Analysis of climate and population dynamics of
Conomoporpha cramerella pest in North Luwu

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Abstract. Indonesia is one of the most widely grown cocoa growing countries in the world and is the third largest cocoa producing country after Ivory Coast and Ghana. Cocoa is a plant that is not native to Indonesia but is able to adapt and grow well in Indonesia. Geographic Information System (GIS) is a system created to facilitate mapping by using structured data by setting spatial or geographical coordinates in utilizing and planning land use. Decrease in yields on cocoa is partly due to Cocoa Fruit Borer (CPB) (Conomoporpha cramerella Snellen). There is a very close relationship between local climatic conditions and the dynamics of pest populations, especially the factors of temperature, humidity, and altitude. The lowest percentage for mild attacks of CPB pests over the past 5 years ignoring missing data is in April 2014, 2015 and 2016 was 15.30%. Whereas the highest percentage of severe CPB pests in the last five years was in February 2015 which was 88.09%. Controlling the CPB pests can be done by using CPB pest resistant clones as well as improving plant maintenance management.

1. Introduction
Indonesia is one of the most widely grown cocoa growing countries in the world and is the third largest cacao producing country after Ivory Coast and Ghana. Even though cocoa is not Indonesian native plant, it is able to adapt and grow well in Indonesia. The Center for Agricultural Data and Information Systems of the Ministry of Agriculture stated that the total area of Indonesian cocoa in the 1980-2016 period was dominated by People's Plantations (PR) with an average contribution of 91.30% while State Large Plantations (PBN) of 5.71% and Plantations Large Private Sector (PBS) 6.18% of the total area of Indonesian cocoa. In the period of 2012-2016 (last five years), the contribution of the area of PR cocoa area increased slightly to 97.42% while PBN and PBS was 1.41 and 1.92%, respectively, of the total area of cocoa in Indonesia [1].

One of the factors causing low cocoa crop productivity includes the influence of pests and plant diseases [2]. South Sulawesi is one of the largest cocoa contributing provinces in Indonesia, cocoa crop production in the interval of 2010 to 2015 experienced the highest fluctuations in production at 772.8 tons/year in 2015 [3]. The decline in yield on cocoa is partly due to the Cocoa Fruit Borer (Conomoporpha cramerella Snellen). Cocoa Borer (CPB) is very difficult to control due to damaged caused by the larvae is inside the fruit. Larvae of CPB enter the cocoa fruit and damage the placenta in the fruit so that the cocoa beans become hollow and harden [4]. Pest attacks directly affect cocoa
production causing yield losses of up to 82.2% [5]. The impact of climate change indicates the emergence of secondary pest explosion (resurgence) which can reduce crop productivity [6]. Short-term climate change studies are now very important [7]. The development of climate information systems is necessary as it is one of the ways to adapt to the impacts of climate change [6].

2. Methodology
The research was carried out on farmer's land located in North Luwu Regency. The making of the map of the earth was carried out in the Climatology and Biostatistics Laboratory of the Department of Agronomy, Faculty of Agriculture, Universitas Hasanuddin. The research was carried out from April to July 2019 using survey methods. Two forms of data used were primary and secondary data. Primary data consisted of soil analysis data, data collected by interviews, questionnaires, and observations the respondents. In addition, interviews and discussions also was conducted with experts and cocoa farmers using prepared questionnaires relating to internal and external factors that affect cocoa productivity. Secondary data consisted of data obtained from various literatures, publications of related institutions, books, journals as well as from previous research results that are still relevant and valid. Secondary data collected included land area, production and productivity of cocoa plants.

Technical implementation of the study was conducted by collecting primary and secondary data needed in running the geographic information system (GIS) program. A field observations were conducted including collecting data related to coordinates on the surface of the earth, research locations, geometric shapes (dimensions), and coordinates of each location using Global Positioning System (GPS) to produce a map of the earth's appearance. In addition to these data, climate data also collected namely rainfall, humidity and temperature taken from the Meteorological Climatology and Geophysics Agency of the Masamba station.

Following data collection, the data input into the GIS technology was carried out using the ArcGIS application. The results obtained were in the form of maps, photos and other research location attributes. Validation of the results was done to compare the results of predictions on observational data so that the level of accuracy of the results can be at least close to the actual conditions on the ground.

3. Results and Discussion
The total area of North Luwu Regency is 7,502.58 Km² with a population of 321,979 people and the Government is administratively divided into 11 districts with 167 villages, 4 sub districts and 4 Transmigration Settlement Units (Figure 1).

![Figure 1. Sabbang district administration map](image-url)
Sabbang is one of the districts in the North Luwu Regency which has an area of around 525.08 Km². Sabbang district consisted of 20 villages where all villages have definitive status. The village with the largest area is Malimbu Village (114.86 Km²) or covers about 21.87% of the Sabbang District area. The village with the smallest area is Batu Alang Village (4.11 Km²) or 0.78% of the total area of the district.

![Figure 2. Monthly evaporation data of North Luwu region in years 2014 - 2018](image)

Based on monthly evaporation data from 2014 – 2018, shown in figure 2, monthly evaporation data is unstable. The highest monthly evaporation data was in October in 2014 at 193.4 millimetres and the lowest value in October was in 2016 at 143.2 millimetres (Figure 2).

![Figure 3. Average monthly humidity of North Luwu region in years 2014 - 2018](image)

The average monthly humidity in the last five years (2014 - 2018) ranged between 70% - 87%. In Figure 3, the average humidity at the beginning to the middle of the year (January-August) tended to have a higher average humidity (approaching and even exceeding 80%) compared to September-November (<80%). The graph in figure 3 shows a similar pattern for the average humidity in the last five years. Humidity is very closely related to air temperature, both will change from time to time. Humidity is the amount of moisture in the air [8]. Humidity is inversely proportional to temperature, if humidity rises the temperature will decrease, and vice versa [9].
Figure 4 shows that the average monthly temperature in North Luwu in January - September 2016 showed the highest average value compared to other years. The average temperature was between 26.9°C - 28.1°C. The lowest average monthly temperature was in January – September 2014. The average temperature was between 26.1°C - 27.2°C. Altitude affects temperature and environmental humidity which correlate to the level of CPB attacks and their population [10].

Figure 5. Monthly rainfall in North Luwu in 2014 - 2018

Monthly rainfall data is presented in Figure 5. Rainfall data is observed from 2014 - 2018. The graph in Figure 5 shows that rainfall data in the last five years has been volatile. According to Koesmaryono [11] explosion of a pest population may be very closely related to the periodicity of the rain distribution. Seasonal variations in rainfall affect species abundance. High rainfall increases humidity in the plant environment so it is very supportive of pest development [12].
Figure 6. Map of rainfall distribution of Sabbang Subdistrict, North Luwu Regency

Figure 7. Relationship between temperature and light attack area (a) and severe attack area (b) in North Luwu area in 2014.

Figure 8. Relationship between temperature and light attack area (a) and severe attack area (b) in North Luwu area in 2015
Figure 9. Relationship between temperature and light attack area (a) and area of severe (b) in the North Luwu region in 2016

Figure 10. Relationship between temperature with light attack area (a) and severe attack area (b) in North Luwu region in 2017

Figure 11. Relationship between temperature and light attack area (a) and area of severe attack (b) in North Luwu region in 2017

Figure 12. Relationship between rainfall and light attack area (a) and area of severe attack (b) in the North Luwu region in the year 2014.
Figure 13. Relationship between rainfall and light attack area (a) and area of severe attack (b) in the North Luwu region in the year 2015.

Figure 14. Relationship between rainfall and light attack area (a) and area of severe attack (b) in the North Luwu region in the year 2016.

Figure 15. Relationship between rainfall and light attack area (a) and area of severe attack (b) in the North Luwu region in 2017.

Figure 16. Relationship between rainfall and light attack area (a) and area of severe attack (b) in North Luwu region in 2018.
All insect species in general are difficult to adapt to high temperature conditions and are below the species threshold, so that the impact on propagation will experience a phase change to be faster than normal time it causes the reproductive maturity in male insects will take place faster so that it affects the life cycle of these insects. Spatial shifts in the distribution of plants under changing climate conditions will also affect the distribution of insect pests in the geographical region [13].

High rainfall also affects the survival of pests but with climate change the insect's lifestyle also changes, based on observations, if extreme rainfall conditions will affect pests primarily imago to lay their eggs on the host so that in extreme conditions of CPB pest attacks also decrease if compared to the condition of areas that have normal rainfall which is one of the ideal factors for breeding pests [14].

4. Conclusions
The primarily factors of local climatic conditions closely related to with the dynamics of pest populations were temperature, humidity, and altitude. The lowest percentage for mild attacks of CPB pests over the past 5 years, ignoring missing data is in April 2014, 2015 and 2016, was 15.30%. Whereas the highest percentage of severe CPB pests in the last five years was in February 2015 which was 88.09%.

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