

Dynamic models of farmers adaptation to climate change (case of rice farmers in Cemoro Watershed, Central Java, Indonesia)

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Abstract. Farming activities are generally very sensitive to climate change variations. Global climate change will result in changes of patterns and distribution of rainfall. The impact of changing patterns and distribution of rainfall is the occurrence of early season shifts and periods of planting. Therefore, farmers need to adapt to the occurrence of climate change to avoid the decrease productivity on the farm land. This study aims to examine the impacts of climate change adaptation that farmers practiced on the farming productivity. The analysis is conducted dynamically using the Powersim 2.5. The result of analysis shows that the use of Planting Calendar and Integrated Crops Management technology can increase the rice productivity of certain area unity. Both technologies are the alternatives for farmers to adapt to climate change. Both farmers who adapt to climate change and do not adapt to climate change, experience an increase in rice production, time after time. However, farmers who adapt to climate change, increase their production faster than farmers who do not adapt to climate change. The use of the Planting Calendar and Integrated Crops Management strategy together as a farmers' adaptation strategy is able to increase production compared to non-adaptive farmers.

1. Introduction

Farming activities is generally very sensitive to the vary of climate change. Agriculture sector is very affected with the existence of climate change [1]. The indicators of climate change phenomenon are the rising of temperature and uncertainty of rainfall which affects to the shift of early season and planting period. This will cause the lower productivity of land followed by disturbance of food security [2]. Some countries will face food insecurity caused by climate change [3]. Thus, farmers need to adapt to climate change phenomenon to avoid lower productivity on their farming land.

Adaptation is basically an adjustment conducted to human or natural system in reacting the impact of climate change that is being or going to occur. Adaptation against climate change may consider a responds against climate change phenomenon [4]. Meanwhile, for farmers, adaptation means to maintain income or at least to minimize loss possibility emerged due to the climate change. Thus, income may become an indicator of farmers' success in adapting against the climate change. Without adapting, climate change will cause bigger loss [5]. Farmers who able to remain their income or minimize their loss by conducting adaptation, it is said that they are success adapting.

Farmers at the Cemoro watershed of Bengawan Solo River, have particular customs and ways to maintain their success in farming, against the climate change effects. Farmers have conducted



adaptation due to climate change effects to their farming land, according to the local condition they have experienced. Analysis related to the forms of farmers' adaptation against climate change, should be conducted to gain best adaptation model for farmers' profit.

2. Methods

This research is conducted at Cemoro watershed in Central Java, Indonesia. It includes parts of Semarang regency, Boyolali regency, Karanganyar regency and Sragen regency. This study is addressed for farmers with rice farming.

The organization of adaptation model by farmers against climate change, uses a dynamic model with support of Powersim 2.5. Dynamic model is a picture of complex system that strived for describing system with good output. There are three steps in organizing dynamic model:

- a. First step is to arrange the black box, that shows relation between input, process and output.
- b. Second stage is to arrange the causal relation between variables that are related to the farmers' adaptation to face the climate change phenomenon.
- c. Third step is to arrange dynamic model of farmers' adaptation against the climate change.

3. Result and Discussion

Observation at the research area shows two strategies applied by the farmers in adapting to climate change. They are Planting Calendar utilization and Integrated Crops Management utilization. It is according to the study conducted by [6]. Planting Calendar is basically giving information related to the area's potential wide to the upcoming planting season: Planting Season I, Planting Season II, or Planting Season III. Integrated Crops Management is an effort to increase farmers' productivity and income, through land management, water, plant, organism and pest in integrated and continued way.

Both strategies applied by the farmers are form of adaptation, noticing balance and harmonious relation between components that support farming. Scenario of farmers' adaptation in facing climate change is formulated based on the strategies applied by the farmers. Scenario of farmers' adaptation model against climate change is seen on Table 1.

Table 1. Scenario of farmers' adaptation in facing climate change at Cemoro Watershed in Central Java, Indonesia

Scenario	Applied Technology	Description
Scenario 1	Not practicing adaptation	Average wide of land owned
Scenario 2	Practicing Planting Calendar and Integrated Crops Management	by farmers 0.35 ha of irrigation rice field and 0.36
Scenario 3	Practicing only Planting Calendar	ha of rain-fed rice field
Scenario 4	Practicing only Integrated Crops Management	

Scenario 1 is a model in condition that farmers do not adapt to the climate change phenomenon. Scenario 2 is a model in condition that farmers adapt to climate change by applying both Planting Calendar and Integrated Crops Management. Scenario 3 is a model in condition that farmers adapt only the Planting Calendar to their farming activities. Meanwhile, scenario 4 is a model in condition that farmers adapt only Integrated Crops Management as an adaptation against climate change.

Black box may be formulated by paying attention to the arranged scenario, as a foundation to formulate dynamic model of farmers' adaptation in facing climate change. Black box shows several indicators that describe relation between input, process and output. Adaptation process to climate change is meant to gain expected output and to avoid unexpected output. The expected output for farmers means improvement in production and income. Meanwhile, the unexpected output is decline in production and income. Adaptation process may run well by keeping attention to existed-input. There are three inputs that influence adaptation process, such as controllable input, uncontrollable input and policy input. Amongst three, controllable input is the only input that might be adjusted

according to the willing of how adaptation be processed. Uncontrollable and policy variables have 'given' character. Black box shows relation between input, process and output, as seen on Figure 1. Meanwhile, diagram of causality related to the adaptation against climate change is shown on Figure 2.

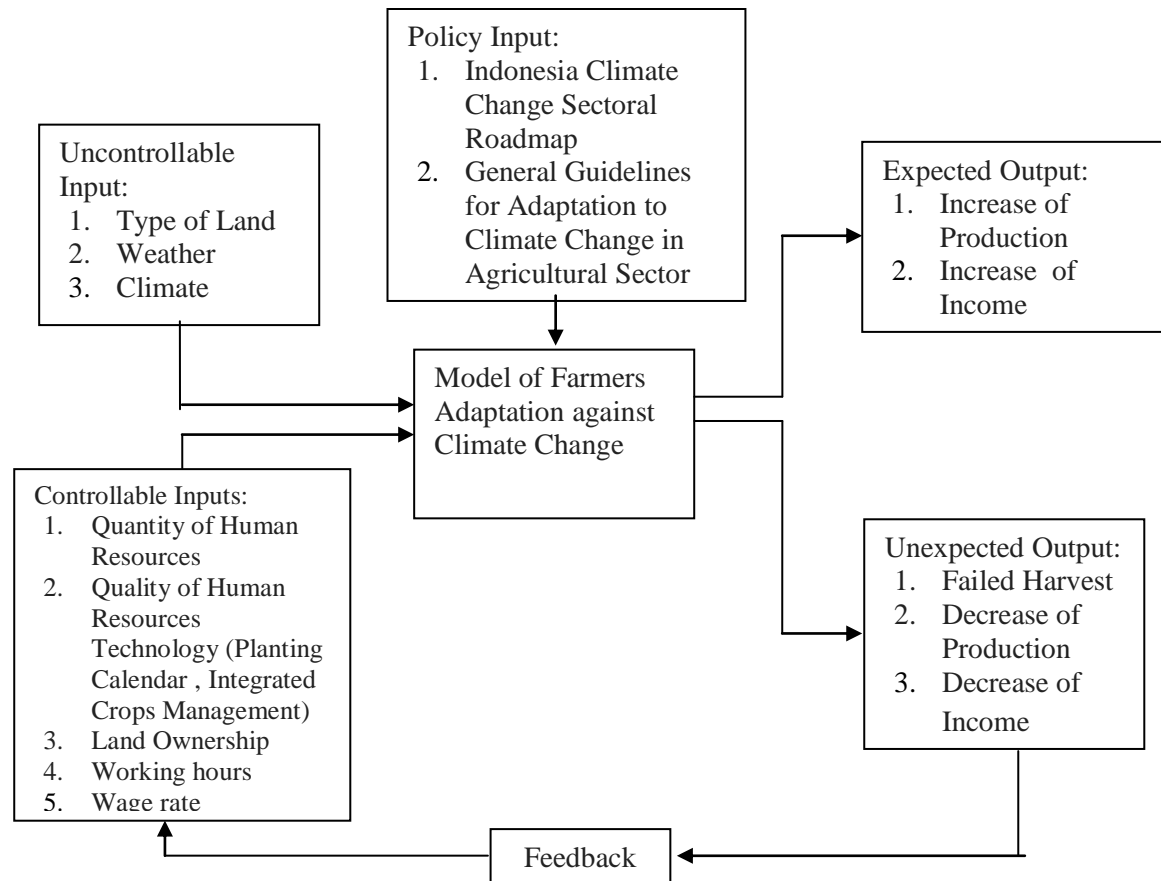


Figure 1. *Black Box of Farmers' Adaptation Model to Climate Change*

The analysis result of dynamic model by using Powersim 2.5 shows that farmers who use technology of Planting Calendar and Integrated Crops Management, are able to increase rice productivity. The use of Planting Calendar and Integrated Crops Management at once, is a scenario chosen for the farmers' adaptation dynamic model against climate change. Another scenario is that farmers only practice Planting Calendar or Integrated Crops Management. Comparing the two models, it is reviewed that the usage of both Planting Calendar and Integrated Crops Management at once, is able to increase productivity of farming and production of rice. The next impact is increase of farmers' income and farmers' welfare.

The increase of production due to farmers' adaptation against climate change, is not significant in the beginning. However, the big gap of production increase, will appear on the next period. Figure 3 shows difference of rice productivity between adaptive farmers and non-adaptive farmers. It is seen that farmers who do not conduct adaptation, produce fewer rice than ones who adapt to climate change.

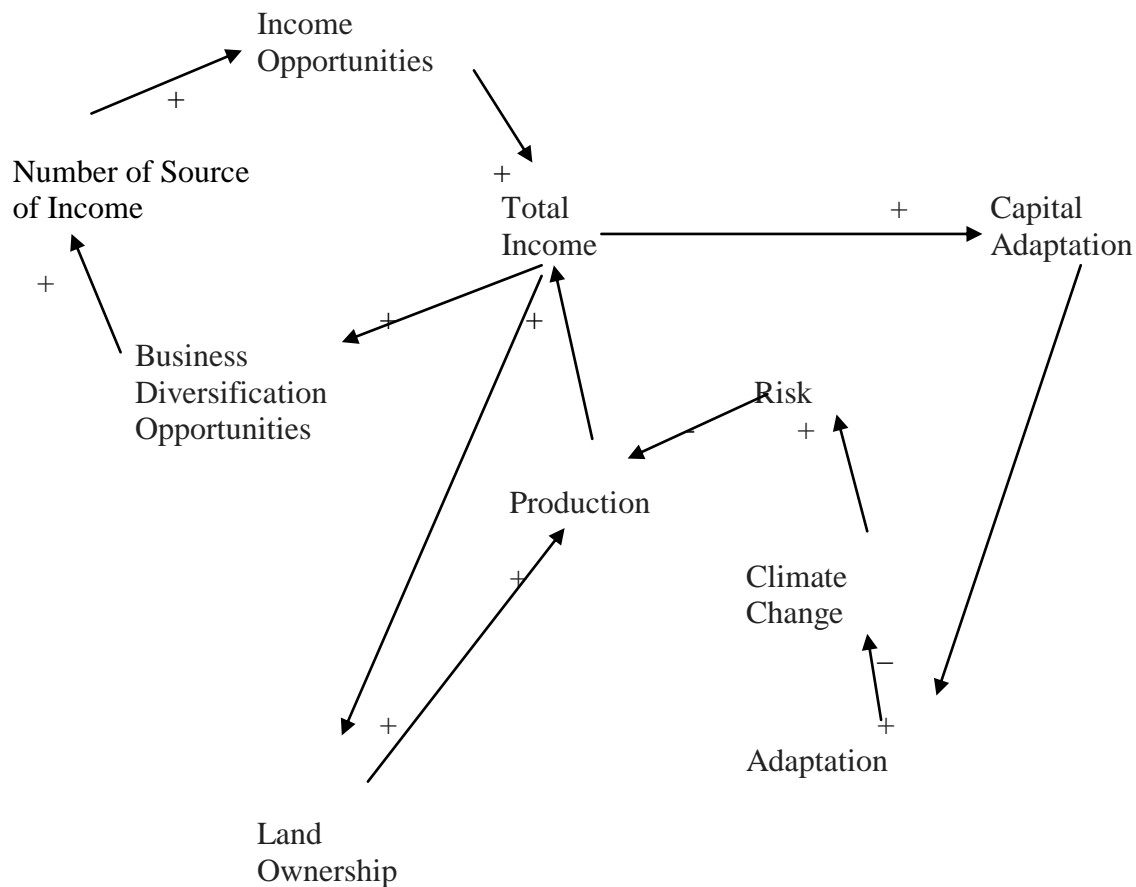


Figure 2. The causal relationship of dynamic models of adaptation against climate change

Scenario 1 describes the amount of rice production gained by farmers who do not adapt to climate change, while scenario 2 describes the amount of rice production gained by farmers who adapt to climate change by practicing Planting Calendar and Integrated Crops Management. Scenario 3 describes the amount of rice production gained by farmers who practice only the Planting Calendar, while scenario 4 describes the amount of rice production gained by farmers who practice only the Integrated Crops Management. Based on the Figure 3, it is seen that adaptive and non-adaptive farmers, have more amount of rice production time after time. However, adaptive farmers experience faster increase of rice production compared to non-adaptive ones.

In 2015, the gap of the amount of rice production between adaptive and non-adaptive farmers against climate change, is small. However, time has proven that the gap is growing increase year by year. Table 2 shows the rice production gap between adaptive and non-adaptive farmers against climate change.

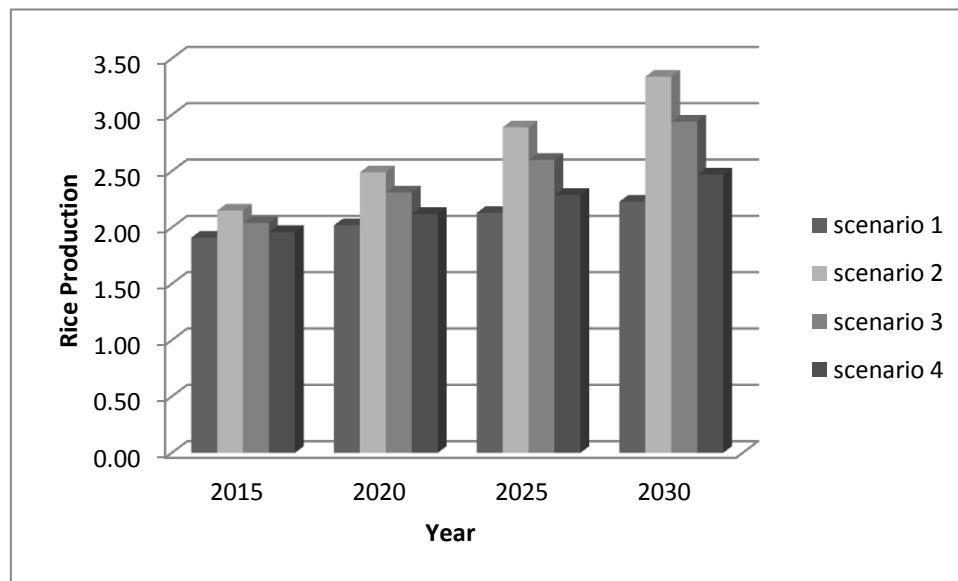


Figure 3. Gap of Rice Production between Adaptive and Non-Adaptive Farmers against Climate Change

As seen on Table 2, if farmers practice both Planting Calendar and Integrated Crops Management (scenario 2), then an increase in rice production is most significant compared to others. In 2015, the gap of rice production is 12.57%, increases to 49.8% in 2030. As well as with scenario 3 and scenario 4 where they have more significant increase of rice production, compared to scenario 1, but less than scenario 2. This proves that effective adaptation ways, will minimize the production decline due to climate change. This condition should be informed to the farmers, so that they are willing to adapt to climate change, in order to increase production and income.

Table 2. Gap of Rice Production between Adaptive and Non-Adaptive Farmers against Climate Change

Year	Production (ton)				Production Gap (%)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	(3)-(2)	(4)-(2)	(5)-(2)
1	2	3	4	5	6	7	8
2015	1.91	2.15	2.04	1.96	12.57	6.81	2.62
2020	2.02	2.49	2.31	2.12	23.27	14.36	4.95
2025	2.13	2.89	2.60	2.29	35.68	22.07	7.51
2030	2.23	3.34	2.94	2.47	49.78	31.84	11.66

Description :

Scenario 1 : Not practicing adaptation

Scenario 2 : Adapting with Planting Calendar and Integrated Crops Management

Scenario 3 : Adapting with Planting Calendar

Scenario 4 : Adapting with Integrated Crops Management

4. Conclusion

The results of the analyses show that each scenario shows an increase in production. The highest amount of production is emerged at condition that the farmers apply the adaptation in the form of Planting Calendar and Integrated Crops Management. Farmers who do not adapt to climate change, have the fewest rice production

References

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