Tobacco farmers Perspective towards increasing climate change risk on agriculture sector: a case study of Temanggung- Indonesia

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Abstract Predicted increasing climate variability and change in the future by the Intergovernmental Panel of Climate Change have significant impact towards agricultural sector in Indonesia. Local farm commodities in Indonesia, such as tobacco, are very sensitive to changing climate. This study aims to measure tobacco farmers perspective towards increasing climate risk in Indonesia. Tobacco plantation area in Temanggung District is selected as a case study since it is well known for its tobacco production, particularly for cigarette. Focus Group Discussion (FGD) towards local tobacco farmers has been conducted to identify how the weather and climate affect the farmer activity, as well as the climate risk due to increasing unpredictability of weather and climate. The result shows that in farmers perspective, it becomes more difficult to manage the farmlands. For the case of tobacco, excessive rainfalls or insufficient rainfall could cause crop failure. As a result, the tobacco productivity is not as large compared to the past. The farmers also have lower income compared to the past 5 years due to lower tobacco quality and quantity.

1. Introduction
Agriculture is expected to be one of the major sectors mostly affected by climate change due to several reasons[1,2]. First, it affects two main factors in determining plant growth, namely precipitation and temperature. These two factors are very crucial for Indonesian agriculture sector, where the agricultural area mostly consists of paddy field and produce rice as staple food over the entire region. Therefore, it is very sensitive to climate variation because it requires large amount of water supply to grow. Adverse effect of climate change therefore could possibly emerging due to decrease of precipitation followed by increase of temperature, yielding less water supply and increase loss of water due to evapotranspiration[3–6]. Thus, water availability continuously decreasing over time, hence the land becomes unsuitable for supporting plant growth[7].

Agriculture is one of the most important sectors in Indonesia since more than 50% of the population work as farmer. Agriculture products also account for approximately 13% of National Gross Domestic Products (GDP) and take a role as the foundation for food security over the country. Up until now, more than 60% of national rice production comes from Java Island, which is one of the five biggest islands in Indonesia. The island one of the most suitable area for paddy field due to existence of rich nutrients volcanic soil and large amount of precipitation during rainy season.
However, agricultural sector over the island are now perceive various obstruction due to both natural condition and human influence.

The climate change also possibly affects intra-seasonal and inter-seasonal atmospheric variance, for example Madden–Julian Oscillation (MJO) and El-Nino/Southern Oscillation(ENSO)[5,8,9]. Therefore, it may yield longer dry or rainy season over specific area, increase possibilities of flood inundation over agriculture areas due to higher flood magnitude and frequency in rainy season and yield major crop failure due to severe drought in dry season[10,11]. Climate change also leads to seasonal shifting of rainy season and dry season, both in term of earlier and delayed season onsets. On the other hand, farmer often follow specific date from the calendar to decidentarting time for planting season. Therefore, a shifting on rainy season or dry season resulted in farmer’s difficulties in determining starting time for planting season.

Land use conflict has turned into very serious problem as a result of rapid urban development. At present, a large number of productive agriculture areas have been converted to settlement and other build up area. This condition is unavoidable since about 60% of Indonesian population life in this island[4]. Moreover, in the viewpoint of emerging hydrometeorological hazards as affected to the climate change, the island also very prone to natural hazards, particularly drought and flood. Apparent increase in both magnitude and frequency of those hazards has recently observed, followed by an increase of crop failure at many parts of the island. The driven factorfor these conditionis not only due human influence in term of land use conversion, but also combined with increasing climate variance over several past decades, for instance due to increase surface temperature and change of precipitation pattern. Higher evapotranspiration in dry season acts as restricting factor for plant growth. While in rainy season, parts of productive agriculture area become inundated due to its position at a lowland topography.

Temanggung is a district in Central Java Province which is one of the largest tobacco productions across the country. The area is characterized by mountainous area, with elevation higher than 700 m above mean sea level. The area consists of 20 sub-districts, where tobacco farmlands can be found from almost all the sub-districts. About 60% of the population work in agriculture sector, particularly tobacco farming. The tobacco farming has the highest generated revenue towards the local government after rice production[4].

The future climate prediction in Indonesia in general resulted in higher rainfall over rainy season, but less rainfall over dry season[12]. This condition is predicted to have significant impacts towards agricultural sector in Indonesia. Increasing drought and flood frequencies are now has been observed from many areas. This condition might be also occurred in the study area and affects the tobacco productivity. To identify potential condition of changing climate and its impacts towards tobacco productivity in the research area, this research is conducted to address two specific questions:

1. How is the perspective of the farmers related to the increasing climate variability and change towards their farmlands?
2. How is the perspective of the farmers related to the impact of changing climate towards their farmlands, and how is the actual condition at present?

2. Methods

The population in this study is all official farmer groups in 14 sub-districts in Temanggung. Thosesub-districts are known as tobacco production centers, namely Parakan, Candirototo, Ngadirejo, Tembarak, Kedu, Kledung, Wonoboyo, Tretep, Bulu, Bansari, Temanggung, Selopampan, Tlogomulyo and Jumo. The official groups are selected as the populations since they connect the government (Especially department of agriculture) with the local farmers. They also selected as the population since they have capacity and influence towards the local farmers. Therefore, a total of 70 research samples are selected for Focus Group Discussion (FGD). The selected samples also represent the lowland areas (with heights of less than 700 m above sea level) and highland areas (higher
than 700 m above sea level). In general, the lowlands are dominated with rice fields, while the highlands are dominated by dry farming areas, particularly tobacco. Over the lowlands, the farmer also plant tobacco in addition to rice fields, particularly in dry condition where the water is not enough for rice fields.

![Figure 1. Map of sub-district (kecamatan/kec. in indonesian) in the study area and the location of Focus Group Discussion. Elevation data are obtained from national digital elevation model (DEMNAS) of Indonesian Geospatial Agency (BIG).](image)

Information about tobacco farming in Temanggung was obtained through Focus Group Discussion (FGD). The FGD is a data collection method conducted through the interaction of a group or individuals through a discussion to produce a mutual consensus[13]. The form of interactions can produce information if they have similarities in several ways, such as the similarity of individual characteristics in general, social status, issues/problems, and the similarity of social relations[14]. The FGD are conducted by semi-structured interviews of a group of individuals who are guided by a moderator in order to collect data or information for a specific topic/issue[15]. The FGD method was chosen because it is more effective, fast, economical, and can produce information or data, as similar as questionnaire-based interviews. In addition, participation of respondents in FGD are more active and varied when they are in a discussion forum compared to individual interviews[13].

The FGD activities is conducted for four days, which are July 11th, 12th, 15th and 16th of 2019 (Figure 2). The first day FGD was held at the Tembarak Sub-district Agricultural Extension Office (“BalaiPenyuluhPertanian” or BPPTembarak in Indonesian). In this FGD, 15 participants coming from Tembarak, Selomampang and Tlogomulyo Sub-districts. The second day is conducted at the BPP Kedu with a total of 15 participants from the Sub-districts of Kedu, Bulu and Temanggung. The third day is conducted BPP Parakanand is attended by representatives of farmer group leaders from Parakan, Bansari, Kledung and Ngadirejo Sub-districts. While the last day is conducted at BPP Candiroto with participants from Candiroto, Tretep and Wonoboyo Sub-districts. The FGD content are related to the condition of tobacco farming in Temanggung, including the initial planting and harvest.
time, constraints from pre-planting to post-harvest, the influence of climate, especially rainfall and temperature on tobacco farming, tobacco production trends over the past 5 years, and efforts that has been done in the face of climate change and variability as well as general agricultural cropping patterns in each region.

![Figure 2](image.jpg)

**Figure 2.** Example of the FGD activities in Kedu Sub-district (top) and Parakan Sub-district (bottom). Image courtesy by the authors

### 3. Result and discussion

#### 3.1 Problems related to tobacco agriculture and the impact of climate change around Tembarak Sub-district

Based on focus group discussion in this area, most problems that experienced by farmers due to changing climate is related to the knowledge of how to respond to the increasing climate variability. Farmers are still having difficulties to find proper ways to adapt with changing climate. In 2016 and 2017, excessive rain-rates are considered too much and affects the tobacco harvesting, in which decrease the production. While in 2018, an extreme drought occurs so the rain-rates become much less than expected, which also affects lower harvest. Therefore, optimal steps should be taken in more advanced ways so the farmers can be skillful in anticipating extreme weather and climate phenomena. Practical knowledge about water provision is also important during extreme drought.

Based on the FGD, the participants consider that the tobacco production around Tembarak and surrounding areas is considered decreasing from year to year. It is indicated that weather and climate, particularly temperature, is causing excessive heat that reduce the water availability. The frequency of rain that began to decline in the beginning of planting season recently is causing tobacco leaves becomes smaller than the normal size. The amount of leaves also become less and the plants become rapidly flowering which is not favorable to farmers. The amount of fertilizer that should be given is

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IOP Publishing

**IOP Conf. Series: Earth and Environmental Science 451 (2020) 012101**

**doi:10.1088/1755-1315/451/1/012101**
also increasing to maintain its productivity. In the past, usually only require one truck of fertilizer for an average farmland. However, it now becomes more than one and a half for the same area. Currently, it becomes harder to keep the plant in order to remain fertile as compared to the past. This is particularly due to losses of top layer of the fertile soil due to land conversion from forests to tobacco farmlands. Increasing heavy precipitation in rainy season due to climate change causing faster losses of the fertile soil.

Farmers in general are still overwhelmed and confused in facing the increasing climate variability, especially in efforts to adapt with the changing seasonal patterns. This is particularly problematic during extreme wet and extreme drought seasons. According to the interviewees, the distribution of rain that fell in their area was uneven. In several area, problems due to water shortage had lasted for more than 3 years.

Source of water is available only at the lowland of Temanggung. While at the study area, which is mountainous area, it is difficult to access the water resources. Although there is a possibility to make a reservoir to keep the water for the tobacco farmland, but the quantity is still not enough to cover the entire area. On the other hand, the need for water is also quite high. It becomes more complicated due to existence of “water thefts” that are troubling the tobacco farmers since the water become much less than their demands.

Late tobacco harvest times currently occur more often and reducing the farmers profitability. This is because the tobacco harvest time outside the region starts earlier than the study area. This makes mediators who collect tobacco from farmers already bought the tobacco from outside the region. Besides, the local tobacco from the region which has typical smell, only be used an aromatic source for illegal tobacco mixtures that circulate in the market. The mixtures are then claimed as native tobacco by the seller. As a result, some people began thinking that the quality of native tobacco is considered declining. It leads to farmer losses because of the tobacco harvested by them are not salable.

3.2. Problems related to tobacco agriculture and the impact of climate change around Kedu Sub-district

Tobacco production surrounding Kedu Sub-district is highly dependent to weather and climate, where the farmer’s knowledge in adapting to the climate change are important to maintain that the results of the harvest. The farmers consider that the main factor that becomes the foundation of success in tobacco farming is the weather and climate. Furthermore, they state that the weather condition highly determines the results from the planting process to the harvest process. For example, the tobacco growing season in 2015 is considered good and was allegedly due to warm but not too dry climate condition. In 2016, heavy rain-rates occurred particularly due to La-Nina which led to the declined production. In 2017 and 2018, the weather condition is difficult to guess and led to the lower production than expected. Both tobacco quality and quantity are affected by the climate change. However, although there are deterioration on the production, the farmers keep growing tobacco. Therefore, most of them consider that they need accurate information about weather and climate.

In addition to tobacco farming, the farmers also plant a variety of crops. They adjust the system of planting based on the topographical conditions. In the mountainous area with high elevation, most of plant are rainfed crops. This is because of their limitations in the construction of technical irrigation. The plants are mainly onions, garlic, scallions and corn. While at the lowland and plain areas, it is dominated by irrigated plants, particularly rice fields.

The farmers also said that pests and plant diseases are currently increasing due to changing weather and climate, especially due to higher moisture. Diseases of plants are now dominated mainly by endemic viruses. The viruses rapidly spread and its symptoms causes tobacco plant shrinking and drying like rice crackers. Another type of virus causes the tobacco leaves becomes yellowish and drying. Currently, it still very difficult to cure such kind of viruses. Therefore, the farmers need some methods that can prevent the transmission of those viruses, which are affected by the humidity.
3.3. Problems related to tobacco agriculture and the impact of climate change around Parakan Sub-district

Based on the characteristics of the Parakan and the surrounding areas, there are two types of agricultural land according to how the farmers manage the area. The areas are dry farming area and wet farming area used for paddy fields. On the two types of land, the land which is considered the most productive in quantity is wetland farming area, particularly for rice fields. However, the farmers consider that the quality of dryland farming is more superior. Although the time of planting are relatively much longer than the rice field, the price of commodity planted in these areas is valued higher than the rice fields. Therefore, it is economically beneficial for planting on the dryland areas, particularly for tobacco and coffee. For the two areas, Difference in time of planting can be seen by the beginning of planting season. The dryland planting season begins in March-April, while for the rice fields, new beginning of planting started from April to May. The period of harvest remains similar between September-October.

The farmers in this area also consider that information about weather and climate are important in determining the time of planting season. For example, if there are possibilities that droughts will take place for long time over particular area, the farmers could decide to plant the tobacco early. In contrary, when the excessive rain-rates are predicted to occur, the farmer could delay the time of planting. Based on the interview to the farmers, from 2006 to 2013, an increase in the tobacco production has been occurred. However, since 2014 until present, the tobacco production is declining. The farmers experienced a peak of tobacco price from 2009 until 2011, in which very profitable for them. However, the profit from tobacco farming are continuously declining until the present.

The local farmers also grow paddy, garlic, scallion, and other vegetables in addition to tobacco. Weather and climate factors are considered as the most important factor for the successful harvesting for each commodity hat planted by the farmers. The system of tobacco planting is mainly conducted through a system that is called “tumpangsari”. In this system, the tobacco is planted in combination with other crops. The farmers in the study area usually planting broccoli one month before planting tobacco. After the tobacco are planted for one month, the broccolis are harvested. In this system, it should be ensured that after one month, there are no other plants grow side by side with the tobacco. This condition is considered suitable for optimum growth of the tobacco.

The constraints experienced by the tobacco farmers are currently come from weather and climate factors. According to the farmers, the weather currently less supportive to the tobacco farmers. It is inhibiting the growth rate of the tobacco plants, and even generates crop failure. In addition to crop failure, the changing weather and climate also trigger the spreading of pests and plant diseases. Fortunately, for some pests and diseases problems, they still can be overcome by the farmers by using certain pesticides. Other constraint that are experienced by the farmers is related to the lack of laborers that is able and willing to cultivate the land. This constraint is experienced by the old farmers started from the time of planting until the harvest time.

3.4. Problems related to tobacco agriculture and the impact of climate change around Candiroto Sub-district

Due to the land characteristics in Candiroto area, tobacco plants are mostly grown on dry farming area with harvest time usually in August. The tobacco planting in this area took time around 3 to 4 months until harvested. The time of planting are also influenced by the elevation. Crops that are planted at an altitude of 1100 m above sea level are usually planted from February-March, while the tobacco plants grown on an altitude of 700 m above sea level usually planted in April-May. The tobacco planting systems in this area are separated into two types, namely monoculture and “tumpangsari” systems. However, most of the farmer adopt monoculture system since they consider that tobacco is a type of plants that reach its optimum growth without interference of other plants. In addition, the tobacco plants are considered not good to grow in conjunction with other plants since it is also highly influencing the odor and color of the leaf.
There are changes on planting season from the past five years as affected by changing weather and climate. Farmers still have difficulties in adapt to the changing climate, particularly in determining the beginning of planting season. In the past, the farmers are used a traditional system passed from generation to generation which is called “pranotomongo” to determine the beginning of planting season. The “pranotomongo” is a traditional method to determine beginning of planting season based on sign in the environment, for example when specific trees begin growing leaves and certain types of insects start to emerge. However, it now becomes less accurate because weather and climate become more unpredictable. The greatest impact of changing weather and climate is particularly related to the decreasing quantity and quantity of tobacco plants. The decreasing quality of tobacco plants affects to the lower tobacco price and makes unfavorable condition for tobacco farmers.

The farmers state that in general, the tobacco plants need adequate water to grow, but not too excessive or not lacking than its minimum requirement. Therefore, excessive rainfall during rainy season could decrease the tobacco quality. Excessive runoff in rainy season also can dissolve the fertilizer that had just given to the plant. In contrast, when precipitation is much less, the fertilizer is not going to dissolve to the soil. The soil becomes low in nutrients and the tobacco plants do not grow well. At present, the farmers expect an accurate weather and climate information to adjust the beginning of planting season. They expect that it could help them working effectively and efficiently by reducing weather and climate risks. In addition, a well-established information system could also help them to be economically sustainable and reducing crop failure.

Another problem faced by the farmers is related to price fluctuation at the post-harvest event. This is related to the farmer’s competition in selling the tobacco. In some cases, it causes disadvantages because of fluctuations in tobacco prices and speculative action by tobacco traders. Therefore, the farmers consider that they got unfair price for their tobacco. However, this condition occurs frequently since they have weak selling power compared to the buyer.

3.5. Strength, Weakness, Opportunity, and Threat (SWOT) analysis of the tobacco production under the influence of climate change

From the interview process over the four locations, we could obtain information related to potential impact of climate change towards agriculture. The result is summarized in Table 1. In general, it seems that increasing climate variability and drought frequency already experienced by farmers, as well as increasing temperature. The above condition causing increasing erosion of fertile soils, spreading of pests and crop’s diseases. The social problem are also emerging in the term of “water theft” issue. Therefore, the problem related to climate and water are very significant to the farmers.

Table 1. Summary of the problems related to tobacco production as affected by climate change in each FGD location.

| Problems related to climate                                      | Tembarak | Kedu | Parakan | Candirototo |
|---------------------------------------------------------------|----------|------|---------|-------------|
| Weather pattern becomes more unpredictable / shifting seasonal rain pattern | o        |      |         |             |
| Increasing heavy rain at rainy season                         | o        |      |         | o           |
| Prolonged drought at dry season                               | o        | o    | o       |             |
| Increasing temperature                                        | o        | o    | o       |             |
| Plant diseases due to higher atmospheric moisture             |          | o    | o       |             |
| Heavy rain causing erosion of fertile soil                     | o        |      |         | o           |
| Late tobacco harvesting due to changing climate                | o        |      |         | o           |
| Lack of water related infrastructure at mountanous area        | o        | o    |         | o           |
| “Water theft”cases                                             | o        |      |         |             |
Lack of laborer / machine intensive farming to speed up the planting process as climate change mitigation efforts  
Decreasing water resources due to deforestation  

Figure 3 highlights the SWOT analysis of the tobacco production in the study area as influenced by the climate change. In general, the farmers have established good initiatives, openness, and active involvement in managing their farmlands. However, it is often limited by the knowledge and capital to maintain the tobacco production in addition to limited water related infrastructures. Fortunately, the local government support the development of water related infrastructures and conservation even with limited budget. The local government also have initiatives to introducing alternative crops, such as coffee and avocado, as a form of conservation. However, limited capitals of the local farmers is the main factors for high climate change susceptibility. Several threats related to the tobacco planting could lower their capital and becomes more susceptible. In addition to the threat from the strong change of the climate pattern, the threats also come from competition between farmers, weakness in set the selling price, and large amount of illegal tobacco mixtures.

**Figure 3.** SWOT analysis of the tobacco production in Temanggung as influenced by the climate change.
4. Conclusion
In summary, the climate change related problems in the study area have a large impact to the farmer daily lives. It can be concluded that the risk associated with climate change impact in the study area are very high. In building the resilience towards climate change, the strength, weakness, opportunity, and threat owned by the local farmers must be considered. The SWOT analysis in the previous section shows that it becomes important for the farmers to manage their farmland in more sustainable way. Changing climate variability, when combined with environmental degradation and farm mis-management, could produce higher exposure to climate change. This particularly true particularly in term of decreasing water resources and increasing soil erosion. All of the problems above are closely linked each other and need strategic implementation to be solved. Therefore, effective channels are still required to bridge climate change science with its implementation both to local government and community in the study area.

Although farmer’s perception could bring information about the impact of climate change in agriculture sector, there are several limitations related to this research. For example, the perception related to the change of climate variables in not always in line with direct measurements of climate observation data. This condition is possibly derived from several factors that comes from farmers itself, social condition, and environment. Internal factor that could derive farmer’s perspective consist of farmer experience and observational skill of farmers to detect change in their environment. These two factors are therefore very dependent to how long they already become farmers. Socioeconomic factors, especially sourced from farmer groups and local community, could give an influence to the farmer’s perception. Our finding suggests several inputs to policy maker. First, new and robust mitigation and adaptation measures are important so the farmers become resilient to future climate change impacts. Second, national and regional action plan related agricultural climate change mitigation should be constructed to ensure food security since major losses in agricultural sector could trigger famine among the country.

Acknowledgements
This research is supported by grants of “Hibah Penelitian Terapan Unggulan Perguruan Tinggi (PTUPT)” in 2018-2019 by Ministry of Research and Education of Indonesia (KEMENRISTEKDIKTI) with title: “Pengembangan Sistem Articulated Weather Generator for Seasonal Climate Prediction (AWGenSCP) Untuk Proses Decision-Making Pola Adaptasi Pertanian Lokal Dalam Menghadapi Perubahan Iklim”

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