PROBABILITY OF CROP FAILURE DUE TO CLIMATE CHANGE, STUDY OF TOBACCO PLANT COMMODITIES IN TEMANGGUNG

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ABSTRACT

The objective of the study is to determine the probability of tobacco farmers experiencing crop failure as a result of climate change. The agricultural sector, includes tobacco, is a commodity that is vulnerable due to climate change. Climate change is a natural phenomenon that cannot be avoided. Symptoms of this natural phenomenon are rainfall, humidity, irradiation and temperature of floods, droughts or shifts in seasons. If these symptoms are not anticipated, the farmers have the potential to experience loss and declining in the production of copper in the temanggung, as the backbone of the economy of Central Java Province. The research method used is Qualitative Descriptive statistics with Logistic Regression. Techniques for collecting data using questionnaire techniques, interviews, observation and literature. The sample in this study amounted to 100 respondents who were tobacco farmers in the Parakan District. Based on the results of the study of independent variables that affect the probability of harvest failure of tobacco farmers in the Parakan sub-district are: (1) Age, (2) Duration of Farming, (3) Labor Wage Level, (4) Farmer Group Membership.

Keywords: *Adaptation, Climate Change, Logistic, Crop Failure*

JEL classification: *B41, C18, L66, Q59*

1. INTRODUCTION

Temanggung Regency is an area that has advantages in producing tobacco. Tobacco products from Temanggung Regency have high quality so that they become raw materials used in the production of famous cigarette products in Indonesia. The quality of tobacco products from Temanggung is recognized and acceptable to consumers. The problem now is that, farmers experienced difficulties in maintaining the quality of tobacco products. Tobacco quality is vulnerable to excessive rainfall which will greatly affect the productivity and quality of tobacco. The decline in production and productivity will certainly lead to threats of vulnerability or resistance of tobacco production which will eventually caused poverty in the area.

Based on the research of Susilowati (2016) which based on the application of GIS in Temanggung Regency, there are three sub-districts that are vulnerable to climate change, namely Parakan, Ngadirejo and Bansari. Research conducted by Susilowati (2017) shows that tobacco farmers in the Parakan sub-district of Temanggung Regency based on calculations with the LVI-IPCC Index value of 0.040 and the value of LVI 0.325 included in the vulnerable category. This means that tobacco farmers in the Parakan sub-district have a huge risk of reduced welfare because most farmers depend on their income from tobacco farming.

In Indonesia, agriculture in general is conventional agriculture, most of which still use traditional cropping patterns so that they rely heavily on natural conditions, weather, climate and geographical location. The imbalance between the amount of demand for an agricultural commodity and the availability of existing commodities disturbs the existence of agricultural production in the long run. Besides that, agriculture in Indonesia is not only as a human production activity but also as a form of long-term investment to produce a product in terms of agriculture which is expected to obtain the desired results and even expect a profit from these results.

Farmers who are vulnerable to loss as a result of climate change are farmers who cultivate seasonal crops. Seasonal farmers include rice, tobacco, and secondary crops. They face a dilemma to determine the right time in managing their crops in order to succeed in their farming business.

The development of tobacco area and production in Temanggung Regency has decreased. The following is presented in the development of land area and tobacco production in Temanggung Regency:

Table 1
Development of Tobacco Area and Production in Temanggung Regency 2010-2014

No	Year	Area	Production (Ton)
1.	2010	14.537	6.373,99
2.	2011	14.244	9.126,4
3.	2012	15.587	9.978,5
4.	2013	14.517	7.146,12
5.	2014	12.587	6.922,92

Source: Temanggung Local Goverment

Based on data on land area and tobacco production fluctuating. The fluctuating production will certainly have an impact on the availability of raw materials in cigarette production in Indonesia. This will affect the level of income of farmers, employees and even cigarette companies.

The Agriculture and Plantation Office noted that the total area of tobacco in Temanggung Regency in 2014 was 12,587 hectares which had decreased from previous years. The total land area is spread in 14 of the 20 sub-districts in this district. Only 6 sub-districts did not have tobacco land, namely Gemawang, Bejen, Kandangan, Kaloran, Kranggan, and Pringsurat Districts. The land area of tobacco plants in Temanggung is actually only a small part (around 12%) of the total agricultural land area of 24,543 ha. During the last five years in 2014 tobacco land area has experienced a sharp decline from 14,517 ha to 12,587 ha. The quality of Temanggung tobacco will determine the price on the market. This means that productivity increases, but the quality of the product is low, it will not provide adequate benefits for farmers.

Based on the urain, tobacco farmers in Temanggung have a risk or vulnerability to climate change so that it is necessary to further examine how the productivity of the impacts of climate change is.

1.1 Production Theory

Production is an activity of adding use / benefit value to a factor of production (input) or making new goods and services to meet needs. According to Heizer and Barry in Christian (2011), production is an activity in producing goods or services by changing the factors of production (input) into (output).

1.2 Production Factors

Both production and productivity are strongly influenced by production factors. To achieve maximum profit, there are two kinds of decisions that must be made by a producer when deciding to produce: (1) The amount of output that must be produced, (2) Amount and combination of what will be made with the factors of production (input) used. According to Sukirno (2013: 193), the factors of production can be divided into four, namely: (1) Capital, (2) Land, (3) Labor, (4) Entrepreneurship expertise.

1.3 Production Function

The technical foundation in each production process, in economic theory, is called the production function (Boediono, 1988: 64). The production function shows the maximum amount of output that can be produced in a certain period of time using various combinations of resources used in production (Reksoprayitno, 2000: 228). Mathematically simple, the production function can be written as follows:

$$Q = f(K, L) \quad \text{(equation 1)}$$

where:

Q = Output
K = Capital
L = Labor Input

In economics, Q is output in the form of goods or services produced by production. Whereas (K) and (L) are inputs as a form of simplification of production factors such as land area, labor, dummy variables, and so on. These production factors can also be denoted by (X) with the number (X) which is equal to the number of production factors used. In more detail, the function can be written as follows:

$$Q = f(X_1, X_2, X_3, \dots, X_i) \quad \text{(equation 2)}$$

The basic assumption in the production function is where all producers are required to submit to a law called The Law of Finishing Returns (Boediono, 1988). This law means to add output, can add one input unit while the other input remains. However, if the input is continuously added, the output will actually decrease. Because additional input continuously will only make productivity ineffective, so that production cannot be maximum.

2. RESEARCH METHOD

2.1 Population and Sample

In this research, population is resident in Parakan, Temanggung which is working as a tobacco farmer. The determination of sample's amount is referring to Slovin (1960), if population is not yet to be known then proportion sample need to be estimated by:

$$n = \frac{N}{1 + Ne^2}$$

where:

n = amount of wanted
N = population
e = false data rate that can be tolerated by the researcher

2.2 Operational Definition of Variable

2.2.1 Dependent Variable

Dependent variables in this research is crop failure. This variable is measured by farmer's crop failure probability due to climate chage, dicotomus dependent variable. Farmer which experienced crop failure = 1, farmer who do not = 0.

2.2.2 Independent Variable

Independent variables in this study are: (1) Climate Change Impact, is determined with 3 probability, crop failure, reduced in product's quality, and reduced in product's quantity, (2) Climate Change Adaptation, is determined by farmer's probability at adapting to climate change. That probability covers adjusting planting time, changing planting pattern and changing plant's type or land conservation which can withstand the current climate, (3) Labor wage, is given every planting period. Labor wage is a cost from a land owner to the farmers who works cultivating the land. Unit to measure farmer's labor wage is Rupiah per planning season (Rp/planting season), (4) Land area, is measured in meter square (m^2). Land area is a space or soil that use as crop producing activity, (5) Capital, measured with unit of Rupiah (Rp). Capital consist of cost by farmer to buy fertilizer, pesticide, and paddy seed, (6) Age, is respondent's age when this research is held. Variable measure with unit of year, (7) Education level, describes last formal education that experienced by respondents before working as a farmer, (8) Farming duration, determined by how long someone has been working as a farmer. The unit for this variable is year, (9) Income variable consist of income that received by farmers every month. Unit of this variable is Rupiah (Rp), (10) Farmer's group member is a dummy variable, score 1 for farmer who is currenly joined farmer's group, and score 0 for those who do not.

2.3 Data Analysis Method

2.3.1 Analysis Descriptive

Analysis descriptive in this research is used to explain the condition of research's subject generally. Research's subject consist of farming production, land area owned by farmer, climate change's effect, and farmer's adaptation towards climate change.

2.3.2 Logistic Regression Method

Data analysis in this research is using logistic regression due to dependent variable in this research is using dummy variable. Scire 1 for farmers who adapting to climate change and score 0 for those who do not. Logit mode is formed as follow:

$$\text{Ln}\left(\frac{\hat{P}}{1-\hat{P}}\right) = B_0 + B_1 X \quad \text{(equation 3)}$$

where:

Ln = natural logarithm
$B_o + B_1X$ = equation in OLS
$\hat{P}$ = Logarithmic probability

In that equation, $\hat{P}$ gained from equation:

$$\hat{P} = \frac{Exp\ (B_0\ +\ B_1X)}{1+\ Exp\ (B_0\ +\ B_1X)} = \frac{e^{B_0\ +\ B_1X}}{1+e^{B_0\ +\ B_1X}} \quad \text{(equation 4)}$$

Research model by Sukartini and Solihin (2013) is:

$$\Pr(Y = 1|X_i) = \beta_o + X'\beta_i + Z'\delta_i + \varepsilon_i \quad \text{(equation 5)}$$

where:

$\Pr(Y = 1|X_i)$: Farmer doing adaptation's probability.

Climate change impact: (1) Experiencing reduced quantity of production, (2) Crop failure occurred.

Climate change adaptation: (1) Changing planting time, (2) Changing planting pattern.

X' (crop production factorv vector): (1) Labor, (2) Fertilizer, (3) Pesticide.

Z' (Farmer's individual characteristic vector): (1) Age, (2) Gender, (3) Education background, (4) Farming experience, (5) Farmer's group participation.

β and δ_i is estimated paramter.

ε is model residual.

Estimated model in this research has been determined by equation from Sukartini and Solihin (2013) :

$$\Pr(Y = 1|X_i) = \beta_o + Q'\beta_i + R'\beta_j + X'\beta_k + Z'\beta_l + \varepsilon_i. \quad \text{(equation 6)}$$

where:

$\Pr(Y = 1|X_i)$ = farmer's adaptation towards climate change
β = estimated parameter
Q = Climate change impact:
- Q1: Crop failure occurrence
- Q2: xperiencing change in production's quality
- Q3: experiencing change in production's quantity

R = Climate change adaptation:
- R1: Planting time shifted
- R2: Changing planting pattern
- R3: Changing variety of crop according to climate or season

X' = Farming production input vectore
- X1: Capital
- X2: Land area
- X3: Labor's wage

Z' = Farming individual characteristic vector
Z_1: Age
Z_2: Education background
Z_3: farming experience
Z_4: Income
Z_5: Farmer's group participation
ε = model residual

3. RESULTS AND DISCUSSION

3.1 Respondent's Characteristic

This research's population is farmers in Parakan district which consist of 51.919 farmer. Sample determination in this research using Slovin formula (1960). Based on calculation, researcher obtained sample amount of 99,80≈ 100, researcher give quistionaire to 100 respondents.

General description of farmer's condition in Parakan distrik can be identified from quistionaire that has been given to 100 farmers. Those identifications cover amunt of farmer that impacted by climate change, climate change adaptaion, labor's wage, land area, capital, age, education background, farming experience, income, and farmer's group participation in Parakan Distirctm Temanggung, Central Java. The following is tobacco farmer's characteristic that become respondent in this research :

3.1.1 Climate Change Impact

Farmers in Parakan district experiencing a decreaseing in production as an impact of climate change. Based on farmer, 72% of them are experiencing decreasing in production rate, whereas thos who do not are 28%.

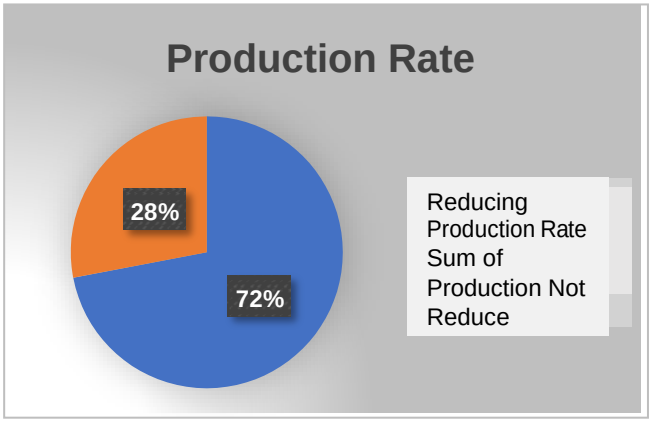

Figure 1. Production Rate
Source: Processed primary data

3.1.2 Climate Change Adaptation

Not all tobacco farmer in Parakan district that also take part in questionnaire are adapting to climate change. For examples of climate change adaptation are: shifting planting time, change the planting pattern land conservation, and other. Based on survey to farmers that performing climate change adaptation, 44% are doing it and the other 56% did not adapting due to climate change.

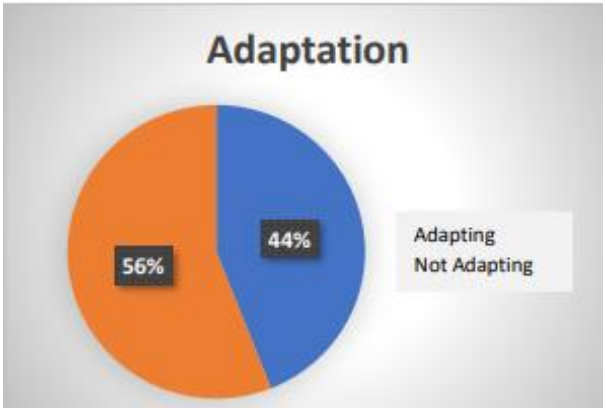

Figure 2. Climate Change Adaptation
Source: Processed primary data

3.1.3 Labor's Wage

Tobacco's maintenance that has been doing by the tobacco farmers starting since land cultivation, planting, nurturing, harvesting, and post-harvest. And for the labor's wage up until post-harvest time is about Rp 100.000 – Rp. 1.000.000 is at 71%, Rp. 1.100.000 – Rp. 2.100.000 is at 27%, and above Rp. 2.200.000 is only at 1%.

Figure 3. Labor's Wage
Source: Processed primary data

3.1.4 Land Area

Based of survey to 100 farmers that willingly to be respondents, land area that used for tobacco farming is as follows : 0,01-0,1 Ha is 17%, 0,11-0,21 Ha is 19%, 0,22 – 0,32 Ha is 29%, 0,33-0,43 is 12%, 0,44-0,54 is 16%, and land area more than 0,55% is 7%.

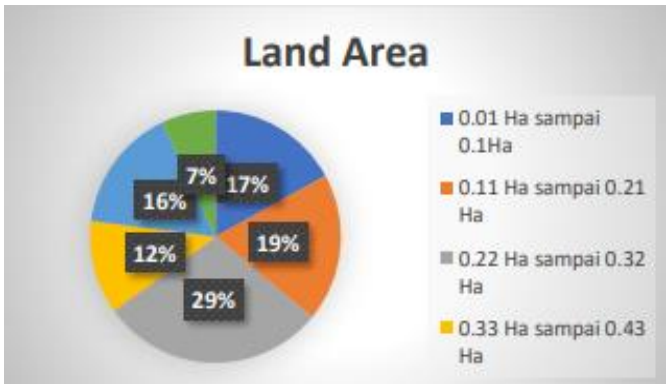

Figure 4. Land Area
Source: Processed primary data

3.1.5 Capital

Capital that has been used by the farmer in Parakan district to produce tobacco is various, starting with Rp. 100.000- Rp. 1.000.000 is 11%, Rp. 1.100.000- Rp. 2.100.000 is 15%, Rp. 2.200.000- Rp. 3.200.000 is 18%, Rp. 3.300.000- Rp. 4.300.000 is 10%, Rp. 4.400.000- Rp. 5.400.000 is 18%, Rp. 5.500.000 - Rp. 6.500.000 is 5%, Rp. 6.600.000- Rp. 7.600.000 is 3%, Rp. 7.700.000-Rp. 8.700.000 is 7%, and above Rp. 8.800.000 is at 13%.

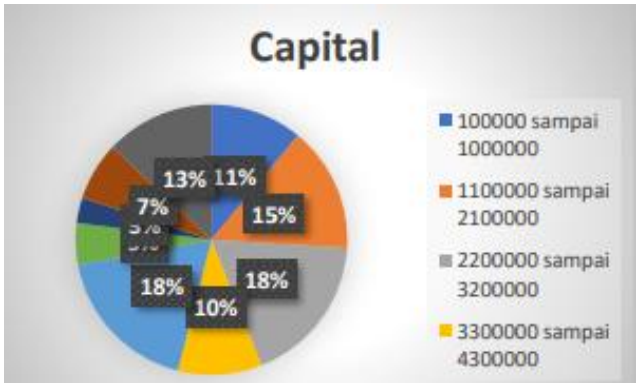

Figure 5. Capital
Source: Processed primary data

3.1.6 Repondent's Age

Farmer's age has an influence towards work productivity that will also effect the tobacco production. The older the farmer gets, the productivity will decrease until certain level due to physical incapability of the farmer itself. Farmer that still in a productive age tend to work better. But, in agricultural terms, usually the older the farmer is, they will have more experience and will do the work faster and better. The total amount of famrmer based on their age is shown on the following figure:

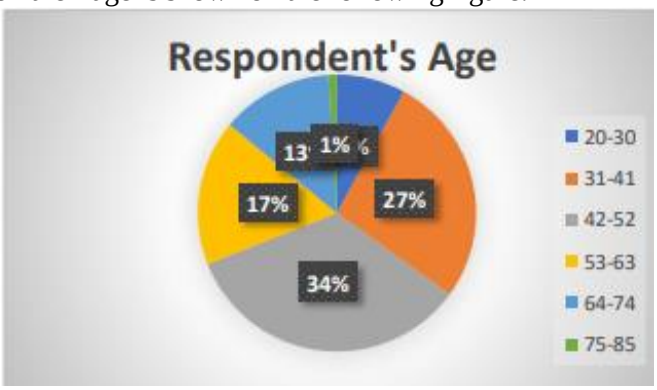

Figure 6. Respondent's Age
Source: Processed primary data

Based in survey, the highest age percentage is around 42-52 years old with 34%, and the lowes is around 75-85 years old with only 1% population. The age of the farmer can influenced the respondent's productivity, as age increasing, productivity decreasing. Majority of respondent in this research are include in a productive age range, with 27% (31-41 years old) and 17% (53-63 years old).

3.1.7 Educational Background

Farmer's ability usually based on knowledge and experience that each individual had. Knowledge is learned through formal or nonformal institutions. Experience of farmer also need tob supported with education. Education can help farmer in forming the thinking structure simply and can be used to receive, process, and utilize some information. Educational background will also determine farmer's reaction towards an opportunity. Respondent's educational background on this research can be seen as follow:

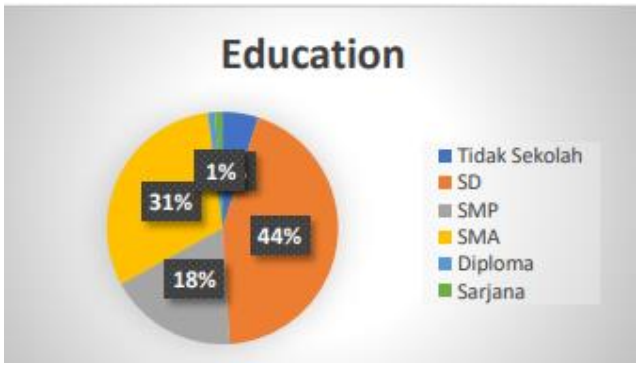

Figure 7. Educational Background
Source: Processed primary data

Based on survey, educational background of tobacco farmer in Prakan district with the highest percentage is elementary school with 44%, and the lowest is bachelor or diploma with each 1%. In this research, the highest educational background that the farmer has is at senior high school. Based on the data, we can conclude that the majority of farmer only had elementary school education with the highest percentage.

3.1.8 Farming Experience

People in Parakan district mostly works as a farmer, tobacco farmer to be exact. Most of them already working as farmer for 11-21 years with 31% and who works only 1-10 years only 19%.

Figure 8. Working Duration as Farmer
Source: Processed primary data

3.1.9 Income

Household's income can show the economic state a household. Respondent's income varies from one another. And income does not come only from main job but it also include total earning that received by respondent every year. This are the data about the farmer's income in Parakan District.

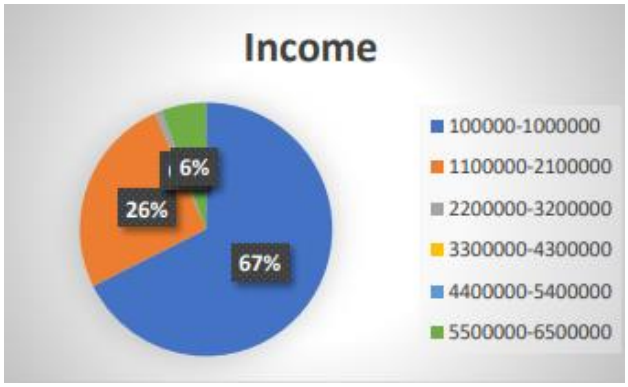

Figure 9. Income
Source: Processed primary data

Based on survey, we can conclude that most of tobacco farmer's income in Parakan district is around Rp. 100.00 – Rp. 6.000.000 every month. The highest percentage is about Rp. 100.000 – Rp. 1.000.000 with 67%. Whereas for the lowest percentage is about Rp 5.000.000 – Rp. 6.500.000 with only 6%.

3.1.10 Farmer's Community Member

Based on survey, we can see that most of those who become this research's respondent are joined in Farmer's Community Member with 68%, and the other 32% did not joined. These are reasons to join farmer's community: (1) developing farming ability, (2) expanding the product's marketing, (3) gaining farming's information moreover about tobacco, (4) as an exchanging ideas and experience among members, (5) solving mutual problem such as climate change that affecting tobacco crops. So with the existence of this community can increase the prosperity if tobacco farmer's life.

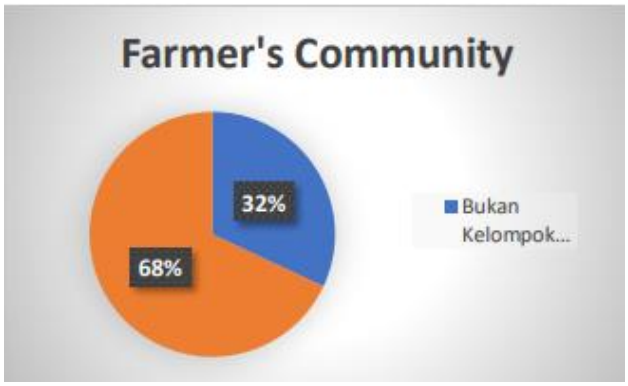

Figure 10. Farmer's Community
Source: Processed primary data

3.1.11 Land Ownership Status

Tobacco farmer in Parakan Disrict mostly plant tobacco crop on their own land is at 75% percentage, whereas pn;y 25% frmer rent a land for planting tobacco.

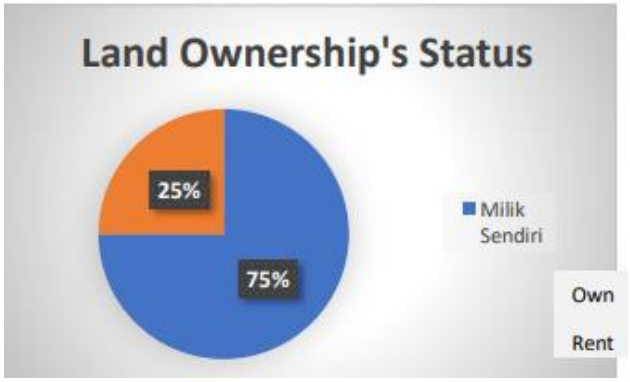

Figure 11. Land Ownership's Status
Source: Processed primary data

3.2 Data Analysis

Data analysis in this research is using logistic regression because th variable dependent in this research is using dummy. Score 1 for farmer who experienced crop failure, and score 0 for those who do not due to climate change. Logistic regression model in this research is:

$$\text{Ln}\left(\frac{P}{1-P}\right) = B_0 + B_1X \quad 14{,}214 + 0{,}318\ X1 + 0{,}801X2 - 0{,}251X3 + 2{,}834X4 + 2{,}042X5 - 2{,}005X6 - 2{,}724X7 - 1{,}156X8 - 6{,}417X9 + 3{,}401X10 \quad \text{(equation 7)}$$

where:

$$\text{Ln}\left(\frac{\hat{p}}{1-\hat{p}}\right) = B_0 + B_1X$$

= experiencing crop failure probability
X1 = age
X2 = education background
X3 = farming experience
X4 = land area
X5 = capital
X6 = income
X7 = labor's wage
X8 = climate change adapation
X9 = farmer's community membership
X10 = climate change's effect

3.2.1 Logistic Regression Significance Test

Based on the result of logistic regression, we received an output as follow:

Table 3
Summary's Regression Logistic Model
Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	22.867[a]	.256	.600

Source: Temanggung Local Government

where:

a = Estimation terminated at iteration number 8 because parameter estimates changed by less than 0.001.

Table 4
Regression Logistic Result

Variable	Koefisien	Wald	Sig
Age	.318	5.803	.016
Educ	.801	1.004	.316
Experience	-.251	4.856	.028
Lnlandsq	2.834	.137	.711
Lnasset	2.042	3.277	.070
Lnincome	-2.005	.790	.374
Lnwage	-2.724	5.914	.015
Adaptasi	-1.156	.496	.481
Family	-6.417	4.535	.033
Climate Change Impact	3.401	2.280	.131
Constant	14.214	.263	.608

Based on a regression logistic result, we can see the impact of each independent variables towards dependent variable (Crop failure as an effect of climate change's probability), are:

Age Variable (XI): Regression result shows that age variable effect partially towards crop failure's probability. That result shoed from the value of P in wald (sig) tes which is 0.016 < 0,05. The positive correlation shows that the older the farmer are, they have 1,374 times more of experiencing crop failure compared to younger farmer. We get 1,374 shows from value of Exp (B) or odds ratin. This result supports the founding of Ellis (2016), the older the farmer is, they become less and less cared and pay attention towards climate change.

Education Variable (X2): Regression logistic's result shows that education variable did not influenced partially towards crop failure probability. The result shows with P value on wald (sig) test which is 0,316 > 0.05. Education background of tobacco farmers in Parakan district is varies from uneducated to bachelor degree. Those variatons of education background did not influenced towards crop failure due to climate change. Different result with published founding by Satutyningsih and SUryanto (2011), Koatchen, Boyle, and Leiserowitz, (2013), Gazanfhar, et al. (2015). Education beckground makes society cares about risks that will be faced. This result indicates that education background less likely to be influenced towards climate change knowledge.

Farming Experience Variable (X3): Logistic regression result shows that farming experience variable influenced partially towards crop failure probability. The result shown based on P value Wald (Sig) Test which is 0,028 < 0,05. Farmer who had more farming experience have lower crop failure probability at 2,227 times more likely than new tobacco farmer. This result affirm the Ghazanfar, et al. (2015) research. The more experience someone has experience of doing farming, the have more experience and knowledge to farm tobacco better and more efficient.

Land Area Variable (X4): Logistic regression result shows that land area variable did not influenced partially towards crop failure probability. Land area that own by tobacco farmer in Parakan District does not influenced farmer in the crop failure probability. This result shown by P value Wald (Sig) test which is 0,711 > 0,05. Based on land ara survey that owned by tobacco farmer varies start from 0,1 Ha – 2 Ha that used to tobacco farming.

Capital Variable (X5): Logistic regression result shows that capital variable that used for tobacco farming is not influenced crop failure probability. Based on statistic calculation we got P value wald (sig) test o,97 > 0,05 so no matter the amount of capital used for farming did not affect towards crop failure probability.

Income Variable (X6): Regression logistic result shows that tobacco farmer's income did not influenced partially towards farmer's crop failure probability. The result shown by P value wald (sig) test at 0,374 > 0,05. Farmer's income in Parakan district varies, but neither much or few income the got did not influenced them to adapt towards climate change so that also did not influenced towards crop falure probability. This research is corresponding wih Sadiki et al. (2017) and Cheung and Jim (2014)'s research about a high income rate influenced toward paying willingness. Higher income will affect towards consument's choice which is better towards environment's quality.

Wage Variable (X7): Regression logistic result shos that labor's wage's rate influenced partially towards crop failure experienced by farmer. That result shows p value wald (sig) test at 0,015 < 0,05. Wage that spent by farmer since land cultivation, planting, maintenance, harvesting, and post-harvesting can affected tobacco's growth and also affect towards quality and quantity of tobacco itself. Farmer that spend wage for planting and maintenance for tobacco plant have a 0,066 times more crop failure probability than those who did not spent any wage at all for plant maintenance.

Adaptation Variable (X8): Logistic regression result shows that adaptatoion that done by tobacco farmer did not influenced crop failure probability partially. This result shown by P value wald (sig) test at 0,315 > 0,03. Adaptation that applied by tobacco farmer in Parakan district are : change the planting pattern, changing planting time, solaritation, fertilization and others in fact can not reduce the impact of climate change in these past few years.

Farmer's Community Variable (X9): Logistic regression result shows that farmer's community membership partially influenced towards crop failure probability. This result got from P value wald (sig) test is 0,033 < 0,05. Tobacco farmer's activity on farmer's community can increase knowledge, insight and also become a farmer's media to exchange insights to overcome climate change's impact. Farmer's probability that joined this community compared to those who do not is 0,002 times more likely.

Climate change's Impact Variable (X10): Based on logistic regression result can be seen that climate change's impact did not partially influenced towards crop failure. This result shown by P value of wald (sig) test is 0,131 > 0,05. Correlation impact climate change positive means that the higher climate change's impact will give more impact farmer's chance experiencing tobacco farming crop failure in Parakan district.

4. CONCLUSIONS

Based on research's result can be concluded that independent variable can influenced crop failure's probability tobacco farmer in Parakan district is: (1) age, (2) Farming experience, (3) Labor's Wage, (4) Farmer's Community Member. Crop failure's prediction in Temanggung Regency generally can be equalized with other commodity farmer's characteristics. Interestings variables are farmer's age and farming experience significant to be used as a predictor. This this imply that the more traditional people do the farming, the chance of experiencing crop failure is higher.

Based on research result, implication of this research is as follows: (1) Farmer can increase their knowledge and awareness in effort to reduce crop failure's risk due to climate change, (2) Government can increase their role in giving counseling, facility, and infrastructure that can improve knowledge and awareness for farmer to reduce the climate change's impact.

Suggestion for development and next generation are respondent in this research can be increased to other disctrict other than Parakan, such as Ngadirejo and Basari District. Based on Susilowati (2016), those two districts also fragile towards climate change, so we can make a caomparisan among those three districts in adapting towards cliate change and crop failure probability.

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