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Impact of the Adoption of Agricultural Index Insurance on Food Security and The Level of Poverty of Households in Sud-Borgou (Benin)

Alain Togbédji AGUIDA[1*], Jacob A. YABI[2]

Laboratory of Analysis and Research on Economic and Social Dynamics (LARDES), Department of Rural Economics and Sociology (DESR), Faculty of Agronomy (FA), University of Parakou (UP), BP 123 Parakou. E-mail: Email: altags@yahoo.fr; Tel: 00229 67673706/96472827.

Laboratory of Analysis and Research on Economic and Social Dynamics (LARDES), Department of Rural Economics and Sociology (DESR), Faculty of Agronomy (FA), University of Parakou (UP), BP 123 Parakou. E-mail: jacob.yabi@fa-up.bj, Tel: (+229) 97320856 / (+229) 65455441, Email: ured.lardes@gmail.com, Website: www.fa-up.bj/lardes-benin, Republic of Benin

***Corresponding author:** Alain Togbédji AGUIDA, Laboratory of Analysis and Research on Economic and Social Dynamics (LARDES), Department of Rural Economics and Sociology (DESR), Faculty of Agronomy (FA), University of Parakou (UP), BP 123 Parakou. Email: altags@yahoo.fr

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Abstract

The management of agricultural climate risks is a major concern in rural Benin. In order to cope with this, producers sometimes resort to index-based agricultural insurance. This article analyzes the contribution of the adoption of these index-based agricultural insurances on food security and the level of household poverty. The data was collected from three hundred and twenty (320) heads of farms in 3 municipalities in northern Benin with the KoBoCollect application on Smartphone. Descriptive statistics, propensity scores and mean treatment effect (ATT) were estimated with STATA v15. The results revealed that the adoption of index-based agricultural insurance contributes to improving the food consumption index by 6.274 UA and therefore has a positive impact on food security. Insurance insurance takers therefore had more access to food and dietary diversity. The results also show that the effect of index-based agricultural insurance on poverty is not perceptible, i.e., there is no link between the poverty index and insurance.

Keywords: *Index insurance; Food Security; poverty; North Benin.*

Introduction

In many developing African countries, agriculture is the backbone of the economy and is characterized by a focus on cash crops for export. This is the case of Benin whose contribution is 33% to GDP, 75% of export earnings, 15% of State revenue and employs about 70% of the active population with cotton as the main crop [1]. Overall, it ensures food self-sufficiency for the Beninese populations in cereals, legumes, tubers and roots [2]. Unfortunately, it is threatened by climate change, which has lasting consequences for populations (drought, floods, rainfall deficit, heat waves, etc.) [3]. While most of it is seasonal and rainfed agriculture [4]. Climate change negatively affects agricultural yields through its impacts on plant growth, development and varietal diversity (Rahman et al. 2015). Faced with the consequences of climatic hazards and human activities, while at the same time the food needs of the populations are increasing due to the strong demographic pressure in the country. Food security is in question. Because food self-sufficiency remains precarious. In fact, 52.5% of the population have an acute lack of physical and economic access to adequate food. They live in a situation of extreme food insecurity or famine, while the other 47.5% of the population have limited access to adequate food and risks of deterioration of the food situation [5]. In 2019, 38.5% of the population lives in extreme poverty [6]. In 2012, Srivastava et al revealed that declining agricultural yields due to poor soil and climate conditions are sure to lead to increasing food insecurity, vulnerability of farming communities, reduced household incomes and increased poverty. However, to cope with these effects of climate change and to minimize agricultural risks, many adaptation strategies have been developed. These are: the adoption of new resilient varieties, the practice of sustainable land management, and the adoption of index insurance. This is how insurance has been the subject of several studies such as Troye (2013) [7] which reveals that agricultural insurance is perceived as a tool for the management of agricultural risks which covers losses linked to the effects of climate change. and other natural phenomena. According to Aguida (2017) [8], also known as a tool for adapting to climate variations and change, agricultural insurance makes it possible to secure the income of producers and contribute to more intensive development and therefore more productive and promoters of the local, national and the regional economy. Hountondji et al. (2018) [9] in their study carried out in the districts of Ouèssè, revealed that despite the many efforts made by the members of the Beninese Agricultural Insurance Structure, producers are struggling to subscribe to this insurance. Previous work done in Benin by Aguida et al., 2021; Hountondji et al., 2018 and Aguida, 2017 [3,9,8] discussed index insurance on the analysis of producers' perception of insurance, the factors that influence their decision to underwrite and the contribution of index-based agricultural insurance to strengthen the resilience of family farms in Benin. However, these studies did not specifically address the impact of agricultural insurance on food security and the income of family farms. This research aims to assess the impact of the adoption of agricultural insurance on food security and the level of poverty.

Materials and methods

A. Description of the study area

Benin is a West African country with a total area of 114,763 km2. It is bordered to the west by Togo, Nigeria to the east, Burkina Faso to the northwest, Niger to the north and the Atlantic Ocean to the south. The climate is subequatorial in the south, with two rainy seasons and two dry seasons. To the north it is tropical with only one rainy and dry season. Rainfall varies between 900 and 1450 mm of water per year and temperatures oscillate between 22°C and 37°C. The pilot index insurance program that is the subject of this study is developed in agro-ecological zone III (southern Borgou food-producing area) through the pilot municipalities of N'Dali, Bembèrèkè and Nikki (Figure 1). In this zone, the production system is based on food crops (especially maize and yam). However, there are some cash crops such as cotton and groundnuts (PANA, 2008). This area is in the department of Borgou where poverty is most severe (INSAE/ EHCVM, 2019).

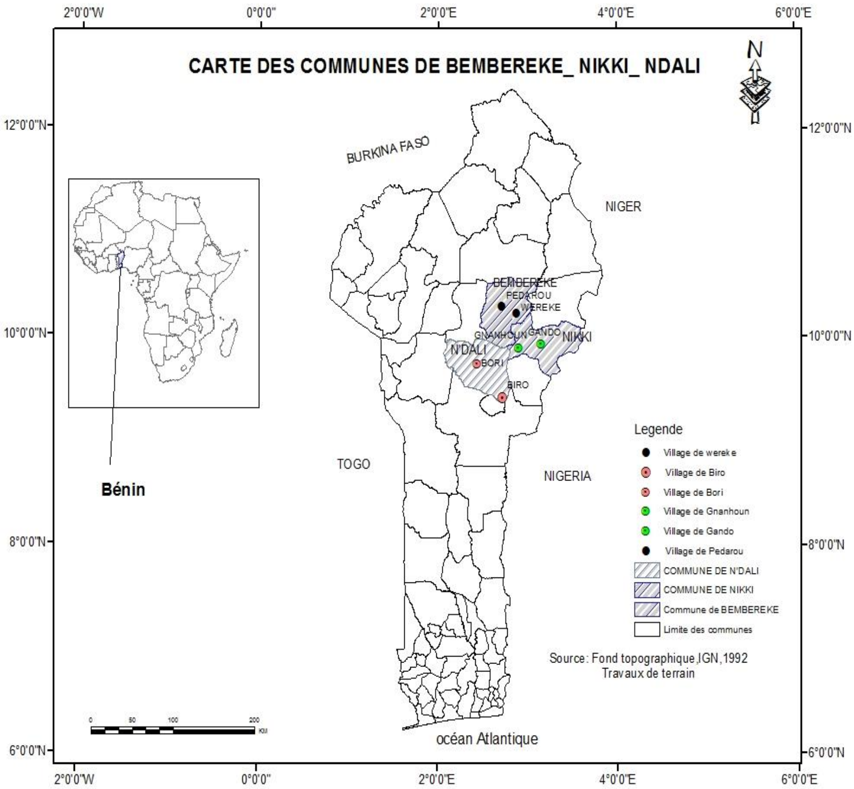

Figure 1: Presentation of the study area

B. Sampling methods

Based on an exploratory study of the environment, sampling was done in two. The first step consisted in the random selection of survey villages based on the complete list of pilot villages. Thus, in each municipality, two villages were chosen: the villages of Gando and Bori in N'Dali, Biro and Gnanhoun in Nikki, Pédarou and Wèrèké in Bembèrèkè. The second stage consisted in the selection of the survey units which are the agricultural holdings. The selection was made randomly and weighted according to the number of insured persons per village selected. A total of three hundred and twenty (320) farm managers were surveyed, including one hundred and sixty (160) insured farms and one hundred and sixty (160) uninsured. The size of the sample was determined in relation to the number of insured holdings to be surveyed on the basis of the formula below for a level of precision of +/-7%.

$$n = \frac{N}{1 + N \times e2}$$

N = Population size of insured holdings; e= precision level at +/- 7%

In order to make a fair comparison, non-member farms were also selected by survey village on the basis of a list of farm managers drawn up by resource persons in the village. The selection was carried out randomly and the size is proportional to that of the insured farms selected per survey village.

C. Collection methods and materials

In order to effectively carry out this work and identify the contours of the problem to be studied, we adopted a combination of approaches as suggested by Pretty and Vodouhè (1997). This will involve combining qualitative and quantitative methods. The qualitative method, flexible and holistic, is used both for the collection of data and for their analysis. It consists of the use of the tools, techniques and principles of the Accelerated Method of Participatory Research (MARP) such as: semi-structured interviews, participant observation, exploitation of existing data, revealing quotes and triangulation. The quantitative approach was used for the collection and analysis of data through the questionnaire survey, mathematical calculations and estimates using analysis models.

D. Collection of data

Two types of data were used to carry out this study. These are primary and secondary data. The primary data are those obtained in the field using structured individual and semi-structured group interviews (focus groups) with farm managers and a few resource persons. Secondary data concerns information obtained mainly from the literature review. Indeed, it is on the one hand, quantitative and qualitative data that can best be used to analyze the relevance of index insurance as an instrument for managing risks related to family farms as well as the factors that determine the adherence of farm managers and the contribution of the instrument to the sustainable strengthening of the resilience of farming systems in Benin. The data collected concerns: the loss ratio, the assessment of claims, the compensation rate, premiums collected, the conditions for compensating claimants, average yield per farm, rate of access to credits, rate of coverage by type agricultural index insurance breakthrough, growth rate of beneficiary farms, food security data (food categories, number of meals consumed per day, market accessibility of food).

E. Method For Assessing the Level of Food Security and Poverty of Households

- **Calculates household food consumption scores**

$$SCA = Acéréales \times Xcéréales + Alegumessecs \times Xlegumessecs + Alegumes \times Xlegumes + Afruits \times Xfruits + Alait \times Xlait + Aanimal \times Xanimale + Asucre \times Xsucre + Ahuile \times Xhuiles$$

Where: Ai = the weight assigned to the food group.
Xi = the number of days of consumption relative to each food group (≤ 7 days).

It should be noted that the measurement of the quantities consumed is not integrated into the calculation of the food consumption score. Details on the different food groups with their weights are recorded in the table below.

Table 1: Food groups and their weights in the food consumption score.

Food	**Food groups**	**Weight**
Maize, rice, sorghum, millet, bread and other cereals	Cereals and tuber	2
Tubers, cassava, potato, yam, plantain, sweet potato and other tubers		
Beans, peas, groundnuts, soya, cowpeas, lentis etc	Dried vegetables	3
Vegetables - Leaves	Vegetables and leaves	1
Mangoes, oranges, bananas and other fruits	Fruits	1
Beef, goat, poultry, pork, eggs, fish and other meats	Animal protein	4
Milk, yogurt and other dairy products	Milk	4
Sugar, honey et sweet products	Sugar	0,5
Oils and fats oils	Oils	0,5
Condiments, spices	*Condiments	0
Source: WFP, used by AGVSAN-Bénin 2009		
(*) Condiments are not considered a food group due to their zero weight.		

The values of the scores thus calculated for each household are reported on a scale ranging from 0 to 112. The standard thresholds 21, 35 and 45 are used to determine the household food consumption classes (poor, borderline, moderately acceptable and acceptable). Thereby:

- If SCA < 21: the household has poor food consumption;
- If 21 ≤ FCS <35: the household has a borderline food consumption;
- If 35 ≤ FCS <45: household food consumption is moderately acceptable;
- If SCA ≥ 45: consumption is acceptable.

F. Impact Analysis Method for Agricultural Insurance

To assess the impact of agricultural insurance, a so-called "naive" approach [10] would consist in taking a random sample of producers (men and women) who participated in the insurance and producers who did not participate in the insurance; and to use the simple difference of the average observed results of the two groups as the impact of the contract. This difference in results would not, however, indicate an a priori causal relationship, as it is possible that at least part of the difference existed even before the use of the practice (or insurance) [11]. Estimating the effect of agricultural insurance on any outcome indicator using this "naive" approach is therefore biased. To correct the observed biases and generate unbiased estimates, experimental (social experiment or randomization) and non-experimental approaches have been developed. The experimental approach consists of following two groups of producers with similar socio-economic characteristics: those who participate in the insurance (treatment group) and those who do not participate (control group). Since the beneficiaries of the insurance were chosen randomly, any difference with the non-beneficiaries is only due to the treatment. The experimental approach gives unbiased estimates and the easiest results to interpret [12], but it is difficult to put into practice because it requires planning, finding groups of interested producers and ensuring monitoring over time. The present study opted for the non-experimental approach introduced by Rubin (1974) [13] and used to deal with the problem of selectivity biases. Let be the binary variable that indicates the producer's participation in agricultural insurance, with $\boldsymbol{Ci} = \mathbf{1}$ for producers participating in the insurance and $\boldsymbol{Ci} = \mathbf{0}$ for non-participating producers. If $\boldsymbol{yi}$ is an outcome indicator (yield or income for example), each producer i presents two potential outcomes: an outcome denoted $\boldsymbol{y1i}$ if he participated in the insurance ($\boldsymbol{Ci} = \mathbf{1}$) and $\boldsymbol{y0i}$ if not ($\boldsymbol{Ci} = 0$). For an individual i in the population, the causal effect of insurance participation on the outcome indicator is: y= $\boldsymbol{y1} - \boldsymbol{y0}$ (1).

The main difficulty encountered in estimating this causal effect is that, when a treatment intervenes, we cannot observe the value of $\boldsymbol{y0}$, and if it does not intervene, we cannot observe the value of $\boldsymbol{y1}$. Otherwise, a producer cannot be simultaneously a participant and a non-participant in insurance, so it is impossible to observe both $\boldsymbol{y1}$ and $\boldsymbol{y0}$ for the same producer. In this data-poor (counterfactual) situation where the treatment effect is never observed directly, Rosenbaum and Rubin (1983) state that the average causal treatment effect can be determined provided that $\boldsymbol{y1}$, $\boldsymbol{y0}$ and $\boldsymbol{Ci}$ are all independent. Under this assumption of independence, the average effect of insurance on an individual drawn at random from the ATE study population (Average Treatment Effect = average treatment effect) is the difference between the average level of the indicator of producers who participated in insurance and that of non-participants [11]: $\boldsymbol{ATE} \equiv (\boldsymbol{y1} - \boldsymbol{y0})$ (2).

Similarly, the average effect of insurance on a producer from the sub-population of producers participating in insurance (ATET: Average Treatment Effect on Treated = the average effect of treatment on the population treated) and that of a producer of the sub-population of non-participating producers (ATEU: Average Treatment Effect on the Untreated= average treatment effect on the untreated population) can also be determined:

$$\boldsymbol{ATET} \equiv (\boldsymbol{y1} - \boldsymbol{y0} \,/\boldsymbol{C} = \mathbf{1}) \ (3)$$
$$\boldsymbol{ATEU} \equiv (\boldsymbol{y1} - \boldsymbol{y0} \,/\boldsymbol{C} = \mathbf{0}) \ (4)$$

ATE, ATET and ATEU are, however, subject to two types of bias: the bias due to the difference between observable characteristics (overt bias) and that due to the difference between unobservable characteristics (hidden bias) affecting producers' access to information and their decision to adopt or not the treatment (Rosenbaum, 2001). We corrected some of these biases by randomization.

Results

A. Difference between insurance takers and non insurance takers of insurance

Table 2 presents the socio-demographic characteristics of respondents following the adoption of insurance. From this table, it appears that there is no link between the study area, level of education, religion and the adoption of producer insurance (Chi2> 0.1). However, the gender of the producer, his ethnicity, his mode of access to the land and his membership in a producer organization have a link with the adoption of insurance (Chi2 <0.1). In terms of gender, there are more women adopting insurance than men. We also noted that polytheistic religions (Animist) adopt insurance much more than monotheistic religions (Christians, Muslims). Finally, producers belonging to a producer organization, and those with access to land by donation/purchase also adopt insurance much more than those who do not belong to producer organizations.

Table 2 : Socio-demographic characteristics.

Adoption of Insurance		People who adopt insurance	People who do not adopt insurance	Chi2
District	Bembèrèkè	57,58	42,42	0,609
	N'dali	56,72	43,28	
	Nikki	50,00	50,00	
Gender	Female	37,04	62,96	0,065*
	Male	56,07	43,93	
Educational level	None	51,72	48,28	0,566
	Primary	58,46	41,54	
	Secondary	47,37	52,63	
Ethnic group	Bariba	52,35	47,65	0,100*
	Peulh	73,68	26,32	
	Fon and others	36,36	63,64	
Religion	Animist	33,33	66,67	0,502
	Christian	50,85	49,15	
	Muslim	55,56	44,44	
Access to land	Heritage	56,60	43,40	0,053*
	Lease	52,00	48,00	
	Donation/purchase	25,00	75,00	
Membership of an agricultural organisation	Yes	48,76	51,24	0,096*
	No	60,76	39.24	
*Source: survey, 2021; * significant at 1%, ** significant at 5%, *** significant at 10%*				

Table 3 presents quantitative socio-demographic characteristics of producers. The results reveal that age, household size and agricultural assets do not affect the adoption of insurance. On the other hand, the experience in Agriculture of the producer and the area cultivated in 2021 by the producer have a link with the adoption of the insurance. The results show that producers who adopt insurance are those with experience and small areas.

The results in Table 4 show the Per capita and food security of individuals in the households surveyed. The results show that total household expenditure differs from one municipality to another. Overall, the household expenditure of the district of N'dali is higher than that of the other districts. The poverty index (Per capita/day) also differs from one municipality to another. Only the Nikki producers who have a poverty index above 400. However, note that the average poverty index in the entire study area is less than 500 FCFA. With regard to household food security, it appears that the FCS average in the area is 50.74 (21.41). This is above 45, which shows that this area has acceptable food consumption. Nevertheless, households in the districts of Bembèrèkè and N'dali have a moderately acceptable food consumption (35 ≤ FCS <4).

Table 3: Quantitative socio-demographic characteristics.

Insurance	Non-taker	Taker	t-student
Age	46,53 (9,603)	45,69 (9,724)	0,538
Household size	9,89 (5,844)	9,77 (5,353)	0,887
Farming experience	22,60 (9,66)	18,68 (8,88)	0,0034***
Agricultural asset	5,35 (4,03)	4,80 (2,87)	0,2759
Area cultivated in 2021	8,17 (8,37)	6,13 (4,59)	0,0375**
*Source: Survey, 2021; * significant at 1%, ** significant at 5%, *** significant at 10%*			

Table 4: Per capita and food security.

	Bembèrèkè	N'dali	Nikki	Total
Total household expenditure per day	3220,01±1155,95	4239,10±8466,69	2926,82±1987,16	3414,81 ±5129,22
Poverty Index	330,10±144,16	396,86 ±945,54	445,99±385,58	410,42±612,85
Food Safety	35,83±18,71	43,65±21,65	60,41±17,14	50,74±21,41
Source : Survey, 2021				

B. Estimating The Impact of The Adoption of Agricultural Insurance on Poverty and Food Security.

Table 5 presents the different classes of SCA according to the adoption of the insurance. The results show that more than 65% of households have an ACS greater than 45 UC. The results also reveal that about 13% of households surveyed have an SCA of less than 21 UC, 15% of households have an SCA of between 21 and 35 UC and 6.50% of households have an SCA of between 35 and 45 UA. These households are mostly households that do not adopt agricultural insurance.

From Table 6, it appears that the average Food Security (SCA) of households differs according to the adoption of insurance (t-student=0.069). Indeed, the average Food Security of insurance takers (53.68 ± 21.26) is higher than that of non-insurance takers (48.18 ± 21.31). Compared to average household expenditure, there is very little difference between insurance takers (3202.17 ± 1981.82) and non-insurance insurance takers (3599.62 ± 6775.56). The per capita of individuals in the households surveyed shows that the average poverty index differs slightly from an insurance taker (419.365 ±402.95) to a non-insurance taker (402.63 ±751). Note that this difference is zero from a statistical point of view (t-student=0.847).

Tableau 5: Insurance adoption and different classes of SCA.

Insurance	Non-takers	Takers	Total
SCA < 21 en %	62,96	37,04	13,50
21 ≤ SCA < 35 en %	58,62	41,38	14,50
35 ≤ SCA < 45 en %	53,85	46,15	6,50
SCA ≥45 en %	50,38	49,62	65,50
Source : Enquête, 2021			

Tableau 6: Food security and poverty index.

Insurance	Non-takers	takers	t-student
Food Security Average (SCA)	48,18 ±21,31	53,68±21,26	0,069*
Average total household expenditure per day	3599,62±6775,56	3202,17±1981,82	0,585
Average Expenditure per person in the household (IDH)	402,63±751	419,365±402,95	0,847
*Source: Survey, 2021; * significant at 1%, ** significant at 5%, *** significant at 10%*			

C. Determination of the average treatment effect (ATT)

The average treatment effect of adopting agricultural climate index insurance was determined following probit estimation to establish how the explanatory variables influence the probability of participation. The probit model was used where the treatment variable (take-up of weather index insurance) was regressed. After predicting the propensity score, the matching algorithm was considered.

The matching results are shown in Table 7. On average, adopters of agricultural insurance received more food than non-insurance takers. The difference in magnitudes (in CU) is 6.274 using the nearest neighbor technique, 3.619 with the layering technique, 2.574 with the ray technique, and 2.904 with the kernel technique. This shows that during the period of insurance adoption, farmers adopting insurance increased their food consumption index by 6.274 CU. Adopting farmers therefore had increased food access and a more diverse diet than non-participating farmers. In other words, the adoption of agricultural insurance has contributed to increasing household food security.

Tableau 7: The contribution of agricultural insurance to SCA.

Methods	Adoptant	Non-adoptant	ATT	Erreur standard	t
Nearest Neighbor Matching	93	44	6,274	4,581	1,570
Stratification Matching	86	105	3,619	-	-
Radius Matching	28	23	2,574	6,293	0,409
Kernel Matching*	93	98	2,904	2,959	0,981
* Bootstrap statistics					

Variable	Reps	Observed	Bias	Std, Err,	[95% Conf, Interval]
bs1	50	2,904061	0,3309096	2,877972	-2,879439 8,687561 (N)
					-3,135859 7,937659 (P)
					-3,20891 7,551184 (BC)
N = normal, P = percentile, BC = bias-corrected					

Discussion

The results of this research show that the use of index-based agricultural insurance is one of the most effective ways to improve the state of food insecurity. These results corroborate with the work of Isabokel et al. (2016) [14] which showed that the adoption of index-based agricultural insurance has a positive impact on the food security of farmers. According to Initiative Access to Insurance, (2016) [15], insurance contributes to maintaining the level of income of farmers but also allows access to the credit market and thus to obtain financing for food production. Zou et al., (2022) [16] approach in the same direction and show that agricultural insurance helps to increase labor productivity and cultivated land area per capita and encourages specialized plantations, which promotes the growth of agricultural production. and food security. It is a promising instrument for managing climate risks and enhancing food security (Habtemariam et al., 2021) [17], an important factor that promotes agricultural development, increasing instability in productivity and improving food security (Hazell and Hess, 2010) [18]. It is also a mechanism for reducing climate risks, uncertainty in agricultural production and guarantees food security (Wang et al. 2022). Our results are also similar to those found by Fang et al., (2022); Sinnarong et al., (2022); Chemeris et al., (2022) [19,20,21] who showed that global food security and climate adaptation can be positively affected by agricultural insurance. Regarding the impact of insurance on poverty, our results do not corroborate those found by Christopher and Aragon, 2013 on the impact of insurance on the net loss of agricultural income of rice farmers in the municipalities bordering Laguna, Philippines. Chantarat et al., (2013) also found that agricultural insurance increases agricultural income which has a positive impact on poverty. For Stoeffler et al., (2016) [22], index insurance can have a productive effect on poor farmers and support them in their income growth and asset accumulation strategies.

Conclusion

Agricultural insurance is an important risk management tool for farmers. It contributes to the food security of the population and plays a major role in reducing poverty. While traditional insurance is too expensive for most farmers, especially in sub-Saharan Africa, agricultural index insurance shows the potential to offer a promising solution with lower premiums and faster payouts. Efforts must therefore be made to improve the thrust of insurance in general at the level of producers.

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