

Climate change and farmers' cropping patterns in Cemoro watershed area, Central Java, Indonesia

Sugihardjo^{1,3}, J Sutrisno¹, P Setyono² and Suntoro¹

¹Agricultural Faculty, Universitas Sebelas Maret

²Mathematics and Natural Science Faculty, Universitas Sebelas Maret, Jl. Ir, Sutami 36A, Solo 57126, Indonesia

³Corresponding author: giek_bb@yahoo.com

Abstract. Cropping pattern applied by farmers is usually based on the availability of water. Farmers cultivate rice when water is available. If it is unavailable, farmers will choose to plant crops that need less water. Climate change greatly affects to farmers in determining the cropping pattern as it alters the rainfall pattern and distribution in the region. This condition requires farmers to adjust the cropping pattern so that they can do the farming successfully. This study aims to examine the application of cropping patterns applied by the farmers in the Cemoro Watershed, Central Java, Indonesia. Descriptive analysis approach is employed in this research. The results showed that farmers' cropping pattern is not based on the availability of water. However, it adopts a habit that has been practiced since long time ago or just adopt others farmer's habit. The cropping pattern applied by irrigated paddy farmers in Cemoro watershed area consists of two types: rice-rice-rice and rice-rice-secondary crops. Among those two types, most farmers apply the rice-rice-rice pattern. Meanwhile, there are three cropping patterns applied in the rain-land, namely rice-rice-rice, rice-rice-secondary crop, and rice-rice-fallow. The majority of farmers apply the second pattern (rice-rice-secondary crops). It was also found that farmers' cropping pattern was not in accordance with the recommendation of the local government.

1. Introduction

Climate change is a change in climate status that is identified with the average change and/or variability on climate-related factors and occurs for a longer period [1]. Generally, climate change is characterized by the increase of air temperature on the earth's surface and the increase of sea surface, which in the next step, affects to human's health, agriculture, water resource, and many other life sectors [2].

The agricultural sector is the most prone sector against climate change due to its high dependency to climate and weather, and also because the persons involving in the sector, likely tend to be poor, compared to those working in the industrial sector and service sector. In addition, the agricultural sector is prone to climate change, because it affects to cropping pattern, planting time, production, and the quality of harvest products. The global climate change will affect the occurrence of the change of rainfall's pattern and distribution, which leads to the occurrence of the shift of early season and planting time. Recently, many farmers experience a hard time to decide the right time of cropping or crop failures due to a long drought or unexpected rains [3].

A sufficient amount of water supply is a condition to reach optimum plants' production. The expected rains that occur at the right time with the right amount of water will give positive impacts for the agricultural sector. Climate change may cause floods or drought [3] that can cause the decrease in



the amount of production [4]. Thus, farmers should act to face climate change, so that the farming production does not experience a decreased productivity. The continuity of adaptation conducted by the farmers, in fact, may overcome the climate change and the decrease in crops productivity [5].

Farmers may practice adaptation in several ways. One of them is by changing the planting time, by adjusting the time in the beginning of the rainy season [6]. The change of planting time, by itself, means conducting the change of cropping pattern, which should be applied in their farming. Farmers are supposed to change their cropping pattern in facing the climate change. The change of cropping pattern is meant for keeping the plants' optimum growing because the water supply is expected to be enough. This research examines the usual cropping pattern conducted by farmers in Cemoro watershed area, Central Java, Indonesia. The cropping pattern will also be compared with the one suggested by the government and cropping pattern prediction supposed to be done by paying attention to the rainfall.

2. Research method

This research is conducted in Cemoro watershed area, Central Java, Indonesia. It is located in the southeast of Central Java. Cemoro watershed is situated in several regencies including Semarang, Boyolali, Sragen, and Karanganyar. This research uses 120 farmers cultivating irrigation rice fields and 120 farmers cultivating rain-fed rice fields as the samples. The information collected includes the characteristics and habits of farmers in carrying out their farming. The data are then analyzed descriptively using a cross-tabulation assistance.

3. Result and discussion

Land utilization for farming activities needs to pay attention to the water supply to gain the optimum result. In general, farmers will decide the kind of cultivated plants based on their experience and the recommendation from the government. Kinds of plants cultivated by the farmers based on the time sequence are called cropping pattern. The appropriate and suitable cropping pattern is an expected way to guarantee enough water supply to fulfill water needs for the growing plants. Cropping pattern applied by farmers in Cemoro watershed area is shown in Figure 1.

Farmers in Cemoro watershed area, apply two kinds of cropping pattern on irrigation rice fields, the first is rice-rice-rice and the second is rice-rice-secondary crops, with 72% of farmers apply the first kind of pattern. Meanwhile, three cropping patterns are applied for rain-fed rice fields by the farmers, they are rice-rice-rice, rice-rice secondary crops, and rice-rice-fallow. The applied cropping pattern is commonly based on the farmers' experiences. Farmers pay attention to the surrounding and other farmers' habits.

Cropping pattern practiced by the farmers in Cemoro watershed area seems not suitable for the one recommended by their local government. The rice-rice-rice cropping pattern is not recommended by the government due to the high demands of water supply. Boyolali regency is a region that has issued a resolution related to the appropriate cropping pattern for both rain-fed and irrigation rice fields. The cropping pattern suggested for rice fields in Boyolali Regency, based on the water supply factor to fulfill the needs of growing plants are seen in Figure 2.

The Cropping Pattern 1 is suggested for irrigation rice fields with more than enough water supply. The Cropping Pattern 2 is suggested for irrigation rice fields with enough water supply. Meanwhile, the Cropping Pattern 3 is suggested for irrigation rice fields with lack of water supply. The government recommended farmers to apply the rice-secondary crops-fallow cropping pattern for rain-fed rice fields. This reality shows that farmers do not practice government's suggestion due to the economic problem. Farmers assume that rice has more economic value compared to other commodities. The unsuitable pattern causes a higher risk of crop failure that leads to the decrease in income.

Irrigation Rice Fields												
Cropping Pattern	MT I				MT II				MT III			
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.
Type 1 (72 %)		Rice				Rice				Rice		
Type 2 (28 %)		Rice				Rice				Secd crop		

Rain-fed Rice Fields												
Cropping Pattern	MT I				MT II				MT III			
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.
Type 1 (12 %)		Rice				Rice				Rice		
Type 2 (70 %)		Rice				Rice				Secd crop		
Type 3 (18 %)		Rice				Rice				Fallow		

Figure 1. Cropping plant on irrigation and rain-fed rice fields in Cemoro watershed area

Irrigation Rice Fields												
Cropping Pattern	MT I				MT II				MT III			
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.
Type 1		Rice				Rice				Secd crop		
Type 2a		Rice				Rice				Fallow		
Type 2b		Rice				Secd crop				Secd crop		
Type 3a		Rice				Secd crop				Fallow		
Type 3b		Secd crop				Rice				Fallow		

Figure 2. Suggested cropping pattern on irrigation rice fields in Boyolali regency

The application of cropping pattern actually should adjust with water supply for the growing plants. Thus, farmers should pay attention to the rainfall. Farmers can refer to the monthly average of rainfall, as a reference to start cultivating rice and then other plants. Figure 3 and Figure 4 shows the monthly average of rainfall recorded in Simo District, Boyolali Regency, and Gondangrejo district, Karanganyar regency, which may be a reference for farmers to apply the suitable applied cropping pattern.

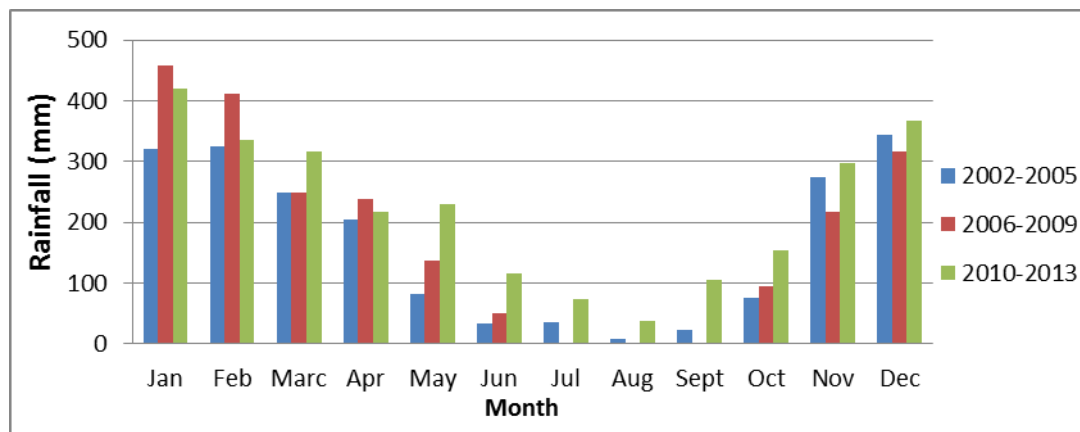


Figure 3. Monthly rainfall pattern in Simo District between 2002 and 2013

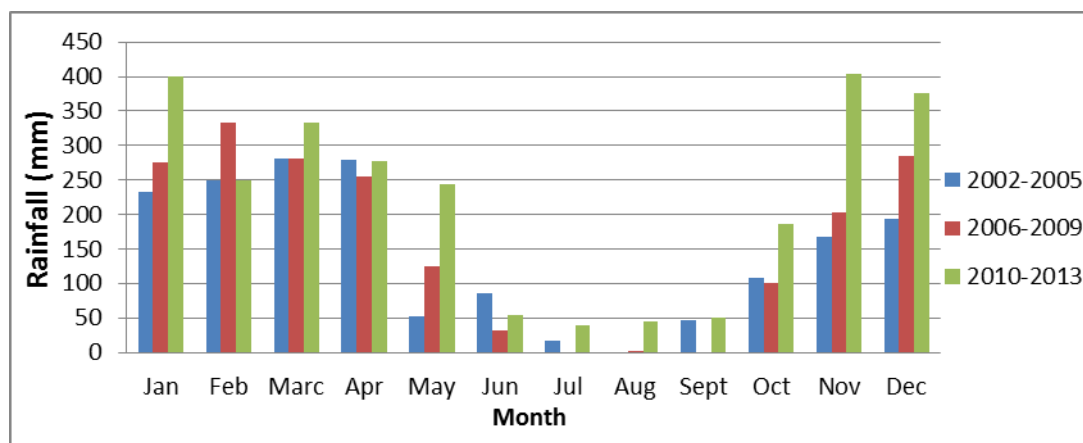


Figure 4. Monthly rainfall pattern in Gondangrejo District between 2002 and 2013

The difference of rainfall pattern between 2002 and 2013 in Simo District and Gondangrejo district may be identified by Figure 3 and Figure 4. The wet month, when the rainfall reaches 200 mm or more, occurs for six months in November, December, January, February, March, and April in Simo district between 2002 and 2005. Meanwhile, in Gondangrejo district, it occurs for four months in January, February, March, and April. Wet month occurs for six months in November, December, January, February, March, and April between 2006 and 2009, and seven months in November, December, January, February, March, April and May between 2010 and 2013. This condition can be an indicator of the change of climate pattern in Gondangrejo district. The wet month is characterized by 200 mm or more of rainfall while a humid month is characterized with 100 mm – 200 mm of rainfall, and dry month with less than 100 mm of rainfall. The development of rainfall in Simo District and Gondangrejo district can be seen in Table 1.

Cropping pattern can be formulated according to the rainfall data mentioned in Figure 3 and Figure 4, based on rainwater supply, which may be utilized for cultivating rice and other plants. Generally, rice may be started to plant when monthly average of rainfall reaches at least 175 mm, not less. According to the rainfall data seen at Figure 3 and Figure 4, the ideal cropping pattern formula, based on rainwater supply in Simo district between 2002 and 2005, 2006 and 2009, is rice-secondary crops-fallow and between 2010 and 2013 is rice-rice-secondary crops. Meanwhile, in Gondangrejo district, the ideal cropping pattern for 2002-2005 is rice-rice-secondary crops and rice-rice-fallow for 2006-2009.

Table 1. Numbers of wet month, humid and dry in Simo and Gondangrejo between 2002 and 2013

No	Period of Time	Wet Month (month)	Humid Month (month)	Dry Month (month)
1	Simo			
	2002-2005	6	0	6
	2006-2009	6	1	5
	2010-2013	7	3	2
2	Gondangrejo			
	2002-2005	4	3	5
	2006-2009	6	2	4
	2010-2013	7	1	4

Cropping Pattern												
District	MT I				MT II				MT III			
	Nov.	Dec.	Jan	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sept	Oct.
Simo												
2002-2005		Rice				Secd crop				Fallow		
2006-2009		Rice				Secd crop				Fallow		
2010-2013	Rice				Rice				Secd crop			
Gondangrejo												
2002-2005	Rice				Rice				Secd crop			
2006-2009	Rice				Rice				Fallow			
2010-2013	Rice				Rice				Secd crop			

Figure 5. The suggested cropping pattern based on rainwater supply in Simo district and Gondangrejo district

These findings show that there are no farmers applying the ideal cropping pattern based on monthly rainfall that occurs in the area of Cemoro Watershed. They prefer to consider their desires and habits in deciding the pattern, although it may cause higher crop failures.

4. Conclusion

The data analysis shows that farmers apply rice-rice-rice cropping pattern on irrigation rice fields. Meanwhile, rice-rice-secondary crops pattern is applied on rain-fed rice fields. Farmers do not apply the cropping pattern suggested by the local government. This unsuitable cropping pattern leads to the higher risk of crop failures.

Acknowledgement

Thanks to the enumerators who helped with data collection and processing.

References

- [1] Angles, Chinnadurai and Sundar 2011 Awareness on impact of climate change on dry land agriculture and coping mechanisms of dry land farmers *Indian Journal of Agricultural Economics* **66(3)** 65-72
- [2] Ayunwuy, Kuponiyi, Ogunlade and Oyetoro 2010 Farmers perception of impact of climate changes on food crop production in Ogbomoso, agricultural zone of Oyo State, Nigeria *Continental Journal Agricultural Economics* **4** 19-25
- [3] IPCC 2001 *Climate Change 2001: Impacts, Adaptation, and Vulnerability-Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press)
- [4] Mburu B K, Kung'u J B and Muriuki J N 2014 Effects of climate variability and change on household food sufficiency among small-scale farmers of Yatta district, Kenya *J. Environ.* **3(2)** 19-27
- [5] Naylor R, Battisti D S, Vimon D J, Falcon W P and Burke M B 2007 *Assessing Risks of Climate Variability and Climate Change fo Indonesia Rice Agriculture - Proceeding of National Academy of Science of the United State of America PNAS* (Washington: Nasional Academy of Sciences) 104(19) 7752-57
- [6] Ofuoku A U 2011 Rural farmers' perception of climate change in central agricultural zone of Delta state, Nigeria *Indonesian Journal of Agricultural Science* **12(2)** 63-8
- [7] Surmaini, Elza, Runtunuwu E and Las E 2011 Agricultural Sector Efforts in Facing Climate Change (In Indonesian) *Jurnal Litbang Pertanian* **30(1)** 1-7