurance for maize was introduced in 2006 (Jeerachaipaisarn, 2012). Crop insurance using the weather index has apparently been implemented in several developed and developing countries, for instance India, Mexico, Peru and the United States (Skees, 2008). Skees (2008) and the Katie School of Insurance (2011) report that the basic idea behind any kind of index-based insurance (e.g. weather index and area-yield index) is to initiate paid claims in the event of severe disaster losses as a result of a loss-event measure going beyond the preset threshold. Therefore, under weather index insurance, paid claims are based on the shortfall of rainfall (also known as the moving dry spell index). That is, if the accumulated rainfall in the period under consideration is below the predetermined range, it indicates a drought and farmers will receive compensation. The level of rainfall is recorded on the basis of the readings provided by monitors installed in various agro-meteorological stations (in other words, the historical weather data is important). After that, the pilot programme for index crop insurance (only for drought risk) for rice (involving cooperation between BAAC and the Japan Bank for International Cooperation (JBIC), with Sompo Japan Insurance as a reinsurer) was launched in 2008. In 2011, a weather index insurance scheme for rice started collecting premiums. These two programmes, covering maize and rice, seem to be in an even better position on the basis of the increases that have been seen in the volume of insurance policies and the level of interest among farmers who would like to have this kind of insurance product. In other words, the average growth rates of the number of participants and insured farms appear to have risen. However, the sustainability of the programmes still needs to be examined.

As mentioned above, the main agricultural product in Thailand is rice. Generally, if farmers encounter unexpected losses from catastrophic events which mean that they are unable to start growing crops immediately, the government will compensate them for some costs (e.g. plant seed and plant nutrition) which are not covered by the basic cropping costs. Therefore, the application of insurance is of interest in order both to save government finances and farmers' budgets, which are used to subsidise losses, and to ensure that farmers have enough support when they are starting another crop cycle. Moreover, while the government contributes to the insurance premium, this should cost it less than subsidising losses. According to Jeerachaipaisarn (2012), for annual crop rice in 2011 the coverage includes floods, drought, windstorms, frost, hailstorms and bush-fires. The insurance company will pay for the additional loss after the government-controlled Disaster Relief Programme has been compensated. The underwriting process is as follows: the farmers contact the Bank for Agriculture and Agricultural Cooperatives (BAAC), and then the pool of local insurers retains 10.7% of the risk passed on by the BAAC and shares 89.3% with the International Reinsurance Market (headed by leading reinsurer Swiss Re). However, within 45 days of selling the insurance policy (15 July - 31 August 2011), the loss ratio reached the fairly high rate of 453%. Jeerachaipaisarn believes that in future there will be cooperation between the key relevant organisations: the Fiscal Policy Office, the Ministry of Finance, the General Insurance Association, the Ministry of Agriculture, the Office of Insurance Commission and the Bank for Agriculture and Agricultural Cooperatives.

## 3. Introduction to the area-yield index method

It is generally held that Halcrow was the first researcher to put forward the idea of area-yield crop insurance, publishing a seminal article on this subject in 1949 (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). However, Skees (2008) and the Katie School of Insurance (2011) claim that the idea was introduced by J.S. Chakravarti in 1920. The general main aims of the type of crop insurance which Halcrow (1949) envisaged were, first, to protect farmers' losses due to the adverse impact of the weather or associated physical causes and, second, to attract farmers as it offered the same indemnity level per unit and premium rate per unit. Later, in 1991, Miranda elaborated on this article, and a number of related papers have been published since then. As previously mentioned, index-based insurance policies apply various mechanisms such as weather and area yield in order to calculate claim amounts (Skees, 2008; Katie School of Insurance, 2011). Therefore, area-yield crop insurance, a pilot test of which in its very early days was the Group Risk Plan (GRP) in the United States, involves indemnity payments as well as premiums based on the area yield (known as county yield in the United States) rather than the individual farm yield. Farmers or insured who are covered by an area-yield crop insurance programme receive a claim payment if and only if the actual area yield is below a critical yield level (or a trigger or guarantee yield) which is calculated on the basis of the expected area average yield, a scale level (or an amount of protection) and a coverage (or 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). (The following three terms are used interchangeably for 'scale level': 'scale', 'protection' and 'coverage' (the last term is widely used in an insurance context). Similarly, with regard to 'coverage', two terms are used interchangeably: 'coverage' (in an agricultural context, it refers to (1-deductible)) and 'deductible' (widely used in an insurance context).) Gordon et al. (1990) refer to Miranda's 1989 working paper which indicates that the area-yield approach can indeed give effective protection for yield loss.

Here is an example of area-yield index crop insurance presented in numerical form. Suppose the expected area yield in the year under consideration is 10 hg/ha - in this case, a farmer chooses a deductible or coverage level of 80% (meaning he will retain a risk level of 20%), and consequently the trigger yield will be 8 hg/ha (10 hg/ha*80%). It is noteworthy that the higher the coverage level, the lower the risk exposure, and vice versa. He also chooses a protection level of 120% (the higher the level, the greater the risk protection), which is equivalent to 12 hg/ha (10 hg/ha*120%). If his actual yield is 6 hg/ha, which is lower than the predefined yield of 8 hg/ha, then the area-yield index crop insurance is automatically exercised, as his yield shortfall is 2 hg/ha (8 hg/ha - 6 hg/ha). Therefore, he will receive an indemnity of 3 hg/ha ((2/8)*12). This mathematical formula will be referred to again in the methodological part of this study.

Therefore, this programme involves the index and the basis risk (i.e. the difference between an individual's yield and an area's yield (Skees et al., 1997; Binici & Zulauf, 2006; Smith & Watts, 2009; Deng et al., 2006; Katie School of Insurance, 2011)), for instance if farmers whose yield is above the predefined area yield or a trigger yield still suffer from yield loss without any indemnities. In other words, those whose yield is less related to the critical yield might consider that this insurance is not appropriate for them (Binici & Zulauf, 2006). Hence, Skees et al. (1997), in brief, proposed four main elements which need to be taken into account in designing the insurance policy: 1) the area selected; 2) the procedures used to predict the future area yield; 3) the payment rules; and 4) the reasonable ranges for the coverage and deductibles.

First, for selection of the area, the main idea is that the insured areas should be similar to each other in terms of for instance the temperature, the precipitation and the crop type, so in other words, the homogeneity of the area (Katie School of Insurance, 2011). In general, the chosen regions are likely to be adjacent to one another. Furthermore, it is the optimal tool to minimise basis risk (Skees et al., 1997; Binici & Zulauf, 2006).

Second, various procedures have been implemented to calculate the expected crop yields (e.g. spline regression). Each approach has its strengths and weaknesses, and therefore the choices made essentially depend on the estimators, as well as the characteristics of the data available. On top of that, the most important thing is that the adopted methods should be simple and robust (Skees et al., 1997).

Third, as the indemnity depends on the area yield in that region, the payment rules relating to the critical or trigger level, the coverage and the deductible need to be carefully designed (Skees et al., 1997; Binici & Zulauf, 2006). For instance, one approach establishes the indemnity based on the multiple of yield shortfall - resulting only from the difference between trigger yield and actual yield - and the coverage (thus in the example shown above, the indemnity would be 2.4 hg/ha (2 hg/ha*120%)), while under the other methodology the indemnity is calculated based on the multiple of the percentage of shortfall (relative to the trigger yield) and the coverage (the indemnity is 3 hg/ha as expressed above) (Skees et al., 1997). Skees et al. (1997) claim that the indemnity for the latter is higher because it generates "the disappearing deductible" (i.e. ignoring the coverage level, the indemnity will reach 100% of the protection level in case of zero actual yield), and therefore, it does not persuade farmers who suffer from only disaster loss to purchase the insurance.

Fourth, Smith et al. (1994) compare a number of contract types, e.g. the Federal Crop Insurance Corporation (FCIC)'s Group Risk Plan, which allows farmers to select a coverage level of less than 150% and a trigger yield of less than 90% of the average area yield; the ideal area-yield crop insurance contract, which affords farmers an unrestricted choice of the coverage level and the trigger level; and the 'almost ideal' area-yield contract, which defines the coverage level as 100% and enables them to select the trigger yield. They claim that the last of these contracts, being simpler and enabling farmers to reduce yield risk, should be considered a potential alternative choice. Meanwhile, the Katie School of Insurance (2011) considers the trigger yield to be 50%, 60%, 70% and 80% of the historical yield.

Area-yield crop insurance has several striking advantages. One significant benefit is that it reduces adverse selection, which arises due to farmers who face a high probability of losses seeking insurance, and moral hazard, resulting from farmers who have insurance being more susceptible to malpractice to increase the likelihood of loss (Halcrow, 1949; Gordon et al., 1990; Miranda, 1991; Skees, 1993; Smith et al., 1994; Skees et al., 1997; Mahul, 1999; Skees et al., 1999; Binici & Zulauf, 2006; Deng et al., 2006; Skees, 2008; Dick, 2010; Katie School of Insurance, 2011; Awondo et al., 2012). In addition, as we mentioned earlier, the indemnities and premiums are mainly calculated on the basis of the aggregate yield in the local area, and therefore crop insurance provides coverage for all risks, e.g. flood and drought, and historical data from the individual farms are no longer required (Katie School of Insurance, 2011). Moreover, the administrative cost of claims is likely to decrease as there is no need for inspection of the loss on a farm-by-farm basis (Miranda, 1991; Skees, 1993; Mahul, 1999; Binici & Zulauf, 2006; Dick, 2010; Katie School of Insurance, 2011). Skees et al. (1997) also report that this kind of insurance is considered an effective risk management tool for areas which have systemic risk (i.e. the risk affects people over a large area). Binici & Zulauf (2006) indicate that systemic risk is not diversifiable, meaning that farmers in the region in question will be affected by the risk, and that area-yield insurance reduces the impact and can be readily transferred to reinsurers worldwide. Besides, the financial burden of insurance is feasible as per hectare the premium paid by farmers (especially those with small farms) in the same region is the same, as is the indemnity they receive (Binici & Zulauf, 2006; Katie School of Insurance, 2011).

However, one disadvantage of area-yield crop insurance is that it is restricted to areas with basis risk. The selection of the area where area-yield crop insurance is to be applied is the prime solution to reduce the basis risk (as presented above), along with the payment rules and the coverage and deductible ranges (Skees, 1993; Skees et al., 1997; Skees et al., 1999; Binici & Zulauf, 2006; Dick, 2010). Furthermore, assessing the actual yields might prove somewhat problematic (Dick, 2010; Katie School of Insurance, 2011), thereby affecting the actual amount that the insurance company is liable to pay. Suitable procedures relating to this problem should be scrutinised before launching the insurance policy, such as self-reported yields, or considering the grain delivered to mills to be the actual amount, as in Ghana (an example presented by the Katie School of Insurance, 2011). Dick (2010) suggests in particular for developing countries that they can learn from the experience of global agricultural insurance, such as the underwriting process or claim management. Although there are some weaknesses, it is still an optimal approach since, as Smith & Watts (2009) indicate, insurance can be regarded as a risk mitigation activity. One point that is crucial to note for our study is that the Thai crop insurance market does not include area-yield index crop insurance, which makes further examination of this phenomenon of such interest.

As emphasised earlier, changes in the climate apparently lead to meteorological change, which is the main influence on crops globally (Katie School of Insurance, 2011). Especially those farmers in developing countries who experience loss might make drastic choices to deal with their risks, such as migrating to towns to find other employment and selling their main items of property, and they might not have enough money to pay loans or start a new crop cycle, leading to dramatic effects on the economic system in general (Skees, 2008; Katie School of Insurance, 2011). Based on a number of articles on this subject, many factors resulting from climate change, such as rainfall, temperature, insect pests and soil erosion, have an impact on crops (Katie School of Insurance, 2011; Massey, 2013). Specifically, Massey (2013) points out that the temperature will increase by between 1 and 3 degrees Celsius before 2050, and temperatures and the other factors will be variable and uncertain. In addition, there are multiple interrelations among these variables. For example, the change in temperature will have an impact on soil erosion, which will eventually affect insect pests. He suggests that mitigation and adaptation are useful strategies - for instance, biotechnologies for crops have maintained land in forests while at the same time increasing yields, or even enabling the useful genes or new genes to be found (see Massey, 2013 for further information - the details go beyond the scope of this paper).

In summary, we found from reviewing a number of articles that weather-related parameters (especially rainfall and temperature) are of considerable significance to predicting crop yield. Therefore, this study will propose a new crop insurance methodology (area-yield index crop insurance) for the Thai context, making yield predictions on the basis of the key weather variable selected for this investigation: rainfall.

## 4. The statistics used for the analysis

The northeast of Thailand clearly has the country's largest harvested area in terms of rice yields (5,702,538 hectares, so accounting for 49.03% of the whole harvested area of rice of 11,630,300 hectares) (OAE, 2011). This study will examine the historical data regarding crop rice (1995-2011) from six provinces (LOEI, NAKHONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI) in the northeast of Thailand, which fall under the supervision of the Office of Agricultural Economics (OAE) (Zone 3). We assume the data received are reliable and there are only minimal errors in the input. In addition, the following variables will be considered in the study (see Table 3):

Table 3. Definition of variables

| Variable | Description |
|---|---|
| Rainfall | Amount of rainfall (ml) |
| Harvested_Yield | The ratio of yield and harvested area (hg/ha) |

The first variable is the independent variable, while the last one is the dependent variable.

Mathematical statistics (in the form of the simple linear regression analysis approach) is often used in modelling - and this investigation is no exception. The statistical programming language R will also be a major feature of this study. A function used for predicting the expected area yields in each province is as follows (Kutner, Nachtsheim, Neter & Li, 2005):

$$Y_{ij} = \beta_j + \beta_1 X_{ij} + \varepsilon_{ij}, \quad (1)$$

where
$Y_{ij}$ are observations;
$\beta_j$ indicates parameters we need to estimate for each province;
$\beta_1$ indicates parameters we need to estimate;
$X_{ij}$ are the values of the predictor;
$\varepsilon_{ij}$ are random error terms (where we assume the mean and variance value of the error term are zero and $\sigma^2$, respectively, and there is no correlation between $\varepsilon_i$ and $\varepsilon_j$);
$i$ stands for 1,…,17 (corresponding to 17 observations in each of the provinces covered by this study);
$j$ stands for 1,…,6 (corresponding to the six provinces in the study).
Obtaining the yield prediction equation above, a suitable area-yield index for rice in particular areas will be developed by adopting the methodology of Skees et al. (1997) and Binici & Zulauf (2006). Suppose the forecasted area yield (or the expected area yield) is $Y_f$. Then the trigger yield (also known as the critical or guarantee yield) ($Y_t$) is calculated in the following way:

$$Y_t = Y_f * cov, \quad (2)$$

where $cov$ stands for the coverage level chosen by the insured or farmers.
In the event that the actual yield is $Y_a$, as reported earlier the insured will receive the loss payment if and only if the actual yield is below the trigger yield. Hence, the indemnity payout in specific years is expressed as follows:

$$Indemnity = max\left[\left(\frac{Y_t - Y_a}{Y_t}\right) * Y_f * scale, 0\right] \quad (3)$$

where $scale$ is the protection level selected by the insured or farmers.
In this study we will examine 80%, 85%, 90% and 95% coverage levels, as these are either below or equal to the 95% level set by the Group Risk Plan of the Federal Crop Insurance Corporation (FCIC). In fact, a 95% coverage level has not yet been applied anywhere (Smith et al., 1994; Skees et al., 1997). The protection level should be less than 150%. To recap, Smith et al. (1994) insist that the 'almost ideal' area-yield contract (defining a protection level of 100%), which is simple and enables farmers to reduce yield risk, is the optimal contract type. Therefore, we will set the protection levels at 100% and 150%.
The anticipated premium rate (in this study, expressed in hg/ha) is calculated on the basis of the expected indemnity payouts without any additional costs (Halcrow, 1949; Skees et al., 1997; Deng et al., 2006). Consequently, the premium rate is the result of the summation of the indemnities shown in equation (8) divided by the total number of observations in the study, as expressed by Binici & Zulauf (2006) in the following form:

$$Premium = \left(\sum_{i=1}^{n} Indemnity\right)/n \quad (4)$$

The next section will present the trigger yield and the indemnity payments along with the expected premiums for the selected coverage and scale levels.

## 5. The results

After collating the data, an evaluation was made of the results. The outcome is given below. In the first section we describe the general characteristics of the Thai provinces that were selected for this study. The second section details the results of our application of linear regression analysis, followed by the calculated premiums.

*5.1 General characteristics of variables in the selected Thai provinces*

Figure 1 relates to the yield per harvested area across the six selected provinces from 1995 to 2011. For five provinces - NAKNONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI - the yields vary between 15,928 hg/ha and 24,798 hg/ha, while for the province of LOEI they range from 21,150 hg/ha to 33,527 hg/ha. Specifically, the average yields for LOEI, NAKNONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI are 24,528.76 hg/ha, 18,690.71 hg/ha, 19,460.88 hg/ha, 19,551.18 hg/ha, 18,920.06 hg/ha and 19,385.53 hg/ha, respectively.
By analogy, Figure 2 illustrates the amount of rainfall across the six selected provinces from 1995 to 2011. The rainfall in each province seemingly increases every year, with the minimum rainfall ranging from 607 ml in LOEI to 2,720 ml in NAKHONPHANOM.

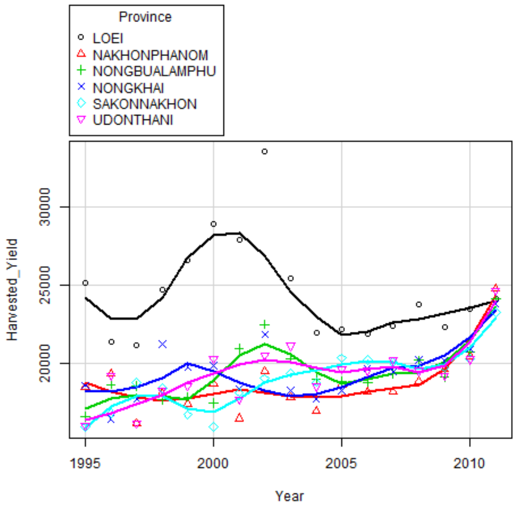


Figure 1. Yield per harvested area (hg/ha) from 1995 to 2011 in each of the selected provinces

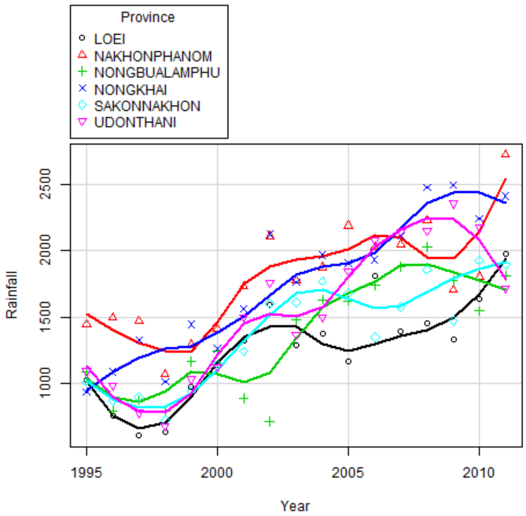


Figure 2. Amount of rainfall (ml) from 1995 to 2011 in each of the selected provinces

*5.2 Yield prediction*

In this section we construct a suitable linear regression equation for rice yield employing rainfall as its central variable. The results of equation (1) demonstrate that the estimated values of the intercepts for NAKNONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI have a negative sign, as those provinces generate a significantly lower yield than LOEI (which is consistent with the descriptions above) when another variable is constant. For instance, the expected yield of NAKHONPHANOM is 6,793.86 hg/ha less than that of LOEI (22,212.65 hg/ha). Thus, the estimated yield for NAKHONPHANOM is 15,418.79 hg/ha = 22,212.65 + (-6,793.86). By the same token, the estimated yields for NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI are 16,976.55 hg/ha, 16,315.56 hg/ha, 16,382.42 hg/ha and 16,557.86 hg/ha, respectively. The R-squared value of 0.5524 can be interpreted as the proportionate reduction in the error in estimating the dependent variable based on the known independent variables. The estimated value of 1.8308 indicates that rainfall has a positive impact on harvested yield. This shows that a 1-ml increase in rainfall is accompanied by a rise of 1.8308 hg/ha in yield. This result is consistent with Halcrow (1949), who demonstrated that for a simple regression function used in crop insurance, only a single variable - annual rainfall - can be employed.

Therefore, the estimated functions for the provinces in this study are:

$$Harvested\_Yield_{LOEI} = 22{,}212.65 + 1.83Rainfall \quad (5)$$

$$Harvested\_Yeild_{NAKNONPHANOM} = 15{,}418.79 + 1.83Rainfall \quad (6)$$

$$Harvested\_Yield_{NONGBUALAMPHU} = 16{,}976.55 + 1.83Rainfall \quad (7)$$

$$Harvested\_Yield_{NONGKHAI} = 16{,}315.56 + 1.83Rainfall \quad (8)$$

 

$$Harvested\_Yield_{SAKONNAKHON} = 16{,}382.42 + 1.83Rainfall \quad (9)$$
$$Harvested\_Yield_{UDONTHANI} = 16{,}557.86 + 1.83Rainfall \quad . \quad (10)$$

*5.3 Estimation of premium rates*

The calculated premiums will be presented in this section. To predict the harvested yield for each region in specific years, we employ equations (5) to (10), where the results vary depending on the number of decimal places. For instance, if the rainfall in LOEI in 1995 is 1,028 ml, the forecasted yield for LOEI in 1995 is 24,093.89 hg/ha = 22,212.65 + (1.83 x 1,028). In this way we obtain the forecasted area yield ($Y_f$) for every year in every province. After incorporating the four coverage levels we are investigating, namely 80%, 85%, 90% and 95% ($cov$), using equation (2), we acquire the trigger yields ($Y_t$). Then the indemnities in each province in specific years can be calculated by means of equation (3). Only two protection scales - 100% and 150% - will be taken into account. Table 4 illustrates the different coverage levels, along with the scales for each province and finally the estimated premium rates arising from equation (4).

Table 4. Estimated premium rates (hg/ha) for the different scales and coverage levels

| Scale | Province | Coverage level | | | |
|---|---|---|---|---|---|
| | | 80% | 85% | 90% | 95% |
| 100% | LOEI | 0.00 | 0.00 | 87.27 | 612.82 |
| 100% | NAKNONPHANOM | 0.00 | 0.00 | 25.50 | 196.11 |
| 100% | NONGBUALAMPHU | 0.00 | 0.00 | 31.45 | 188.22 |
| 100% | NONGKHAI | 0.00 | 0.00 | 13.44 | 187.27 |
| 100% | SAKONNAKHON | 0.00 | 0.00 | 75.22 | 230.15 |
| 100% | UDONTHANI | 0.00 | 0.00 | 44.12 | 232.36 |
| 150% | LOEI | 0.00 | 0.00 | 130.90 | 919.23 |
| 150% | NAKNONPHANOM | 0.00 | 0.00 | 38.25 | 294.17 |
| 150% | NONGBUALAMPHU | 0.00 | 0.00 | 47.18 | 282.33 |
| 150% | NONGKHAI | 0.00 | 0.00 | 20.16 | 280.91 |
| 150% | SAKONNAKHON | 0.00 | 0.00 | 112.83 | 345.22 |
| 150% | UDONTHANI | 0.00 | 0.00 | 66.19 | 348.54 |

Source: Authors' calculations

The analysis shows that the premiums for the 80%, 85%, 90% and 95% coverage levels in both scales for each province are different. It indicates that yields in LOEI are higher than in the other provinces, leading to higher premiums for the former province (0.00 hg/ha, 0.00 hg/ha, 87.27 hg/ha and 612.82 hg/ha for a protection level of 100% and coverage levels of 80%, 85%, 90% and 95%, respectively; and 0.00 hg/ha, 0.00 hg/ha, 130.90 hg/ha and 919.23 hg/ha for a protection level of 150% and coverage levels of 80%, 85%, 90% and 95%, respectively). NONGKHAI seems to have the lowest premiums - 13.44 hg/ha and 187.27 hg/ha for a protection level of 100% and coverage levels of 90% and 95%, respectively; and 20.16 hg/ha and 280.91 hg/ha for a protection level of 150% and coverage levels of 90% and 95%, respectively. There is no indemnity payment at the coverage levels of 80% and 85% in each province. Framed in other terms, the actual yields are higher than the trigger yields for each province at the 80% and 85% coverage levels. Thus, for the region under consideration, premiums range from 13.44 hg/ha for a protection scale of 100% and a coverage level of 90% to 919.23 hg/ha for a protection scale of 150% and a coverage level of 95%.

At the same coverage level of 90% (10% deductible), the premiums appear to be 50% higher for the protection scale of 150% than for the protection scale of 100%; the same applies to the other coverage levels. In other words, if the scale rises by 50%, the premium increases by 50% as well.

## 6. Conclusions

This study, taking the issue of risk management and mitigation for rice-growing in Thailand as its basis, investigates a new crop insurance approach called area-based insurance which in this investigation makes use of the factor of weather. We first examined the general characteristics of variables in six provinces in the northeast of Thailand that are supervised by the Office of Agricultural Economics (OAE) (Zone 3) and then presented the forecasted yield and trigger yields which are consistent with the various levels of coverage. Subsequently, the premium rates corresponding to different trigger yields and scales were established for those provinces (LOEI, NAKHONPHANOM, NONGBUALAMPHU, NONGKHAI, SAKONNAKHON and UDONTHANI).

A model considering the two variables harvested yield and rainfall for each dummy province produces the R-squared value 55.24%. The trigger yields are generated at different levels of coverage (80%, 85%, 90% and 95%). Taking into account such related items, the premium rates required ranged from 13.44 hg/ha to 919.23 hg/ha for both protection scales (100% and 150%).

The study appears to have combined two approaches: the area-yield index approach and the weather-yield index approach from Halcrow (1949). In summary, to promote this policy on the Thai insurance market, several relevant issues need to be considered, as Skees et al. (1999) suggest that implementing this type of insurance in many developing countries mainly depends on government policy and public cooperation (for instance, the restricted choices of coverage and scale and the dissemination of knowledge among farmers in the countryside). Therefore, this research can be used as a basis for guidance regarding the pure premiums for crop insurance policies.

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