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FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE AND FOOD SECURITY OF HOUSEHOLDS OF ORGANIC RICE FARMERS IN TANGGAMUS REGENCY (ORDINAL LOGIT MODEL APPROACH)

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ABSTRACT

These research aims were to analyze: (1) the farmers' adaptation strategies to climate change in farming and in maintaining food security, (2) the degree of food security of farmers' households in both rainy and dry season, and (3) factors affecting the food security of farmers' households. This research was carried out in Pekon Tampang Tua, Pematang Sawa Sub-district, Tanggamus Regency. The sample was taken in the census from 60 farmers who were certified to plant organic rice. Data was taken directly by interview survey on each farmer. Food security was measured by its definition according to FAO (1996) and Law of Indonesia. No.7 Year 1996. Factors affecting the food security of households were analyzed by using ordinal logit regression approach. The results showed that only 10 adaptation and anticipation on climate change strategies which has been applied by farmers Meanwhile, only 5 out of 7 strategies were applied by farmers to maintain the food security during climate change. The food security level of organic rice farmer's households was higher in the rainy season compared to the dry season The analysis result showed that the farmers 'adaptation strategies to climate change, education level of the patriarch, the price of rice, land area, and seasonal dummy variable in rice plantation affect positively on food security. Whilst, the number of family member, the price solid and liquid organic fertilizer negatively affect the food security level of organic rice farmer's households.

Keywords: Adaptation strategies, food security, organic rice, rain-fed rice field

1 INTRODUCTION

Indonesian agriculture is at crossroads, with rice as Indonesian staple food, a rice plantation in Indonesia is important and need to be developed to support the livelihood of millions of Indonesians. Report of Indonesian Statistic Central Bureau (BPS) in 2010 showed that Indonesian population was 237,641,326 with a net increase of 1.43 % annually (Suhendi and Azikin 2010). If the rice consumption level rice is 130 kg/capita/year, thus in 2050,

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Indonesia will need 52.6 tons of rice. Yet the domestic production of rice was predicted only 43.2 million tons, as a result, Indonesia will have a deficit of 9.4 million tons rice in 2050. This condition will affect food security either in national, household, or individual level. Although Indonesian is the third largest country regarding global rice production (FAOSTAT DATA 2004), the Indonesian government has been importing rice mainly from Thailand and Vietnam to safeguard the country rice reserve.

In order to achieve rice self-sufficiency and sustainability, Indonesia government uses two approaches, first is encourage rice farmer to increase their productivity by introducing the proper farming technique, new technological innovation, providing subsidize fertilizer and give funding to farmers. Second, by trying to lower the citizen's rice consumption through "one day a week without rice" campaign. However, these approaches were not a success yet as there is a mild increase in rice production, Indonesian citizen refuse to replace rice with other food products.

The devastating impact on global warming, deforestation, a forest fire has changed the climate in Indonesia which becomes the sensitive issues in crop production (Nurdin 2012). The Climate Laboratory in Bogor Agricultural Institute stated that during 1981-1990 every regency in Indonesia experienced a reduction in rice production annually of 100,000 tons. During the period of 1992-2000, this reduction in rice production averaged 300,000 tons per year (UNDP Indonesia 2007) three times the annual loss in a previous decade. Besides having an effect on agricultural sector especially plantation subsector, climate change also affecting food security. As rainfall decreases which escalate the drought risk and consequently lowering crop yield, food stock and community accessibility on food, climate change will speed up Indonesia's progress on poverty and food insecurity. Therefore, the Indonesian government has to take climate change challenge seriously by putting the climate adaptation into agenda and promote sustainability of land usage. Climate change will act as a multiplier of the existing threat toward food security. In 2050, the risk of poverty is projected to increase 10-20%, and malnutrition of children will be 20% higher compared to the absence of climate change. The key to reaching national food security under the climate change is to decrease the vulnerability of rice production, broaden the distribution of rice which leads to increase in food accessibility (WFP et al. 2009).

An alternative way to determine the climate change is by asking farmers directly (Adiyoga et al. 2012). However, farmers are mostly uneducated about the climate change, therefore their households are very vulnerable (Heltberg and Misha 2011). The farmers who tend the rice fields are currently confused about the irregularity of harvest yield. Thus, in order to survive the climate change, farmers need to be learned how to adapt and anticipate the current and future climate change effect especially in rice cultivation. Cultivation of organic rice has known to produce higher yields compare to non-organic rice cultivation method rice during harsh climate situation. Recently, the demand for organic rice product has also steady growth, because of the increasing awareness of healthy products. Farmers are shift gradually from the chemical-intensive conventional farming to the environment-friendly (organic rice) one. Therefore organic rice cultivation could be the solution in maintaining the food security of Indonesia.

Lampung Province is one of largest rice producer in Indonesia. However, global climate change may affect Lampung rainfall distribution which leads to significant loss in agricultural productivities in several areas in Lampung Province. Therefore, in order to decrease the loss in rice production, Lampung Province also produces organic rice. One of the regencies in Lampung which has produced certified organic rice is Tanggamus Regency. Tanggamus Regency experienced a change of climate type from D1 climate type (based on the data of rainfall during 1976-1990) according to Oldeman, climate type, changed into D2 climate type (based on the data of rainfall in 1991-2010) directing to hotter climate type. Based on the data of rainfall, Tanggamus Regency in June to September 2012 (rainfall average was 45 mm) which was far under the average of normal rainfall, indicating that there had been drought which resulting in the reduction in rice production to the worst. In order to determine the extents of climate change effect on organic rice farmers livelihood based on food security, this study aimed to analyze farmers' adaptation strategies to climate change in farming and in maintaining food security, (2) analyze the level of food security of farmers' household in rainy season and in dry season, and (3) analyze the factors affecting food security of farmers' households.

2 RESEARCH METHODS

2.1 Location, Respondents, and Research Period

Research location was chosen purposively in Pekon Tampang Tua, Pematang Sawa Sub-district, Tanggamus Regency, considering that the area is the central production of organic rice of rain-fed rice field, has a certificate on organic rice from Indofice and had experience drought in 2012.

Respondents were taken using census by taking all farmers who plant organic rice totaling 60 farmers in Pekon Tampang Tua, Pematang Sawa Sub-district. The research was carried out from February to July 2013.

2.2 Data Analysis

The data used in this research was primary data (cross section data) taken by using a direct interview with the respondents, with the help of questionnaire prepared before.

2.2.1 Analytical method of the first objective

To measure the first objective, it was used descriptive analysis by describing in detail the strategies of adaptation which had been taken by farmers in farming and in maintaining food security to anticipate climate change. The strategies which can be taken by farmers in farming were referred from the idea of Las (2007); Surmaini et al. (2011); Adiyoga et al. (2012); and Nurdin (2012).

2.2.2 Analytical Method of the Second Objective

The level of food security of household is measured by food security index based on the indicator of the definition of food security according to FAO (1996) and the law of Indonesian Republic No.7 year 1996, which has been used by Indonesian Center of population research (Nuhfil 2012). Food security is measured from four aspects which are food availability, food stability, food accessibility, and food quality, and further categorized in food security, less food security, and food insecurity

2.2.3 Analytical Method of the Third Objective

To measure the effect of climate change adaptation strategies of farmers in farming and food security, an ordinal logit model was used, then estimated with Maximum Likelihood Estimator (MLE) completed with the help of Stata 11 software. The equation of food security function used was as follow:

$$Pr\ (y_j = i) = \alpha_o + \beta_1 lnX_1 + \beta_2\ lnX_2 + \beta_3\ lnX_3 + \beta_4\ lnX_4 + \beta_5\ lnX_5 + \beta_6\ lnX_6 + \beta_7 lnX_7 + \beta_8\ lnX_8 + \beta_9\ lnX_9 + \beta_{10}\ lnX_{10} + \beta_{11}\ lnX_{11} + \beta_{12}\ lnX_{12} + \beta_{13}\ lnX_{13} + \lambda_1 D_1 + \mu \quad ....(1)$$

Note:

$Pr(y_j=i)$ = Probability of organic farmers' households food security level category, in which I = 1, 2, 3 (1 = food insecurity; 2 = low food security;3 = food security)
α = intercept
β = regression coefficient (predicted parameter) (i=1 to 13)
λ = dummy regression variable coefficient (predicted parameter) (i=1)
X1 = adaptation or anticipation strategies towards the effect of climate change in food security (number).
X2 = adaptation or anticipation strategies towards the effect of climate change in rice farming (number).
X3 = Head of household's education level (year)
X4 = number of family member (people)
X5 = rice price (rupiah/kg)
X6 = sugar price (rupiah/kg)
X7 = egg price (rupiah/kg)
X8 = frying oil price (rupiah/litter)
X9 = solid organic fertilizer price (rupiah/kg)
X10 = liquid organic fertilizer price (rupiah/litter)
X11 = rice seed price (rupiah/kg)
X12 = field width of farming (ha)
X13 = total household revenue (rupiah annually)
D1 = seasonal dummy variable (1 = rainy season; 0 = dry season)
μ = error term

According to Boroah, (2001) in general logit model can be formulated as follow:

$$Pr(X < x) = \Lambda(x) = \frac{Exp(x)}{1+exp(x)} = \frac{1}{1+exp(-x)} \quad \text{.. (2)}$$

The assumption used in ordered logistic model is that error term follows the logistic distribution. Therefore, as the KP having three categories then the equation above can be written into (Boroah, 2001):

$$Pr(y_i=1) = \Lambda(\delta_1 - Z_i) = \frac{1}{1+exp(Zi - d1)} \quad \text{.. (3)}$$

$$Pr(y_i=2) = \Lambda(\delta_2 - Z_i) - \Lambda(\delta_1 - Z_i) = \frac{1}{1+exp(Z_i - \delta_2)} - \frac{1}{1+exp(Zi - d1)} \quad \text{................................ (4)}$$

$$Pr(y_i=3) = 1 - \Lambda(\delta_2 - Z_i) = 1 - \frac{1}{1+exp(Zi - d2)} \quad \text{.. (5)}$$

Note:

Y = Food security (food security of households)

Z_i = $^{Z}{}_{k=1}\beta k.X_{ik}$ (equation of log estimation result)

δ_1 = lower threshold

δ_2 = upper threshold

The marginal effect for independent variable continues from the calculation above is:

$$\frac{\partial Pr(Yi=1)}{\partial Xik} = \frac{d}{dZi}[\Lambda(\delta_1 - Z_i].\frac{\partial Zi}{\partial Xik} = \Lambda'((\delta_1 - Z_i).B_k = \Lambda(\delta_1 - Z_i).[1- \Lambda'((\delta_1 - Z_i).B_k] \quad \text{.......... (6)}$$

$$\frac{\partial Pr(Yi=2)}{\partial Xik} = \frac{d}{dZi}[\Lambda(\delta_2 - Zi) - \Lambda(\delta_1 - Zi)].\frac{\partial Zi}{\partial Xik} = [\Lambda'((\delta_1 - Z_i) - \Lambda'(\delta_1 - Z_i)].B_k = \{\{\Lambda(\delta_2 - Z_i).$$

$$[1-\Lambda(\delta_1 - Z_i)]\} - \{\Lambda(\delta_1 - Z_i).[1- [1-\Lambda(\delta_1 - Z_i)]\}B_k \quad \text{.. (7)}$$

$$\frac{\partial Pr(Yi=3)}{\partial Xik} = \frac{d}{dZi}[1 - \Lambda(\delta_2 - Zi)] = \Lambda'(\delta_2 - Z_i).B_k = \Lambda(\delta_2 - Z_i).[1-\Lambda(\delta_1 - Z_i)]B_k \quad \text{............(8)}$$

Subsequently, the marginal effect for independent dummy variable is the difference between $Z_i^1 - Z_i^0 = B_k$, (because $Z_i^1 = Z_i^0 + B_k$) .... (9)

3 RESULT AND DISCUSSION

3.1 The Strategies of Adaptation and Anticipation of Farmers on the Effect of Climate Change in Rice Farming.

Research result concluded that from 27 options of adaptation strategies asked to anticipate the effect of climate change in rice farming, most of the farmers assumed 3 to 15 strategies of adaptation which is relevant or applicable in organic rice farming. But, the average of strategies of adaptation which had been applied by farmers was 10 strategies, comprising of: (1) better and thorough seeds/seedling preparation, (2) using of organic pesticides, (3) using of organic compost, (4) recommending the planting space, (5) changing or adjust the planting time, (6) postharvest management by minimizing the loss of crop, (7) making dams, (8) increasing wedding intensity, (9) using early ripened variety (to shortened planting period), and (10) making trenches (table 1). Unfortunately, these strategies used by farmers were more short term strategies in anticipating the climate change effect (Nurdin 2012).

3.2 Strategies of Adaptation of Farmers for the Effect of Climate Change in Food Security

The result showed that only 5 to 6 strategies were chosen as a most suitable strategy to maintain food security during climate change, with average strategies used by organic farmers was 5 strategies (Table 1).

Table 1. Distribution of farmers based on farmers' adaptation strategies to climate change in farming and food security.

Average of farmers 'adaptation strategies to climate change in farming	Number of farmers	%	Average of farmers 'adaptation strategies to climate change in food security	number of Farmer	%
3—7	8	13,33	1—2	16	26,67
8—11	36	60	3—4	28	46,67
12—15	16	26,67	5—6	16	26,66
Average = 10	60	100	Average = 5	60	100

Source: Primary Data source, Indonesian central bureau of statistics (BPS) 2013

The strategies which had been taken by farmers comprised of (1) preparing food stock, (2) borrowing food product from farmers' community or middleman seller in the village if there was lack of food, (3) carry out planting, farming and fishery diversification, (4) revenue diversification (on-farm and off-farm jobs), such as motorcycle taxi driver, labor, fisherman, or making furniture, and (5) empowering other family member to gain additional income.

3.3 The Level of Food Security of Households

The analysis result of the level of food security of households of organic rice farmers in the rainy season (RS) and in the dry season (DS) in Tanggamus according to the definition of FAO and Law of Indonesian Republic No. 7 the year 1996 is presented in Table 2.

Table 2. Level of food security of organic rice farmers households in rainy season and dry season in Tanggamus Regency, Lampung Province

No	Description	Organic Rice Farmers (%)	
		Rainy season	Dry season
1	Food Stock		
	-Stock ≥ 180 days	88.33	76.00
	-Stock 1-179 days	11.67	16.00
	-No stock	0.00	8.00
2	Food stability		
	-Stable	88.33	76.00
	-Less stable	11.67	16.00
	-Instable	0.00	8.00
3	Accessibility		
	-direct	86.67	86.00

	-indirect	13.33	14.00
4	Continuity		
	-Continue	73.33	66.00
	-Less continue	26.67	26.00
	-Discontinue	0.00	8.00
5	Stage of Food Security		
	-Food security	60.00	48.00
	-Low Food security	31.67	38.00
	-Food insecurity	8.33	14.00

Based on Table 2, it was found out that the percentage of organic rice farmers' households in rainy season which have adequate food stock, stable food supply, direct food access, and continuity of food supply was higher compared to the dry season. In the dry season, most farmers experienced harvest loss as a result of drought (climate change), which reduce the food stock. Based on the indicator of food stock, food stability, food accessibility, and continuity of food supply, most organic farmers' households in Tanggamus were fall into having food security (>48%). Table 2 indicated that less than 14% of households were having food insecurity, the rice in these type of households, did not come from their own field, but from the co-owned field, therefore, the yield of rice production was shared. In order to fulfill the stock, the insecure households bought rice from the market until the next planting season.

3.4 Factors Affecting the Level of Food Security of Households

To determine factors affecting the food security of farmers' households, ordinal logit regression Analysis was used. In Ordinal Logit, there should be categorization on the level of food security, according to the definition of FAO (1996) and Law of Indonesian Republic No. 7 (1996) food security category was divided to (3), low food security (2), and food insecurity (1). The analysis result of factors affecting the food security of organic rice farmers' households is presented in Table 3.

Based on the result of the analysis in Table 3, it was found out that the model used had Pseudo-value R^2 of 0.4877. This means that the independent variable used in the model was able to explain around 48.77% of food security level, and the rest, 51.23% was explained by other variables which were not included in the model. The goodness of Fit was shown from the value of counted-LR X^2 of 102.33 and significant in the deviation level of 1% with the probability Chi-Square of 0.000 < 0.01, meaning that the independent variables together affected significantly on the choosing of variety so that this model can be said as a good model. The significant estimation coefficient (independent variable) was 10 of 14 variables predicted. The distributions of the categories of food security level were shown by the value of cut off or limit (Table 3).

Table 3. Analysis Result of factors affecting the level of food security of organic rice farmers' Tanggamus Regency

Variable	Coefficient	Std.Error	Z-Statistic	Prob.	OR
Cutt off/Limit 1	-134.4738				
Cutt off/Limit 2	-130.2674				
Food security Adapt.Strategy	1.877617***	0.622658	3.02	0.003	6.537906
Farming Adapt. Strategy	0.816312ns	0.820767	0.99	0.320	2.262142
Farmer education	1.569666**	0.677878	2.32	0.021	4.805045
Family	-2.144298**	0.871444	-2.46	0.014	0.117150
Rice Price	2.949328**	1.372294	2.15	0.032	19.093130
Sugar Price	-3.718546ns	2.946421	-1.26	0.207	0.024269
Eeg Price	-2.929949ns	3.043346	-0.96	0.336	0.053399
Oil Price	-8.209498ns	6.608135	-1.24	0.214	0.000272
Solid organic fertilizer price	-2.040572***	0.662700	-3.08	0.002	0.129954
Liquid organic fertilizer price	-1.038837*	0.618837	-1.68	0.093	0.353866
Land area	1.333934***	0.398100	3.35	0.001	3.795948
Rice Seed price	0.793306ns	0.674305	1.18	0.239	2.210693
Income	-0.055852ns	0.045094	-1.24	0.216	0.945679
Seasonal Dummy Variable	1.741142***	0.586372	2.97	0.003	5.703854
LR index (Pseudo-R2)	0.4586				
LR statistic (14df)	96.21***				
Prob (LR stat)	0.000				

Based on the result of estimation of Ordinal Logit Model (Table 3), it could be seen that there were 2 categories of odds percentage. They are (a) positive odds percentage, meaning that each increase of independent variable of 1 unit caused the increase of odds or probability of food security level. Positive odds percentage comprised of variables strategies of adaptation or anticipation of farmers for the climate change in food security, head of household education level, the price of rice, farmland area, and season dummy variable. Rice price was a variable whose effect was not appropriate with the theory. It should have a negative effect toward food security, but in this research, rice price had a positive effect on food security. This was because rice consumed was own cultivation product (not bought). Rice product beside for consumption, was also sold to buy other food products, therefore the increase of rice price will increase food security of households. (b) The percentage of negative odds meant that each increase of independent of 1 unit would cause the reduction of odds or probability of food security. The negative of odds percentage was a number of family member, solid organic fertilizer price, and liquid organic fertilizer price variables.

The analysis of marginal effect used to find out the marginal effect of the determining factors (significant factors) toward the occurrence probability of food security level (DKP). The result of analysis of marginal effect was presented in Table 3. Table 3 showed that each strategy of adaptation and anticipation of farmers on climate change in food security were 1 strategy. Thus, it would increase the probability of the occurrence of food security (DKP=3) of organic rice farmers' household of 46.75% at the same time will reduce the occurrence probability of low food security (DKP=2) of 44.35%, and food insecurity (DKP=1) of 2.40%.

Table 4. Result of analysis of marginal effect of ordinal logit of factors affecting the level of the organic rice farmers' households in Tanggamus Regency

Variable	Pr(DKP= 3)	Pr (DKP= 2)	Pr (DKP=1)
Food adaptation strategy.***	0.4675309	-0.4435144	-0.0240165
Head of household education level **	0.3908505	-0.370773	-0.0200775
The number of family member.**	-0.5339351	0.5065075	0.0274276
Rice price**	0.7343894	-0.6966647	-0.0377247
Solid organic fertilizer price ***	-0.508107	0.4820062	0.0261008
Liquid organic fertilizer price *	-0.2586727	0.245385	0.0132877
Land price ***	0.3321526	-0.3150904	-0.0170623
Seasonal dummy Variable ***	0.4095378	-0.3826285	-0.0269093

Note: *** = dominant effect, ** = marginal effect, * = low effect,

Subsequently, Table 4 also showed that each increase head of household education level of 1 year, would increase the probability of food security occurrence (DKP=3) in organic rice farmers' households of 39.08%, reduce the probability of lack of food security (DKP=2) of 37.08%, reduce the probability of household who have food insecurity (DKP=1) of 2.01%. The increase in farmers' education level, would increase the farmers' knowledge and master the agricultural technology in organic rice farming, which helps increase the capacity of rice production. The gain in productivity would increase the food stock which leads to food security. The result showed that increase of rice price by 1 rupiah would escalate the probability of food security (DKP=2) by 73.44%, reduce the probability of lack of food security (DKP=2) by 69.67%, and reduce the probability of does not have food security (DKP=1) of 37.72%).

Based on the result of the survey, rice was the staple food products which was regularly consumed by households in the research area. Usually, farmers will save the rice first for food stock as seen in food availability of farmers' households in rain-fed rice field in Tanggamus Regency which was included into the category of having adequate stock (88.33%) stock $\geq$ 6 months/$\geq$ 180 days) and lack of stock of 11.67% (stock 1-179 days). If there an excess in crop production, rice will be sold for other needs. The percentage of households selling their harvest was 85.0%. Those which did not sell their harvest were 13.33%. Meanwhile, a farmer who bought food because the lack of food stock was only 1 household (1.67%). With the increase of rice price, thus farmers would be motivated in organic farming so that it would increase the productivity of rice. With the increase of productivity, thus in would increase food stock in households, which finally would increase food security of those households.

Subsequently, the result of the analysis showed that each increase of solid organic fertilizer price of 1 rupiah would reduce the probability of food security (DKP=3) of households of organic rice farmers of 50.81%, in which at the same time it would increase the probability of lack of food security (DKP=2) of 48.20% and increase the probability of does not have food security (DKP=1) of 2.61%. Solid organic fertilizer was an input used significantly by almost all organic rice farmers. The increase of solid organic fertilizer price would cause the reduction of the use of solid organic fertilizer in organic rice farming. Such a condition would cause the reduction of productivity so that it would cause the reduction of feedstock and would cause the reduction of food security of farmers' households.

The result of the analysis also showed that each increase of liquid organic fertilizer price of 1 rupiah would reduce the probability of food security (DKP=3) of organic rice farmers' households of 25.88%, in which at the same time it would increase the probability of lack of food security (DKP=2) of 24.54%, and increase the probability of does not have food security (DKP=1) of 1.33%.

The result of analysis in Table 4 also showed that each increase of field price of 1 hectare would increase the probability of the food security occurrence (DKP=3) of organic rice farmers' households of 33.22%, in which at the same time it would reduce the probability of lack of food security (DKP=2) of 31.51% and reduce the probability of does not have food security (DKP=1) of 1.71%. The increase of field price of rice farming would increase the number of rice production result owned by households so that it would increase their food stock, which finally would increase their household's food security.

Subsequently, the result of the analysis also showed that season dummy variable (rainy season = 1, and dry season = 0) had a positive marginal effect toward the probability of farmers' households food security. This meant that in the rainy season the probability of an increase of food security in organic rice farmers' households was higher than farmers' households in the dry season.

4 CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions

The farmer's adaptation strategies for climate change in farming applied by farmers were 10 strategies. Meanwhile, the farmer's adaptation strategies for climate change in food security applied by farmers were 5 strategies. Organic rice farmer's households had more food security in the rainy season than in dry season. The head of the household's education level, rice price, farmland area, and planting season had a positive effect on the food security of rain-fed organic rice farmers household. Meanwhile, the number of family member, solid organic fertilizer price, and liquid organic fertilizer price had a negative effect. The rice price variable had the highest influence to increase food security of households of rain-fed organic rice farmers in Tanggamus Regency.

4.2 Suggestions

The strategies of adaptation of farmers on climate change in maintaining food security is a factor which supporting food security of farmer's household. Therefore, the households should continually apply the strategies which include; increase the amount of food stock, increase the business diversity into livestock and fishery, and carrying out diversification of plants in order to add revenue for the family. For the government, it should help to develop a productive business based on a local resource in sea fishery, plantation, and livestock.

Rice price is a very important in supporting food security of households. Therefore, the government should formulate policy to stabilize the price of rice and help to facilitate the marketing of organic rice and increase the price of organic rice to motivate farmers in organic rice farming which an environment-friendly farming method and helps the farmer to survive in harsh climate change effect.

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