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The Effect of Adaptation to Climate Change on Rice Production in the Watershed Region of Cemoro, Central Java, Indonesia.

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Abstract

The effect of climate change is being felt by all sectors of life. In the agricultural sector, the effect of climate change is felt most strongly in the production of food crops. In general, farmers have made adaptations to deal with climate change. In connection with this, this research study investigates the adaptations to climate change made by farmers. The location of the research is the watershed region of Cemoro in Central Java, Indonesia, using a sample of 120 farmers of irrigated rice fields and 120 farmers of rainfed rice fields. The goal of the research is to discover a model for adaptation to climate change that can be used by farmers, and also to look at the risks farmers face when they make adaptations to climate change and the factors affecting these risks.

The results of the research show that most farmers make adaptations to climate change by altering the varieties of rice that they plant. Other forms of adaptation include the use of water pumps, adjustment of planting time, use of organic fertilizer, use of natural pesticide, and change in cropping patterns. The land productivity of farmers who make adaptations to climate change is higher than those who do not make adaptations. Farmers who do not make adaptations to climate change experience a higher risk of crop failure. The factors which affect the risk of crop failure due to climate change are level of education, farming experience, income level, type of rice field, educational activities related to farming, number of family members, size of land, and number of livestock owned.

Keywords: Adaptation, climate change, productivity, risk, rice.

INTRODUCTION

Climate change refers to any change in climate which occurs over a specified period of time, either as a result of natural variations or human activities (anthropogenic causes) (IPCC, 2001). In general, climate change is marked by changes in temperature, changes in patterns of rainfall, and a rise in sea level. The impact of climate change is felt by all sectors of life. According to the United Nations Development Program (UNDP), the effects of climate change in Indonesia will exacerbate the climate problems that already exist. It is estimated that poor communities will be the ones that suffer most from the effects of climate change, and this includes farmers, fishing and coastal communities, and poor communities living in urban areas (UNDP, 2007). Since the agricultural sector is highly dependent upon climate, farmers will feel the effects of climate change most strongly (Li et al., 2010). At present, many farmers are encountering difficulties in deciding when the right time is for planting, or are experiencing crop failure due to erratic rainfall or prolonged drought (Naylor et al., 2007). On a macro level, crop failure will disturb the national food security program.

In general, agricultural activities are highly sensitive to variations in climate change. The climate changes that are taking place on a global levelare causing changes in the patterns and distribution of rainfall. As a result of the changes in patterns and distribution of rainfall, there has been a shift in seasons which has affected when the season starts and when the suitable time for planting is. Results of a study by Runtunuwu and Syahbudin (2007) show that a decrease in rainfall may cause a reduction in the potential length of a period for rice planting. These findings provide evidence that climate change may reduce both production and productivity in the farming sector. The decline in production and productivity of rice will of course have a negative impact on food security.

Uncertain weather conditions mean that crops do not grow properly. It is a well-known fact that air temperature can interfere with the growth of crops and lead to a decrease in production (Furuya and Koyama, 2005, Smit and Skinner, 2002). Lars (2007) states that an increase in temperature causes an increase in transpiration which in turn reduces the productivity of food crops. The results of a study by Peng et al (2004) reveal that for every 1^0 C increase in temperature, there will be a reduction in crop production of up to 10 percent. Temperature changes may also cause the emergence of new pests and diseases which cannot been predicted beforehand (Wiyono, 2007). These attacks by pests and diseases will of course cause a further decrease in crop production (Chakraburty, S., and Newton A.C., 2011).

Estimations by the World Bank state that in the long term, climate change will cause a reduction in soil fertility of between 2 and 8 percent. The subsequent effect of this will be a decrease in the annual production of rice, to the amount of 4 percent, a 10 percent decrease in soybean production, and a 50 decrease in corn production (PEACE, 2007). Ultimately, this will of course have a negative effect on food security, both on a micro and macro level (Edame et al., 2011). For Indonesia, the negative effect that climate change is having on the agricultural sector in general will

disrupt the national economy. This is due to the fact that the agricultural sector still provides a large contribution for the national economy. In addition to providing a source of living for the Indonesian people, the agricultural sector also provides the raw materials for various other sectors. As the managers of farming enterprises, farmers are essentially one of the groups that feels the greatest impact of climate change. Farmers have already made efforts to make adaptations to climate change by anticipating the negative effects that these climate changes will cause. If they fail to make adaptations, climate change will lead to even greater losses (Gbetibouo, 2009). Due to their limited resources, farmers place more importance on using local technology when making their adaptations. Of course the farmers also take into consideration the advantages and disadvantages of choosing to use this local technology for their adaptations. Social, economic, and environmental factors are all taken into consideration by the farmers when choosing their strategies for adapting to climate change (Dhaka et al., 2010).

The habits of the farmers living in the sub-watershed region of Cemoro, in the watershed region of the Solo River are an indication that they have their own special way of ensuring the continued success of their farming enterprises in spite of the effects of climate change. The farmers of course make various adaptations to deal with the effects that climate change is having on their farming enterprises, in accordance with the local conditions that they encounter. As the managers of their own farming enterprises, the farmers constantly strive to make adjustments to their enterprises to deal with the effects of climate change. These adjustments are a reflection of their adaptation to climate change. The adaptations carried out by the farmers are intended to ensure a continued level of production wherever possible, or at least to minimize the possibility of loss due to climate change. Therefore, production can be used as an indicator of a farmer's success in making adaptations to climate change. When a farmer is able to sustain the previous level of production or minimize losses by making adaptations, it can be said that the farmer has succeeded in making adaptations.

RESEARCH METHOD

The research was carried out in the watershed region of Cemoro which is a sub-watershed region of the upstream watershed region of the Solo River. In administrative terms, the watershed region of Cemoro passes through parts of the districts of Semarang, Boyolali, Karanganyar and Sragen. The upstream watershed region of Cemoro is in the west and passes through the districts of Semarang and Boyolali. The downstream region passes through the administrative districts of Sragen and Karanganyar.

The research population for this study includes all of the farmers who have rice farming enterprises in the watershed region of Cemoro. The number of samples taken for this research was 120 farmers who cultivate irrigated rice fields and 120 farmers who cultivaterainfed rice fields. The sampling was made with attention to the agro-ecological characteristics of the upstream, middle, and downstream areas of the

watershed region. The selection of farmers in each of these agro-ecological areas was made according to random proportional sampling based on the area of the irrigated rice fields and rainfed rice fields.

The data analysis uses a unidirectional and/or bidirectional transverse table in order to represent the distribution of farmers who have or have not made adaptations to climate change. In order to discover the factors which affect the risks in making adaptations to the environment, a multiple linear regression analysis is used.

RESULTS AND DISCUSSION

A. Adaptation to Climate Change

Essentially, adaptation in this context refers to the act of adapting or making adjustments to a farmer's business in order to reduce the risk of crop failure as a result of climate change. The actions taken are of course based on the ability and the resources of the farmer. The results of the interviews carried out with the farmers, who acted as respondentsfor the research, show that the adaptations that have been made to deal with climate change include adjusting planting times, using new varieties of rice, changing cropping patterns, using organic fertilizers, using natural pesticides, and using water pumps to provide water for irrigation. The results of the analysis of the data about the kinds of adaptation made by the farmers to deal with climate change can be seen in Table 1.

The most common kind of adaptation made by the farmers to deal with climate change is to use new varieties of rice that have the ability to withstand extreme climates. A total of 90.8 percent of the farmers already use new varieties that are able to withstand climate change. Another form of adaptation that is frequently made is the use of water pumps to syphon water from wells or rivers. Farmers in general frequently make use of water pumps during times when their crops need watering in order to grow properly but there is insufficient rainfall. The number of farmers who claim to use water pumps is 54.6 percent of the respondents interviewed. Another form of adaptation carried out by farmers is to adjust their planting times. As many as 37.5 percent of the farmers said that they adjust their planting times in order to adapt to the climate changes taking place. Other forms of adaptation described by the farmers include altering cropping patterns (10 percent), using natural pesticides (20 percent), and using organic fertilizers (25 percent).

Table 1. Forms of Adaptation used by Farmers in the Watershed Region of Cemoro, Central Java, to Deal with Climate Change

No	Form of Adaptation	Number (%)	
		Implemented	Not Implemented
1	Adjusting planting times	37.5	62.2
2	Planting new varieties	90.8	9.2
3	Altering cropping patterns	10.0	90.0
4	Using organic fertilizers	25.0	75.0
5	Using natural pesticides	20.0	80.0
6	Using water pumps	54.6	45.4

Source: Primary Data Analysis, 2013

By observing the data in Table 1, it can be seen that almost all farmers use new varieties of rice as a form of adaptation. However, if a farmer only uses a new variety of rice without making any changes in other areas, it can be said that the farmer still has shortcomings in the adaptations he has made. A farmer can be said to be carrying out adaptations to climate change if he implements at least two forms of adaptation and one of them is the use of a new variety of rice which is tolerant to climate change.

B. Risks of Climate Change

As mentioned earlier, the effects of climate change are felt by all sectors of life. As managers of farming enterprises, farmers also feel the effects that occur as a result of climate change. Both farmers who make adaptations and those who do not make adaptations will experience the effects of climate change. The effects experienced by farmers include a decrease in production or even crop failure. Reduced production or crop failure are risks that all farmers must face.

It is hoped that farmers who make adaptations to deal with climate change will manage to reduce their risk of a decrease in production or crop failure. The results of the analysis about the size of the risk experienced by the respondents in this study due to climate change can be seen in Table 2. By observing the data in Table 2 it can be seen that there is a difference in levels of productivity between irrigated rice fields and rainfed rice fields. Irrigated rice fields show a higher level of productivity than rainfed rice fields. This is not surprising considering that irrigated rice fields have a relatively adequate supply of water to ensure proper growth. It is interesting to compare the productivity of land among farmers who make adaptations and those who do not.

Farmers who make adaptations to deal with climate change can be seen to experience a higher level of land productivity in their rice fields compared with farmers who make no adaptations. This true for both irrigated and rainfed rice fields. On irrigated rice fields, land productivity is 5.107 ton/ha for farmers who make adaptations to climate change and 4.828 ton/ha for those who do not make adaptations. Productivity on rainfed rice fields is 3.657 ton/ha for farmers who make adaptations to climate change and 3.317 ton/ha for those who do not make adaptations. This data shows that failing to make adaptations will lead to a decrease in land productivity.

The effects of climate change will be felt on both types of rice field, whether or not the farmer makes adaptations. Climate change will lead to a decrease in land productivity. This decrease in land productivity is a risk the farmers must face. Based on the data in Table 2, it can be seen that on average the risk of a decrease in land productivity is greater in rice fields on which farmers have not made adaptations to climate change. On average, farmers who work on irrigated rice fields and make adaptations are at risk of experiencing a 15 percent decrease in productivity, while those who do not make adaptations on average experience a 21 percent decrease in productivity. In the case of rainfedrice fields, farmers who make adaptations on average experience a 27 percent decrease in productivity, while those who do not make adaptations on average experience a decrease in productivity of 32 percent. Overall, in the watershed region of Cemoro, the decrease in land productivity of rice fields due to climate change is 21 percent for farmers who make adaptations to climate change and 27 percent for farmers who do not make adaptations. Thus, the difference in the decrease in productivity between farmers who make adaptations and those who do not is between 5 and 6 percent (Sugihardjo,2015) .

Table 2. Effects of Climate Change on Rice Productivity and Risk of Crop Failure in the Watershed Region of Cemoro

No	Type of Rice Field	Productivity (ton/ha)	Risk of Decreased Production (%)
1	Irrigated Rice Field		
	With Adaptation	5.107	15
	No Adaptation	4.828	21
2	Rainfed Rice Field		
	With Adaptation	3.657	27
	No Adaptation	3.317	32
3	Irrigated and Rainfed Rice Fields		
	With Adaptation	4.382	21
	No Adaptation	4.073	27

Source: Primary Data Analysis, 2013

Theoretically, the risk of a decrease in productivity is affected by the capacity of the farmers, sensitivity, and exposure of the land. Capacity is measured in terms of the level of education, farming experience, and income of the farmer. Sensitivity is measured according to the type of rice field cultivated by the farmer, educational activities related to farming, number of family members, and access to information about weather. Exposure is measured according to the size of the land and the number of livestock owned. The formula for measuring the factors which affect risk due to climate change can be written as follows:

$$R = B_0 + B_1 EDU + B_2 ART + B3 LUT + B_4 TERNAK + B_5 EXPE + B_6 L\_RE + B_7 SULUH + B_8 CUACA + B_9 JENISLAHAn$$

The results of the analysis of the factors which affect the risk of a decrease in land productivity can be seen in Table 3.

The results of the multiple regression analysis, as seen in Table 3, show that of the nine variables that are estimated to affect the risk of a decrease in land productivity due to climate change, only one is seen to have an insignificant effect. Access to information about weather is the variable which is not significant. All the other variables, including level of education, farming experience, income, type of land, number of family members, size of land, educational activities related to farming, and number of livestock owned, all show a significant effect at a confidence level of 95 percent.

Level of education, farming experience, and income, which are the components of capacity for adaptation, are shown to have a significant effect on the risk of making adaptations to climate change. Level of education and farming experience have a negative effect on the risk of a decrease in land productivity. The lower the level of education and the less experienced the farmer, the greater the risk of a decrease in land productivity. Income level, on the other hand, has a positive effect on the risk of a decrease in land productivity. The higher the farmer's income level, the greater the risk of a decrease in land productivity. This is due to the fact that farmers with a high income generally own a larger area of land which means that their risk also increases.

Of the four variables which reflect level of sensitivity, three of the variables have a significant effect and one variable shows an insignificant effect. The type of land, educational activities related to farming, and number of family members all show a significant effect at a confidence level of 95 percent. Information about weather, meanwhile is seen to have an insignificant effect. Type of rice field has a positive effect on the risk of a decrease in land productivity. The greater the proportion of rainfed rice fields that is cultivated, the greater the risk of a decrease in land productivity. On the contrary, the smaller the proportion of rainfed rice fields that is cultivated, the lower the risk of a decrease in land production. The number of family members has a negative effect on the risk of a decrease in land productivity. The

greater the number of family members of the farmer, the smaller the risk of a decrease in land productivity.

Table 3. Results of Analysis of Factors which Affect the Risk of a Decrease in Land Productivity

No	Name of Variable	Symbol	Coefficient	Probability
1	Constant	C	-2818.091	0.0706
2	Education	EDU	-44.165*	0.0359
3	Farming experience	EXPE	-18.604**	0.0067
4	Income	LN_REV	236.115*	0.0160
5	Type of rice field	JENISLAHAN	1048.920**	0.0000
7	Educational activities	SULUH	496.118**	0.0030
6	Information about weather	CUACA	-217.480	0.3443
7	Family members	ART	-118.838*	0.0318
8	Size of land	LUT	1392.857**	0.0000
9	Number of livestock owned	TERNAK	129.198**	0.0009

Note: ** : significant at a confidence level of 99 percent

* : significant at a confidence level of 95 percent

R^2 : 0.329

The two variables which reflect exposure, namely size of land and number of livestock owned, have a significant effect on the risk of a decrease in land productivity, at a confidence level of 95 percent. The size of land has a positive effect on the risk of a decrease in land productivity. Therefore, the larger the area of land cultivated, the greater the risk of a decrease in land productivity. Similarly, the number of livestock owned also has a positive effect, meaning that the more livestock a farmer owns, the greater the risk of a decrease in land productivity.

CONCLUSION

Farmers have already begun to make adaptations to deal with the effects of climate change. The use of new varieties of rice which are able to withstand flooding or drought is the most common form of adaptation made by farmers in the watershed

region of Cemoro. Other forms of adaptation include the use of water pumps, adjusting planting times, using organic fertilizers, using natural pesticides, and altering cropping patterns.

Farmers who make adaptations to deal with climate change have a lower risk of experiencing a decrease in land productivity compared with farmers who do not make adaptations. The factors which affect the risk of a decrease in productivity are level of education, farming experience, income, type of rice field, educational activities related to farming, number of family members, size of land, and number of livestock owned. Information about weather, meanwhile, is the one variable which is seen to have an insignificant effect.

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