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Original Article

Impact of climate change on farmer adaptation and tobacco productivity in Temanggung regency♣

Avi Budi Setiawan[1], Bayu Rizky Pratama[2, 3*], Nisa Sabtiningtias[1], and Widya Fatriasari[4]

[1] *Department of Economic Development, Universitas Negeri Semarang, Semarang, 50229 Indonesia*

[2] *MOQUAS, Institute des Regions Chaudes, SupAgro Montpellier, Montpellier, 34090 France*

[3] *Department of Agribusiness, Universitas Muhadi Setiabudi, Brebes, Central Java, 52252*

[4] *Indonesia Indonesian Institute of Sciences, Cibinong, Bogor, 16911 Indonesia*

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Abstract

Temanggung is one of the largest tobacco producers in Indonesia. To support the production, tobacco farmers initiated how to set proper conditions prior to cultivation. However, there were external factors made tobacco production fluctuations; pest, fungi, and especially climate change. For several years, farmers have struggled by the increase of rainfall caused an impact in pollination process massively. To tackle this, farmers have to conduct adaptation. This research aimed to evaluate how climate change impacted tobacco productivity and farmers' responses in addressing climate change. The method performed including a qualitative approach using in-depth interviews to observe differences in tobacco productivity, while factors affected farmers' adaptation estimated by *Order Logit Model*. The increase in rainfall has impacted negatively to tobacco productivity by 50% on average yearly, which pushed farmers to conduct some adaptations to minimize crop failure risk. The use of adaptation strategies in tobacco cultivation required to be combined with meteorology and climatology, including climate-change information dissemination center. Farmers have been applying the strategies aimed to deduct the impact of climate change, such as (1) improving irrigation channels (47.89%), (2) replacing the input and technological support used by farmers (23.94%), and (3) harvesting earlier / time-mapping cropping (28.17%).

Keywords: tobacco, climate change, adaptation strategies, tobacco productivity

1. Introduction

In recent years, the global climate has undergone quite extreme changes and is the biggest challenge for humanity as well as science. It could be caused by various factors (Surmaini & Faqih, 2016), including increased concentrations of greenhouse gases (GHG). This climate in particular impacted Indonesia where according to geographical location, Indonesia is influenced by climate variabilities such as monsoon, ENSO, and IOD (Cahyarini & Henrizan, 2018). Hidayat, Ando, Masumoto, and Luo (2016) observed that rainfall variability has a strong influence which leads to devastating drought with losses in crop production. It has been impacted massively to the agricultural sector including tobacco production, where the climate variabilities affected significantly the Indonesian rainfall which further

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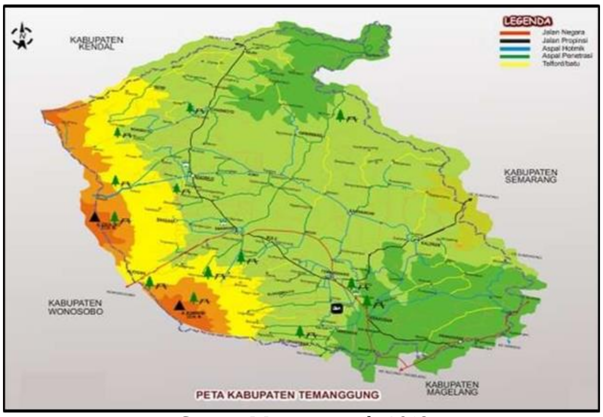
*Corresponding author
Email address: bayurp@umus.ac.id

increase the chances of tobacco crop failure (Muttaqin *et al*., 2019). According to Herlina, Azizah, and Pradiga. (2020), tobacco belongs to the commodities which are very sensitive to climate change, especially during the increase of rainfall. Farmers need to conduct some protection along with an adaptation to secure their tobacco production stability, therefore, avoid crop failure.

Temanggung Regency located in Central Java Province is one of the massive tobacco producers which has dominated the amount of tobacco production both locally and nationally. Moreover, it was known as the producer of good quality tobacco in Indonesia which is used by many big cigarette companies as their raw materials of production. This reliable quality leads Temanggung to dominate the coverage area of tobacco production. From the total 45,085 ha of Indonesia production area, Temanggung has around 16,093 ha which could produce as many as 9,983 tons in annual production (Badan Pusat Statistik [BPS], 2019). Furthermore, Tobacco production could contribute to 21.5 % of gross domestic regional product of Temanggung as well as contribute to the employment for 55.171 households in Temanggung Regency (BPS, 2016), thanks to its suitable area offering high altitude with mountainous cultivation area (Figure 1), where local farmers have been producing tobacco each year (Table 1). However, the two common producers come from Ngadirejo and Kledung Sub-districts usually offering the unique taste and aroma, which accounted for 17.98% and 14.05% of tobacco production respectively, while their productivities are around 0.85 ton/ha and 0.65 ton/ha.

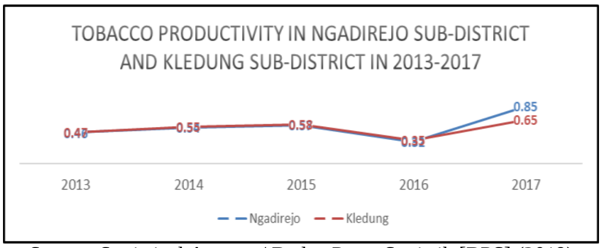
Despite that reason, enhancing farmers' resilience capacity is an important issue, since many of them are lack of accessibility to climate change information. This will lead farmers unable to predict a precise time to plant as well as to harvest their tobacco (Muttaqin *et al*., 2019). A slight miss on the prediction will trade-off them a crop failure. Farmers will produce more when they have a fine average rainfall, otherwise, they could dramatically drop the production once they experience the heavy rainfall (comparison data on Figures 2 and 3). It had been experiencing by farmers during the 2016 season, where commonly farmers' productivity had been dropped from around 0.58/ Ha to 0.32/ Ha, due to an intense average monthly rainfall as much as 195.4 during that season. It, therefore, led to government decree issuance no. 360/ 432 of 2016 informing about disaster-emergency status of tobacco harvest fails namely "*puso*".

In order to tackle its impact, farmers have decided to limit their cultivation areas, assumed as a mitigation strategy. The factors such as (1) the failure of tobacco harvest during the 2016 season and yet, and (2) the high rainfall at the beginning of the tobacco 2017 season were considered as the main reasons to copping the bigger losses from the previous season. Eventually, during the 2017 season, farmers could improve significantly the productivity compared to previous seasons, from around 0.32/ha to 0.85/ha. Thus, instead of climate impact, the farmers' alternative strategies could be defined the tobacco performance during the season which potentially could improve the tobacco productivity. This, therefore, could be presumed that the natural factors are not a single factor to influence agricultural productivity. Yet, there are non-natural factors that contribute to the increasing productivity of tobacco.



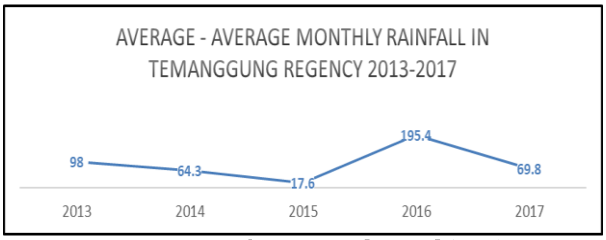
Source: Muttaqin *et al.*, 2019

Figure 1. Map of Temanggung regency



Source: Statistical Agency / Badan Pusat Statistik [BPS] (2019)

Figure 2. Tobacco productivity in Ngadirejo and Kledung sub-district



Source: Meteorology Agency [BMKG] (2019)

Figure 3. Average monthly rainfall in Temanggung regency

2. Research Methods

The population in this study were all tobacco farmers in Ngadirejo and Kledung Sub-district where the samples were partially taken from populations with a similar characteristic (Sudjana, 2005). However, the sampling method performed proportional sampling methods that used *The Lemeshow formula* to calculate (Lemeshow, Hosmer, Klar, & Lwanga, 1990). Thus, this research will be used as many samples as:

$$n = \frac{Z^2\ \alpha/2 * p\ (1-p)}{d^2}$$

$$n = \frac{(1{,}96)^2\ (0{,}50)\ (1-0{,}50)}{(0{,}1)^2}$$

$$n = \frac{(3{,}84)\ (0{,}50)\ (0{,}5)}{(0{,}01)}$$

$$n = \frac{0{,}96}{0{,}01}$$

$$n = 96$$

Table 1. Tobacco production (Ton) per sub-district in Temanggung (2017)

No	Sub-District	Moons areal	Production
1	Parakan	843,00	444,81
2	Kledung	2.128,50	1.392,04
3	Bansari	268,00	264,25
4	Bulu	861,40	516,84
5	Temanggung	10,00	3,50
6	Tlogomulyo	-	-
7	Tembarak	198,40	79,36
8	Selopampang	67,50	40,50
9	Kranggan	792,20	-
10	Pringsurat	2.214,00	1.553,96
11	Kaloran	624,00	427,71
12	Kandangan	925,00	680,20
13	Kedu	973,00	-
14	Ngadirejo	2.090,00	1.781,05
15	Jumo	1.261,79	929,42
16	Gemawang	1.864,00	1.089,94
17	Candiroto	466,00	297,05
18	Bejen	17,00	8,65
19	Tretep	-	-
20	Wonoboyo	455,00	395,60
	Total	16.058,79	9.904,88

Source: BPS (2019)

The study used mix method both quantitative through questionnaires, followed by in-depth interviews conducted to the agriculture office, then, combined with collaborative documentation to see its production and productivity which could be defined by the productivity formula:

$$\text{Tobacco productivity} = \frac{\text{production (ton)}}{\text{land (ha)}}$$

In addition, to find out the factors that influence farmers in adaptation model, *logistics regression models* were used to observe the farmers adaptability performance to sustain their cultivation. $P(Y) = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots\ldots + \beta_p + X_p$, $Y = \{0,1\}$

To come up with the possible factors influenced, this study compared some previous researches, such us (Uddin, Bokelman, & Entsminger, 2014) stated that factors such as age, education, family size, farm size, family income, and coping strategy experience have become a major influence to tobacco farmers' adaptation. In addition, Dang, Elton, Nuberg, and Bruwer (2019), observed a similar result as age, education, assets, household size, farm size, and farming experience become important factors, while resource, services, and technologies, including institutional support, and socio-cultural factor become additional factors to influence farmers' adaptation to climate variability. This study, therefore, taking some factors influencing tobacco farmers as a consideration in adapting to climate change included the age of the farmer (X1), the level of education (X2), the length of farming experience (X3), the farmer's knowledge of climate change (X4), the area of planting (X5), and the location (X6), described as follows:

$$P(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e$$

Note:
P = probability of farmers adapting
β_0 = constant (interception)
X_1 = age
X_2 = education level
X_3 = long farming experience
X_4 = farmers' knowledge of climate change
X_5 = land
X_6 = location
β = regression coefficient
e = *error*

2.1 Research framework

This study was aiming to identify the particular adaptation conducted by farmers in order to increase their productivity during the 2017 season, to find the final policy recommendation to other farmers. Kayombo, Komba, and Almas (2020) revealed that tobacco farmers usually conduct some adaptation strategies such as tree planting, agroforestry practice, cultivation of resistant crops, education of the local community, crop time rotation, and technology. In the other side, crop-livestock diversification, mulching, crop rotation, and the use of improved varieties also will lead to coping strategies and mitigation to reduce the impact of climate change (Fadina & Barjolle, 2018).

3. Results and Discussion

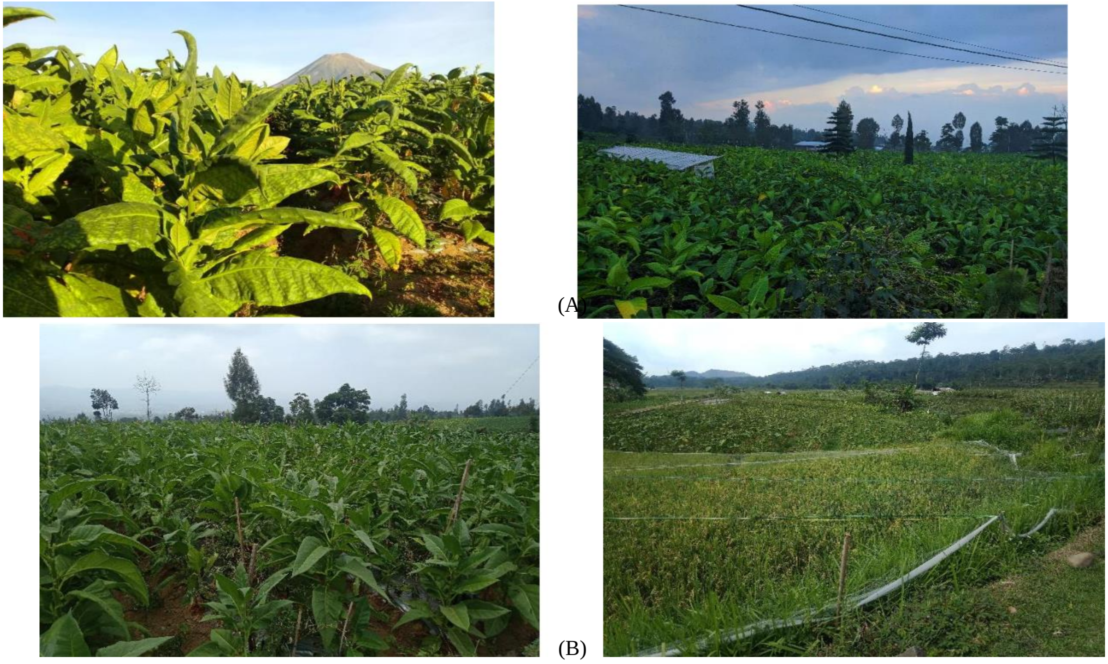
3.1 Results

Temanggung Regency is a proper cultivation area to produce high quality of tobacco, due to the tropical climate followed by characteristics of mountainous area. Aside from some differences in topographic characteristics, both The Kledung and Ngadirejo sub-districts, are the main tobacco producers (depicted in Figure 4). The Kledung sub-district is at 1,138 meters above sea level, while Ngadirejo sub-district is at 600 meters above sea level with a characteristic of flatter surface.

3.1.1 Tobacco productivity and farmers' strategies to climate change

Based on the results, tobacco farmers have claimed their production during the high rainfall dropped to 50%, where both regions have generally produced around 1,700 Ton deducted to around 800-900 tons, compared to production when rainfall is commonly low (depicted in Figure 5). For the Kledung sub-district especially, the climate variability has been impacted worse compared to another, where it has steeper farmland characteristics with more cases of land-slide problems.

In response to climate change, tobacco farmers have been taking some strategies to tackle the higher impact on low productivity. According to the findings, tobacco farmers have developed some strategies both on adaptation and mitigation. Adaptation strategies were conducted when there was occurred a high rainfall which caused adversity in pollination and abundant water source in the soil. The strategies included (1) improving irrigation channels (47.89%). To establish this improvement, farmers are joined in a group to propose the

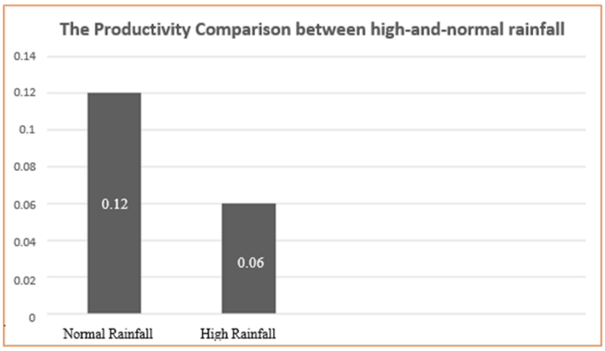


(A)

(B)

Note: (A): Ngadirejo, (B): Kledung sub-district
Source: Study documentation (2020)

Figure 4. Land topography of tobacco farming



Source: Research analysis (2020)

Figure 5. Average of tobacco productivity in Temanggung district

Figure 6. Innovation of irrigation on tobacco farmland

needs of irrigation establishment, particularly in a stepped land to avoid landslide problems. The government coordinated by both the agriculture department and infrastructure department will observe the farmland condition and evaluate it before taking a decision to establish the irrigation for the farmers. To advance irrigation, some farmers groups have been settled drip irrigation to sustain in the drought season (as depicted in Figure 6). Basically, there was no significant difference in the impact of irrigation frequency on tobacco yield (Guang *et al.*, 2019), however, the appropriate low irrigation amount may make it possible in order to increase the yield as well as reduce the water consumption during the drought season. Therefore, the use of water management innovation such as a micro-sprinkler system will be an economically viable alternative to rise which can be watering and gives net present worth for farmers (Rao, Chandrasekararao, Anuradha, & Pande, 2014).

(2) Replacing the input and technological support used by farmers (23.94%). Farmers have been supported by some additional sources of the climate-resistant crop. Dissemination of improved tobacco varieties could be important, but it has to be introduced carefully since it will cause a change of aroma (Rochman, 2012). The local varieties commonly have been known through their specific and unique aroma, while the new one could somehow devour the original aroma as well as taste. In addition, farmers are equipped with especially the smart-agriculture which could precisely help to predict the probability of rainy season before the planting period (*on-season*). It has been coordinated by the department of technology and communication to provide some information input of rainy prediction and knowledge dissemination. The rest strategy is about (3) harvesting earlier/time-mapping cropping (28.17%) which has been done thanks to the support of farmers' group which hold the regular meeting before the mapping strategies.

The mitigation strategies carried out by tobacco farmers aimed to minimize the risk of tobacco crop failure were such that (1) to accelerate or delay tobacco planting depending on rainfall conditions (61.97%), (2) reduce the area of tobacco (21.13%), (3) change the crop/crop rotation (9.86%), and the rest (4) widen the distance of each tobacco planting (7.04%). These strategies were becoming important strategies to reduce the climate change impact. As it was observed by Dhaka, Chayal, and Poonia (2010), the integrated farming system is the most common strategy (84.6%) for farmers aiming to be resilient the climate change, besides the crop rotation (74.8%), intercropping system (72.4%), cropping period/cropping rotation schedule (71.2%), and to develop the resistant variety (62,4). The farmers in both areas, Ngadirejo and Kledung sub-district, have been initiated to improve their capacity by those strategies to be more resilient in climate change impact, where in particular they have rotated the cropping strategies to other commodities, not only depending on tobacco.

However, due to the rainfall fluctuations, farmers have some obstacles to maintain production. A high rainfall had been experienced during 2016 when it caused a dramatic drop in tobacco production compared to previous years. The adaptation of climate for tobacco farmers could become a solution for farmers' resilience. As below analysis was depicted the factors to adapt the climate change.

3.1.2 Factors affecting tobacco farmers adaptation

3.1.2.1 Model due diligence (Goodness of fit)

The test result was a chi-square score of 9,193 and a significant number on the Hosmer and Lemeshow test of 0.326, which was a significant value ($\leq$0.05), thus the hypothesis was accepted.

3.1.2.2 Test overall model fit (Test likelihood ratio)

The independent variables together affecting the dependent variables could manifestly be known through the *likelihood ratio test*. Table 2 showed that *step 1, -2LL* results were decreased by 38,441 to be 71,670, which indicated a good regression model with fit data.

3.1.2.3 Determination coefficient (Nagelkerke R Square)

The determinant coefficient test results were presented in appendix Table 3, by 0.484, which could represent dependent variables by 48.4%, while the remaining 51.6% is explained by other factors outside the model.

Table 3. Pseudo R Squared Test

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	71.670[a]	.330	.484

Model summary
Source: Research Analysis (2020)

3.1.2.3 Partial test

This test was to measure the influence value of all independent variables which would become the main factors on adaptation of climate change, as follows:

Probability of adaptation = -2,847 -0.062 AGE – 0.061 EDUCATION + 0.145 EXPERIENCE + 0.000 LUAS_LAHAN + 2,541 UNDERSTANDING + 2,204 LOCATIONS + e

The value of *Exp*(*B*) named the *odds ratio* (probability) (Table 4) was used to interpret how depth the influence of independent variables to farmers' adaptation on climate change, as the following results:

The age indicates a significance rate of 0.269 > 0.05, meaning the age variable has no influence. The odds ratio for age variables is 0.940. The education shows a significant rate of 0.897 > 0.05, meaning educational variables have no influence. The odds ratio for educational variables is 0.940. The experience represents a significant rate of 0.011 <0.05, meaning the experience variable influences farmers' adaptation to climate change. The more farmers have experience in tobacco farming, they will positively adapt the climate change as much as 1,156 times higher to maintain their productivity. The land area represents a significant rate of 0.922 > 0.05, meaning the variable area of land has no influence. The odds ratio for the variable land area of 1,000. The comprehension shows a significant rate of 0.066 > 0.05, meaning the understanding variable has no influence. The odds ratio for understanding variables is 12,696. The location represents a significant rate of 0.004 <0.05, meaning the location variable has an influence. The location becomes an important factor to protect from climate change impact by 9.058 times. Thus, in case farmers have a more suitable

Table 2. Model due diligence -2LL step 1

Iteration		-2 Log likelihood	Coefficients						
			Constant	Age	Education	Experience	Land	Understanding	Location
Step 1	1	78.962	-1.561	-.032	-.118	.076	.000	1.578	1.119
	2	72.509	-2.364	-.050	-.106	.119	.000	2.165	1.780
	3	71.694	-2.764	-.060	-.073	.140	.000	2.471	2.126
	4	71.670	-2.844	-.062	-.062	.145	.000	2.539	2.201
	5	71.670	-2.847	-.062	-.061	.145	.000	2.541	2.204
	6	71.670	-2.847	-.062	-.061	.145	.000	2.541	2.204

Iteration History[a,b,c,d]
Source: Research Analysis (2020)

Table 4. Partial test

							95.0% C.I.for EXP(B)	
	B	S.E.	Wald	Df	Sig.	Exp(B)	Lower	Upper
Age	-.062	.056	1.220	1	.269	.940	.841	1.049
Education	-.061	.476	.017	1	.897	.940	.370	2.391
Experience	.145	.057	6.475	1	**.011**	**1.156**	1.034	1.293
Land	.000	.000	.009	1	.922	1.000	1.000	1.000
Understanding	2.541	1.381	3.387	1	.066	12.696	.848	190.112
Location	2.204	.760	8.410	1	**.004**	**9.058**	2.043	40.164
Constant	-2.847	2.554	1.242	1	.265	.058		

Variables in the equation
Source: Research Analysis (2020)

location such that location with lower average rainfall, they could perform more adaptation to climate change and maintain their productivity resilience.

Based on the above analysis, the particular factor affecting the adaptation of tobacco farmers is the farming experience of tobacco farmers with an odds ratio is about 1,156 times. Farmers would have more adaptive capability as many as 1,156 times higher if they have more experience (years). Basically, the experience of farmers would lead them to be more reactive and having more capacity to decide faster the adaptation strategies to reduce the crop failure "*pusso*". Regarding farmers' responses to tackle the worse climate change impact on their tobacco production, farmers basically have some agendas prior to the high rainy season which has been done usually by the farmers' group coordination. Farmers with years of experience have been more resistant to climate change problems thanks to their control group with a system to check the farmland characteristics and early adoption of the smart-agriculture system by climate variability information system as well as the usage of GMO tobacco with more water resistance. This is also confirmed by Dhaka, Chayal, and Poonia (2010), the ages of farmers, farming experiences, innovation, environmental awareness, and mass media exposure have a positive relationship with farmers' perception regarding climate change impact.

Another influential factor is the cultivation location factor with an odds ratio of as many as 9,058. This means farmers located in both Ngadirejo and Kledung Sub-district have a higher probability of adaptation to the climate change as many as 9,058 higher than the tobacco farmers in other areas. Location determines the adaptation due to differences in topography. In general, the Ngadirejo sub-district has flatter topography compared to Kledung sub-district, then, affected the amount of tobacco grown. Thus, it is indicated the flatter the tobacco cultivation area, the more tobacco could be grown more easily and suitably. Otherwise, The Kledung sub-district is more difficult for adaptation, since some undulating farmlands avoid them to build irrigation or water resource dam, where particularly, the irrigation program could be managed by the local government to reduce the amount of water flooded on the tobacco farmland.

3.2 Discussion

Climate change especially causing a significant increase in rainfall during tobacco season was very influential to tobacco productivity in Temanggung. According to Alemayehu and Bewket (2016), the climate has an important role and significant influence on agricultural commodity production. Furthermore, Alemayehu and Bewket (2016), confirmed local tobacco farmers had only produced around 50% less during the high rainfall season, compared to the normal rainfall. It is due to the fact that the tobacco is less resistant to water which causes tobacco is difficult to grow during the high rainy season. As it has happened to Ngadiredjo and Kledung which had a higher rainfall average period compared, then eventually it led to the reduction of tobacco productivity.

Based on the result of the *logit model*, it is evaluated that only two variables influenced the farmers' adaptation; farmers' experiences and farming location. Both factors have a significant influence to achieve climate change resilience by 1.156 times (experience) and 9.058 times (location). The longer farmers do tobacco farming (years), the more experience they will get. Thus, the ability to deal with various problems during tobacco cultivation is getting better. This is also confirmed by Putriani, Tenriawaru, and Amrullah (2018), to increase agricultural production, farmers make various efforts influenced by the experience of each farmer. To deal with the climate change problems, the experience of farmers is helping them to survive by doing some mitigation processes to their crops.

Following the climate mitigation, farmers in Ngadiredjo district have developed the system of collective "*timeframe planting*" where they have managed the time for cultivation (planting period). The farmers gather the information of heavy rainy sessions through a group of farmers where they have a controlling post consisting of farmer experienced leaders to search the real-time data such as (1) rainfall estimation period, (2) weather daily forecasting, and (3) the guidance service during the rainfall period to the farmer members. This service has been developed by the partnership with the meteorology agency (BMKG) to overlook the forecasting of weather conditions in some regions of Indonesia. The group leader will communicate and given the estimated period which becomes the proper planting period for farmers to plan their tobaccos. Hence, this service may allow farmers to be effective during the heavy rainy session period where the majority of farmers have been harvesting their tobaccos before the rainy season comes. For a more effective timeframe period of cultivation, the farmers have been prepared the seeds at the end of the rainy season, 3-

4 weeks, thus, after it ends, farmers directly start their cultivation of tobaccos. However, the government could yet improve this service through a combination of agriculture smart-farming systems which include the soil and leaf control system to the extent of quality management control for farmers.

On other hand, the effect of some topography differences between the two sub-districts on the adaptation opportunities of tobacco farmers is the same finding such that Sunariya and Taufiqurrahman (2019) stated that generally the land in Ngadirejo sub-district is more suitable for tobacco cultivation than Kledung Sub-district. This is because of the reason of stepper landside area of cultivation which causes a slight impact to the productivity. In tackling this problem, basically, the government has been committed to establishing the irrigation construction to put the flowing pathways of water to reduce the probability of land erosion or even landslide problems. However, the budget of irrigation construction somehow might take massive budget allocation from the government, thus, the farmers have to search for another option in order to reduce the landslide problem in the rainy season.

Some farmers have been decided to implement the intercropping system with another commodity, especially the massive roots plants which could support the landslide resistance by its massive roots. This has been conditionally applied by the majority of farmers, where they also have another source of income from this intercropping system by planting another agricultural commodity. Dhaka, Chayal, and Poonia (2010) stated that intercropping could benefit farmers by another income generated with more efficient land usage as well as making the balance of soil condition.

Finally, based on these all-findings farmers could react to make a suitable program to prevent a massive climate change impact, particularly a relocation of farmland as a mitigation strategy or even an efficient adaptive strategy such that crop mapping time to harvest earlier prior to the highest rainfall period and an irrigation construction as infrastructure development to reduce the amount of water flooding on the tobacco farmland.

4. Conclusions and Recommendations

4.1 Conclusions

To tackle the climate change impact, farmers have some factors to consider during tobacco cultivation by knowing the condition of climate change. However, the lack of understanding of climate change has been influenced the performance of their productivities. Farmers with more cultivation experiences could withstand by 1,156 times higher, in order by conducting some adaptation and mitigation strategies, such as (1) improving irrigation channels (47.89%), (2) Replacing the input and technological support used by farmers (23.94%), and about (3) harvesting earlier / time-mapping cropping (28.17%). Moreover, by gathering into a group, farmers and government have been tried to develop a system of (1) rainfall estimation period, (2) weather daily forecasting, and (3) the guidance service during the rainfall period to the farmer members. The other factor is cultivation location which influences significantly tobacco production by 9,058 times higher. The cultivation location with lower average rainfall and flatter area could sustain more compared to the other location.

4.2 Recommendations

To support the farmers' effective climate change mitigation, such recommendations have to be delivered:

1. The government needs to invite the regional university to involve in the climate change mitigation by some source of research budget allocation which allows them to apply the proper method in weather forecasting by a mobile platform;
2. There should be an official government body to maintain tobacco cultivation, from the preparation of the seeds to the cultivation and harvest aimed the assist the control system.
3. There should be protection for farmers during "*pusso*" crop failure through agriculture insurance to reduce their losses during their rainy season late harvest.

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References

Alemayehu, A., & Bewket, W. (2016). Local climate variability and crop production in The Central Highlands of Ethiopia. *Environmental Development, 19*, 36-48

Badan Meteorologi, Klimatologi, dan Geofisika. (2019). Average monthly rainfall in Temanggung. Retrieved from *www.bmkg.go.id*.

Badan Pusat Statistik Kabupaten Temanggung (Statistics of Temanggung Regency). (2016). Gross regional product on Temanggung District during 2012-2016.

Badan Pusat Statistik Kabupaten Temanggung (Statistics of Temanggung Regency). (2019). Tobacco productivity in Ngadirejo and Kledung Sub-district. Retrieved from https://temanggungkab.bps.go.id.

Cahyarini, S. Y., & Henrizan, M. (2018). Coral based-ENSO/IOD related climate variability in Indonesia: A review. *IOP Conference Series*: *Earth and Environmental Science*

Dang, H. L., Elton, L., Nuberg, I., & Bruwer, J. (2019). Factors influencing the adaptation of farmers in response to climate change: A review. *Journal Climate and Development*. doi:10.1080/17565529.2018.1562866

Dhaka, B. L., Chayal, K., & Poonia, M. K. (2010). Analysis of farmers' perception and adaptation strategies to climate change. *Libyan Agriculture Research Center Journal International, 1*(6), 388-390

Fadina, A. M. R., & Barjolle, D. (2018). Farmers' adaptation strategies to climate change and their implications in the Zou Department of South Benin. *Environments*, *5*(1), 15

Guang, J., Shao, X., Miao, Q., Yuang, X., Chao, F.D., & Yuan, Y., (2019). Efects of irrigation amount and irrigation frequency on flue-cured tobacco evapotranspiration and water use efeciency based on three-year field drip-irrigated experiments. *Agronomy Journal*, *9*, 624. doi:10.3390/agronomy 9100624

Herlina, N., Azizah, N., & Pradiga, E. P. (2020). The influence of temperature and rainfall to tobacco productivity (Nicotiana tabacum L) on Malang District. *Plantropica Journal of Agricultural Science*, *5*(1), 52-63

Hidayat, R. K., Ando, Y., Masumoto, & Luo. J. (2016). Interannual variability of rainfall over indonesia: impacts of enso and iod and their predictability. *IOP Conference Series*: *Earth and Environmental Science*. doi:10.1088/1755-1315/31/1/012043

Kayombo, C. J., Komba, L., & Almas, K. (2020). Climate change adaptation strategies among tobacco small scale growers at Kiloleli Village in Sikonge District, Tanzania. *East African Journal of Environment and Natural Resources*, *2*(2), 1-9. doi:10.37284/eajenr. 2.2.149

Lemeshow, S., Jr., Hosmer, W. D., Klar, J., & Lwanga, K. (1990). *Adequacy of sample size in health studies*. London, England: John Wiley and Sons.

Muttaqin, A. S., Suarma, U., Nurjani, E., Kurniadhini, F., Prabaningrum R., & Wulandari, R. (2019). The impact of climate variability on tobacco productivity over Temanggung Regency, Indonesia. *E3S Web of Conferences*, *76*. doi:10.1051/e3sconf/20197604003

Putriani, R., Tenriawaru, A., & Amrullah, A. (2018). The influence of the participation of farmers P3A members participation in the activities of the management of irrigation canals. *Socio-Economy Agriculture Journal*, *14*(3), 263-274

Rao, B. K., Chandrasekararao, C., Anuradha, M., & Pande, C. V. (2014). Effect of micro-sprinkler system on input use efficiency, labour cost and economic viability in tobacco (nicotiana tabacum) seedling production. *Indian Journal of Agricultural Sciences*, *84*(4), 439-43

Rochman, F. (2012). Development of improved Temanggung tobacco varieties of resistant to disease. *Journal Litbang Pertanian*, *32*(1), 30-38

Sudjana. (2006). *Metoda Statistika / Statistic Method*. Bandung, Indonesia: Tarsito

Sunariya, M., & Taufiqurrahman, I. (2019). The sustainability of tobacco plantation temanggung district. *Proceeding on Geography National Seminar*, Surakarta, Indonesia: Universitas Muhammadiyah.

Surmaini, E., & Faqih, A. (2016). The extreme climate and its impact on food crops in Indonesia. *Jurnal Sumberdaya Lahan*, *10*(2), 115-128

Udin, M. N., Bokelman, W., & Entsminger, J. S. (2014). Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: A farm level study in Bangladesh. *Climate*, *2*(4), 223-241. doi:10.3390/cli2040223