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Mapping the Model of Ecological Vegetation as Potential Malaria Habitats in a Malaria-Endemic Region in Oesao Village, Kupang Regency, Indonesia

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ABSTRACT

Environmental risk factors, both physical and biological (e.g. ecology of vegetation/plants, forest), equally serve as the risk factors for *Anopheles* mosquitos breeding. This study was designed to determine a model of spatial mapping for the ecology of vegetation and the potential habitats for the *Anopheles* mosquitos. Descriptive epidemiological research was implemented to carry out the project, supported with a cross-sectional design. The research took place in Kupang regency, Oesao village, lasting for 2 months from October to November 2014. The ecology of the vegetation and all habitats of the mosquitos in Oesao village were regarded as the population of the research. They were purposively sampled. The vegetation mapping revealed that the land area for rice fields is 169 ha, coconut and banana tress 56.68 ha, maize 67.03 ha, vegetable plants 59.53 ha, forages 21.52 ha, and forests 16.24 ha. The results of the mapping also revealed that the mosquitos breeding sites entail paddy fields, swamps, irrigation channels, and damps. The ecology of all types of plants mapped serves as potential habitats for the *Anopheles* mosquitos breeding sites. Plant ecology is quite varied in the Oesao Village, as well as extensive areas of the plant that are closely linked to inadequate growth and development of mosquitoes and specific species of *Anopheles*, *An. vagus* and *An. annularis*.

Keywords: *Ecological vegetation mapping; Breeding sites; Malaria mosquitos*

INTRODUCTION

Malaria, a mosquito-borne disease, has caused an enormous number of deaths worldwide, particularly in the developing countries(1). Children and pregnant women are the most vulnerable groups to malaria deaths. The eastern Indonesia province of Nusa Tenggara Timur (NTT) is one of the provinces with the third highest malaria case in Indonesia; there was an estimated of 16.37% of malaria cases confirmed with blood test(2). Based on the Annual Report of the Provincial Health Office of NTT, the annual parasite incidence (API) for Kupang regency has been high for the last three years, with API of 3.55 ‰ in 2009, 6.48 ‰ in 2010, and 6.72 ‰ in 2011(3).

There are community health centers (*puskesmas*) in Kupang regency showing an increase of malaria cases, included as health centers with high case incidence (HCI), i.e. Oesao, Naikliu and Oekabiti. The health center in Oesao district is the one with the highest number of increasing malaria cases. Concerning the Annual Parasite Incidence (API) in Oesao, it reached 4.04 ‰ in 2009, and continuously increased to 7.67 ‰ in 2010 and 10.17 ‰ in 2011(4).

In NTT province the physical and biological environment (plant/plant ecology, forest) serves as environmental risk factors for *Anopheles* mosquitos

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breeding. This is so, for the spread, cluster and varieties of plants greatly vary; it is further supported by temperature, light intensity, air temperature, humidity, wind speed and precipitation, all of which provide suitable breeding environments for *Anopheles* population. The bionomic life of mosquitos that suits both the environment and cultural factors present in the society and the community behaviors becomes reinforcing and enabling factors, supporting the *Anopheles* mosquitos breeding in NTT province. As a result, it still places the province at a high risk of malaria cases and this becomes the major problem in the pursuit of malaria eradication.

There has not been an effort made to carry out spatial mapping (geographically) to map the physical and ecological factors of plants and mosquito breeding sites; the employment of advanced technology for mapping local specific areas with appropriate and accurate equipments is still rare as well. Such technology is pivotal to obtain a description of the physical environment conditions, the ecological patterns (species and area of forests/plants), and the geographical locations of the mosquito breeding sites (river, lake, standing water, ditch).

This study aims to map the risk factors for malaria: mapping of plant ecology and potential breeding habitats of *Anopheles* mosquitos. Furthermore, images of the mapping are used as the basis in establishing malaria intervention and eradication model in malaria endemic areas in Kupang regency.

MATERIALS & METHOD

Research Design

Descriptive epidemiological research was implemented to carry out the project, administering surveys to obtain ecological and geographical information. Furthermore, a cross-sectional study was employed. This research was conducted in Kupang regency, Oesao district. The research lasted for 2 months running from October to November 2014. Population in this research is all *Anopheles* sp mosquito habitats and plant ecology in Oesao distric, Kupang regency.

Data Collection

The mapping of plant ecology and malaria breeding sites is done by mapping the distribution and abundance of plants in the *Anopheles* sp mosquito habitats and measuring the mosquito breeding sites in the malaria endemic areas using GIS and GPS equipments.

Research Instruments

GPS (Global positioning system) was operated to take coordinates and track the mosquito habitats in the research site and a software, was respectively employed to process the data.

Data Analysis

The data obtained were presented in the form of spatial map images, which were then spatially and descriptively analyzed. Spatial data analysis program was used to process the spatial data.

FINDINGS

The larval habitat map consists of 4 habitat types: rice fields, swamps, rivers, irrigation channels, and dams. Based on Figure 1, it can be seen that larval habitats for rice fields have larger areas than other larval habitats; the arable area is 169.00 Ha. Other larval habitats found are water dams, swamps, irrigation channels and rivers, all of which become the breeding sites of *Anopheles* mosquito larvae. From the above map, it appears that all potential habitats for the growth and the spreading of *Anopheles* mosquito larvae reside in this region, covering a quite large area.

As presented in Figure 2, the area for coconut and banana trees covers 56.68 hectare. They are kinds of high-tree plants. So far, there has not been any research finding describing the leaves of coconut and banana trees as favorite resting places for *Anopheles* mosquitos.

Based on Figure 3, the map of the distribution of the maize (not kinds of high-tree plant species) spread evenly throughout the village. The area of maize is 67.03 hectare. From all plant species, maize covers the largest area.

Vegetable plants widely found in Oesao village are mustard, water spinach, cabbage, and root tuber. The land area for the vegetable crops is 59.53 hectare. Most people work to grow fast growing or short-term vegetables that can be immediately harvested. The crops are for local consumption, and they are also sold (Figure 4).

Figure 5 shows the forest land area in Oesao village. The forest land area for large plant types is quite small, covering only 16.24 hectare. It is the smallest area

compared to other areas in the village.

Types of plants included in forage plants are red barons, grasses, and shrubs. In Figure 6 above, it is shown that the land area for the forage plants covers approximately 21.52 hectare.

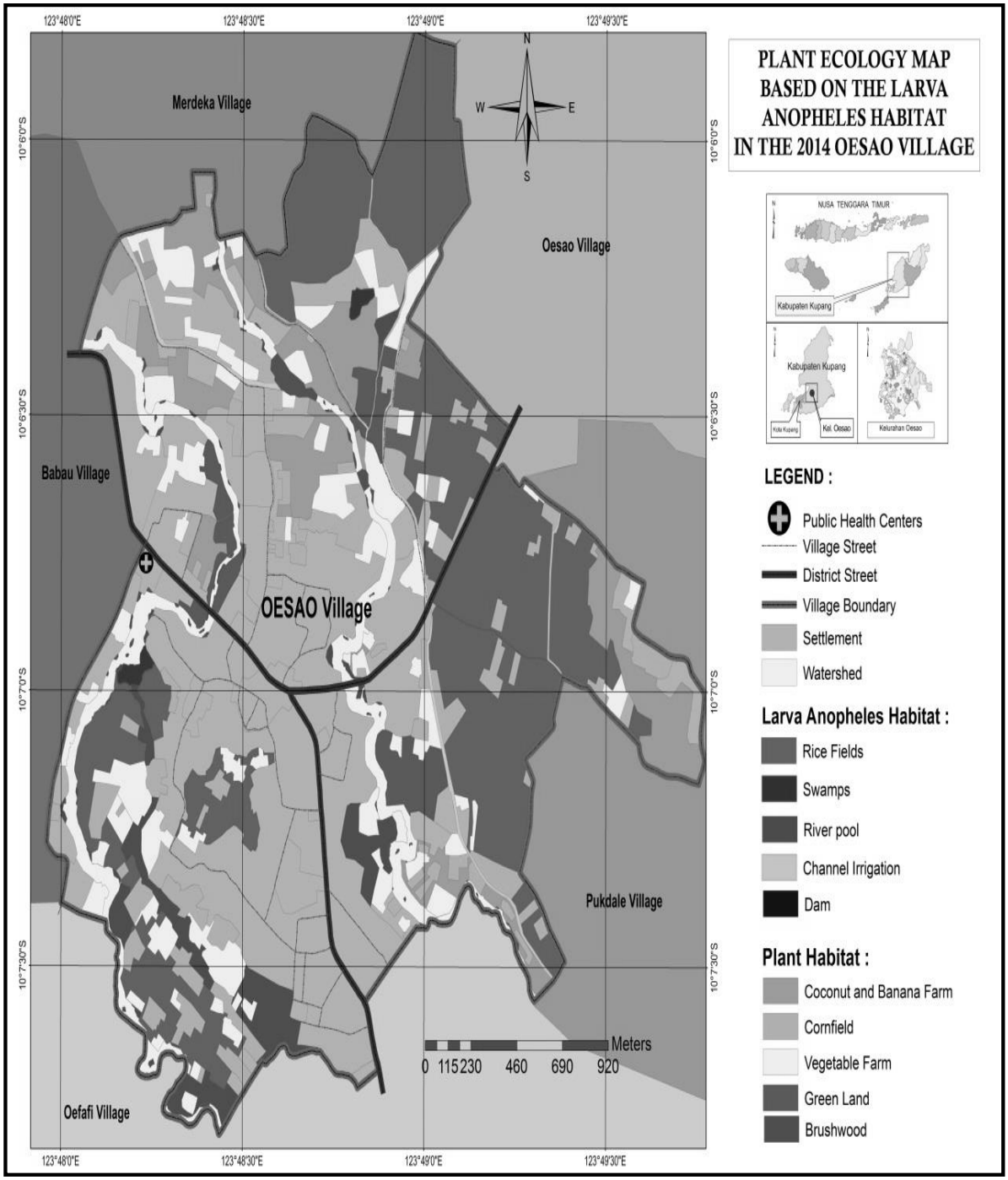

Figure 1. A Map of mosquito breeding sites (*Anopheles Sp* larval habitats) and ecology of vegetation in Oesao Village in 2014

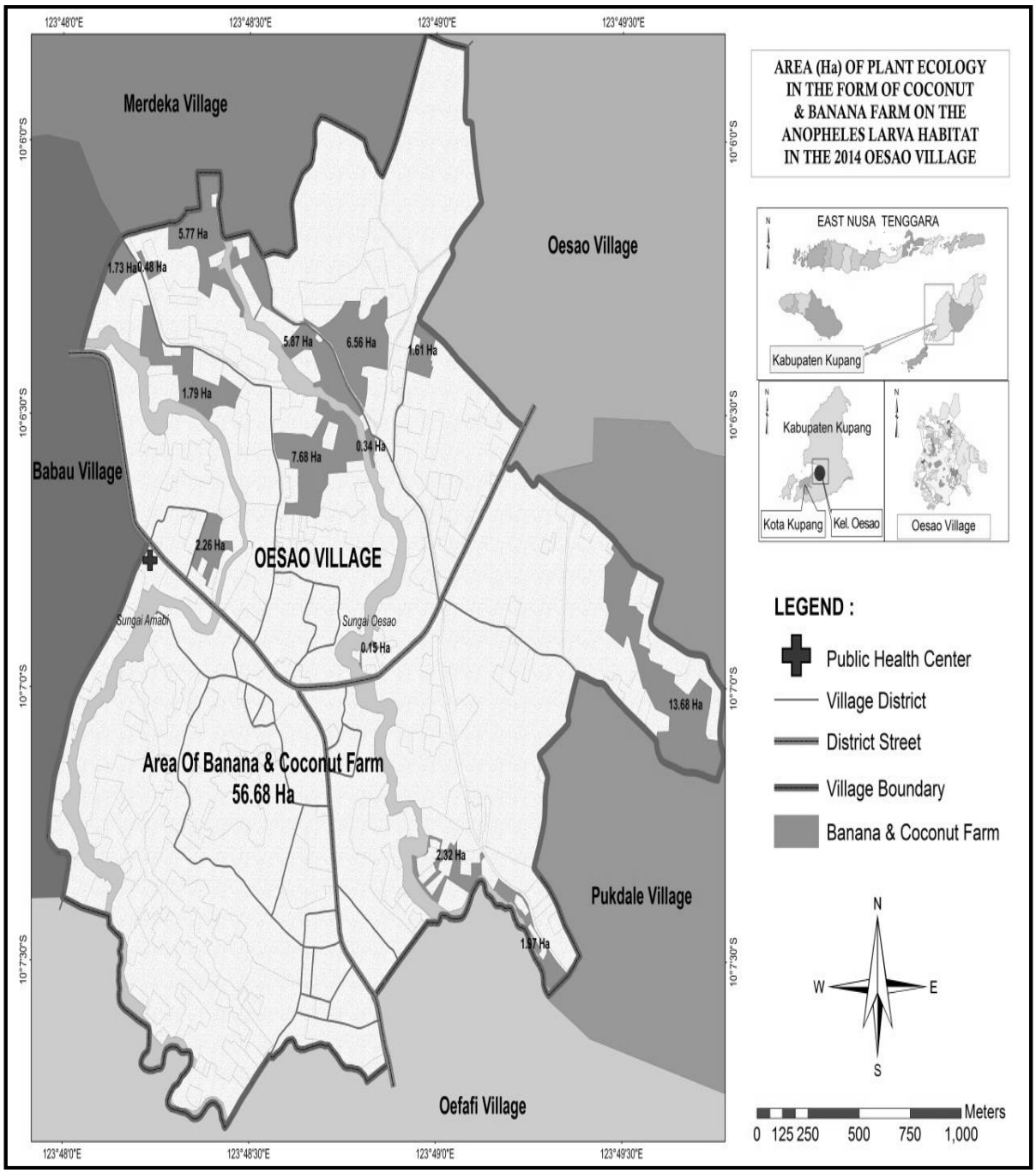

Figure 2. A map of ecology of coconut and banana trees and the land area in Oesao Village in 2014

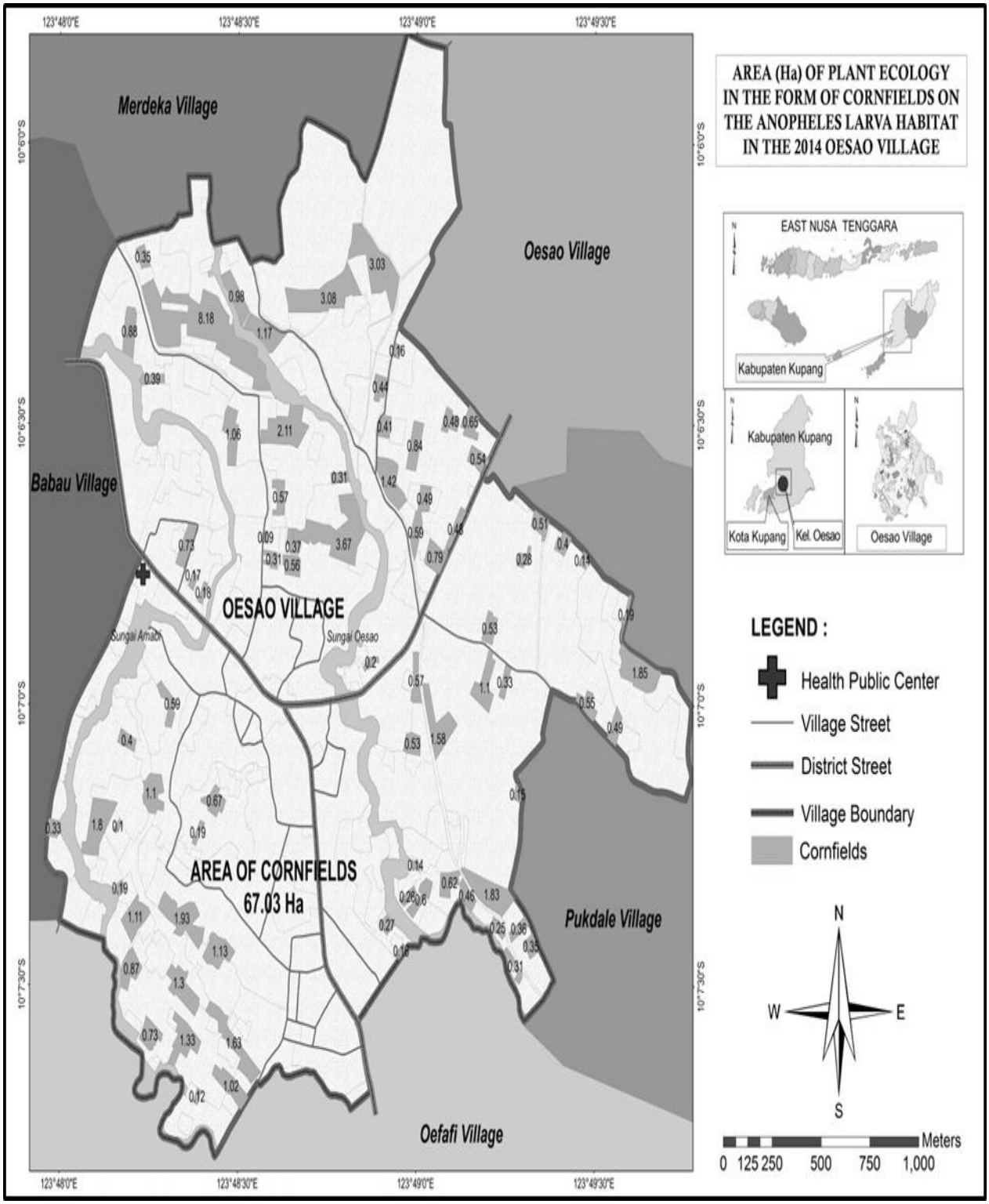

Figure 3. A map of ecology of maize and the land area in Oesao Village in 2014

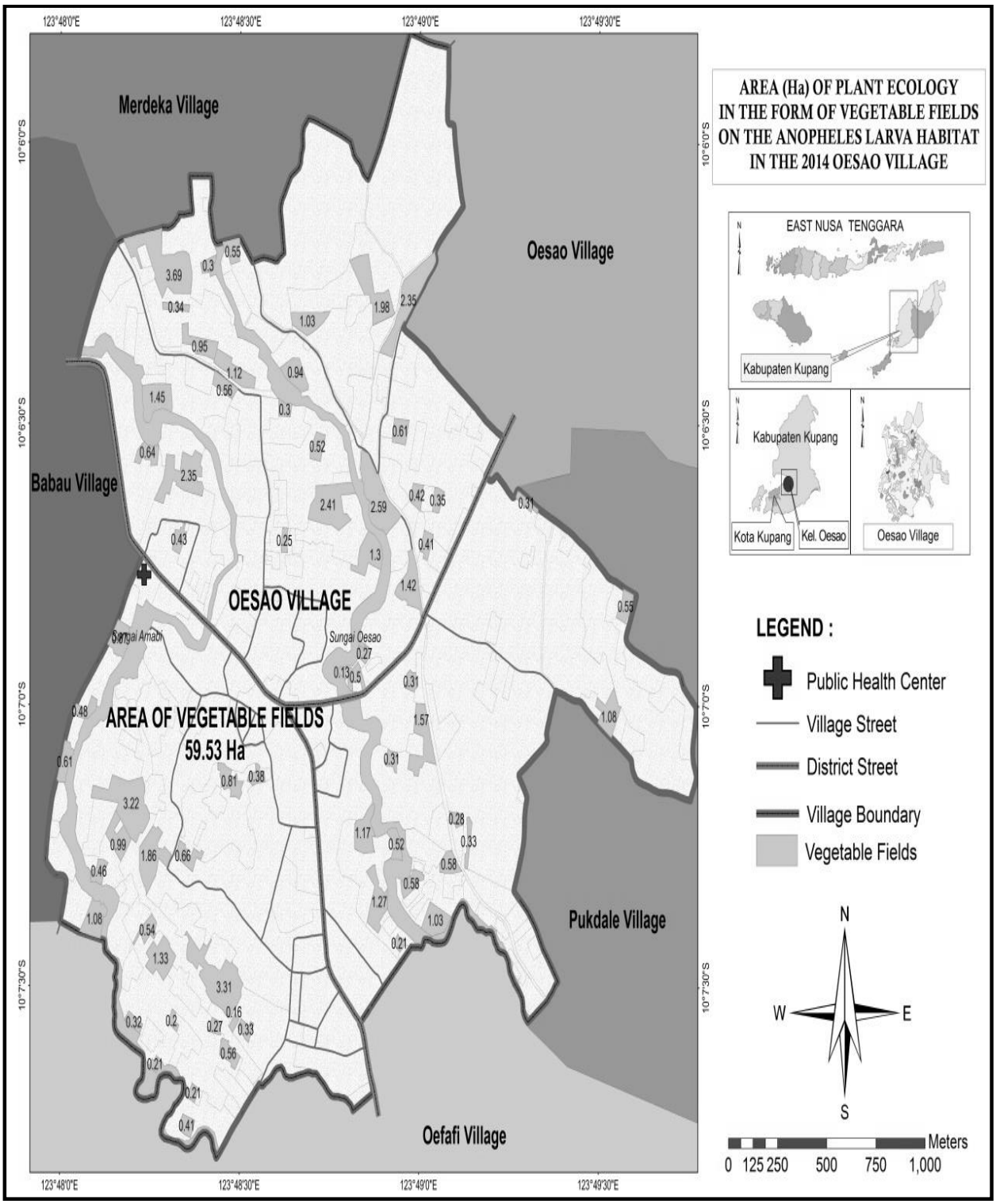

Figure 4. A map of ecology of vegetable plants and the land area in Oesao Village in 2014

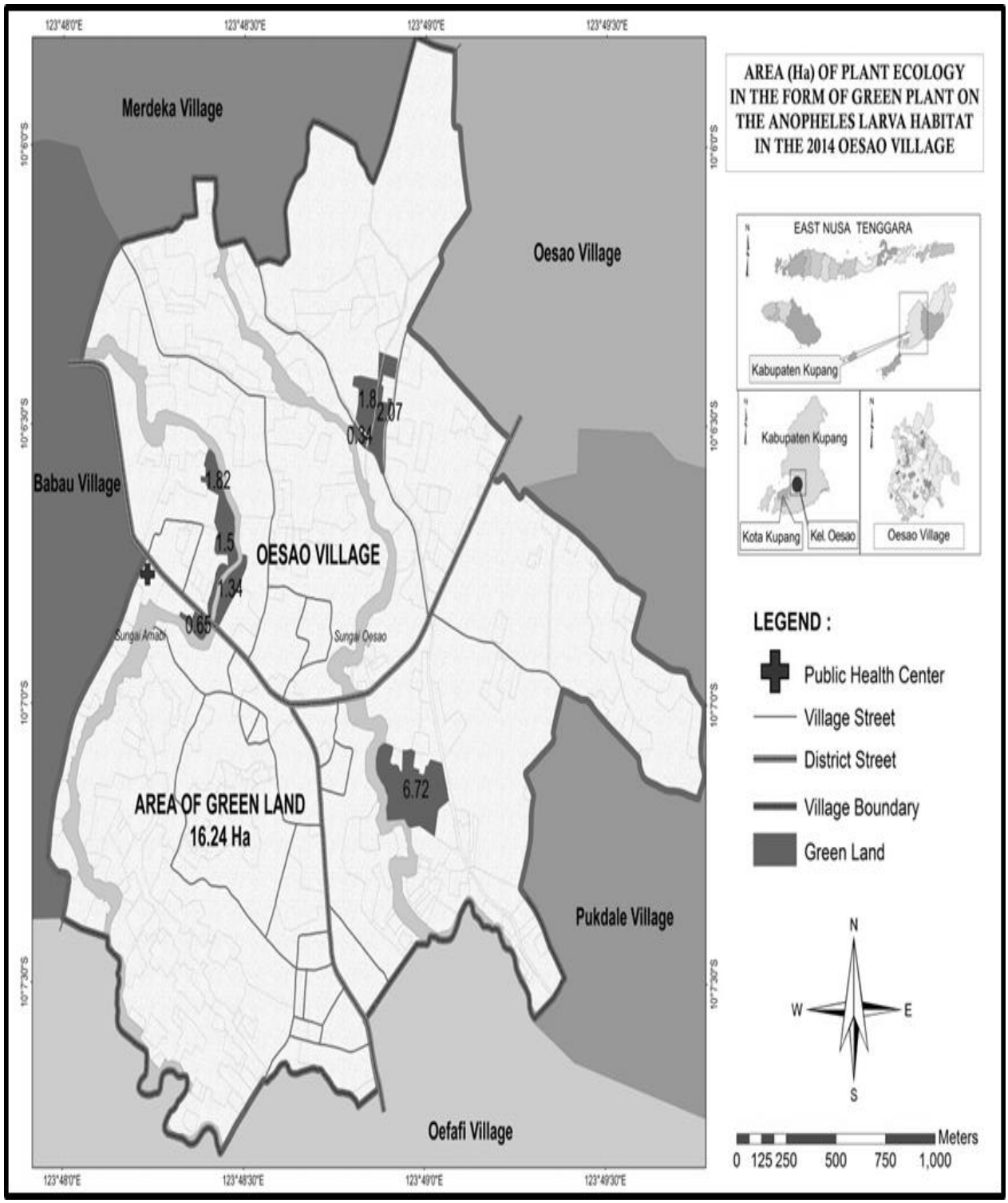

Figure. 5 A map of ecology of forest area/large plants (green area) in Oesao Village in 2014

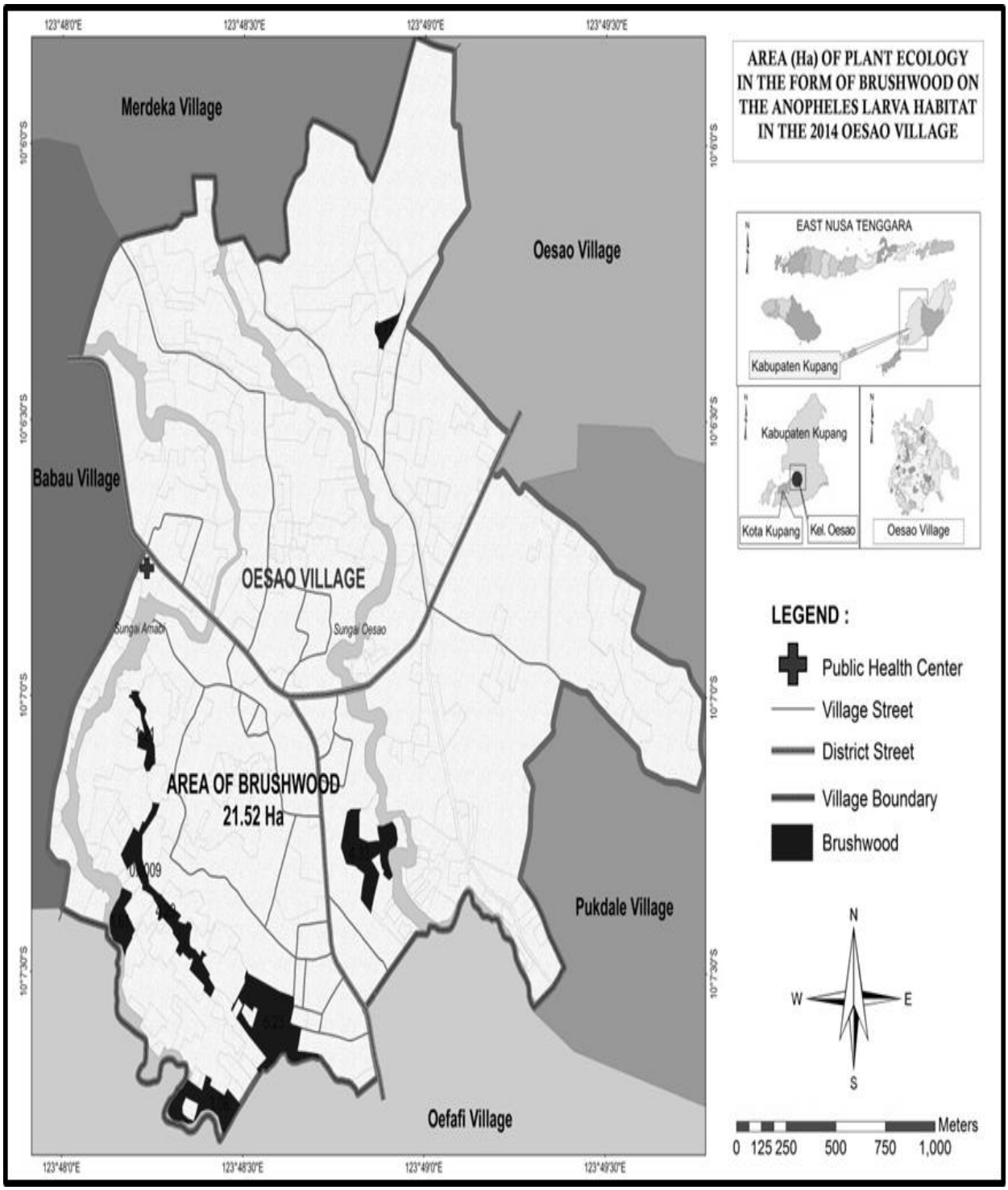

Figure 6. A map of forage plants and the land area in Oesao Village in 2014

From the illustration of the distribution of cases on the map (Figure 7), the spread is evenly distributed, and the types of plasmodium are falciparum and vivax.

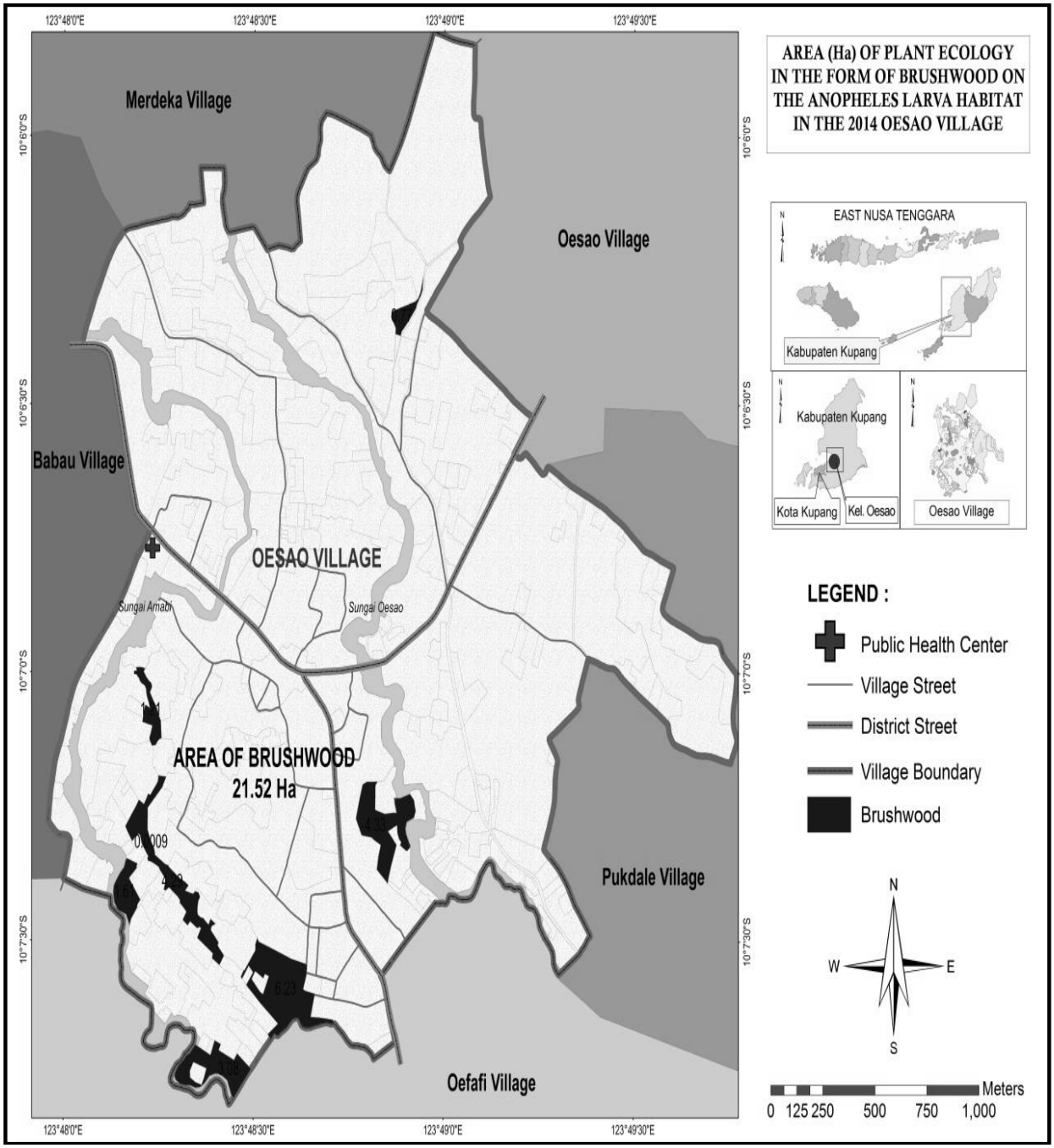

Figure. 7 A map of the distribution of malaria cases and the ecology of vegetation in Oesao District, Kupang Regency

DISCUSSIONS

Ecological Vegetation Mapping

The ecology of vegetation is a community of plants according to their types and distributions that support the vectors breeding and growth of *Anopheles* mosquitos, particularly as resting sites and producers of oxygen supply (O_2) contributing to the survival of mosquitos and other living organisms.

In general, there is a relationship between the plant habitat, types of plant, also the area of arable field on the growth and proliferation of *Anopheles* mosquitos[2]. For some types of plants in arable lands such as rice, kale, root tubers, grasses, blushes, and shrub, they become

very suitable habitats or resting sites for *Anopheles* sp mosquitos. Based on the research results, the researcher found an average of one to three larvae in a cup of water in the arable area. Geographically, rice paddy is the largest cultivation area in Oesao district. This is so, for the soil structure and rainfall intensity of Oeasao district are suitable for the rice cultivation. Therefore, it reasons out why most Oeasao people choose rice cultivation as the main source of their livelihood.

Theoretically, the ecology and area of rice paddy in Oesao district including irrigation canals and standing water along with grass as its protector make them suitable sites for *Anopheles* mosquitos breeding. In addition, another factor that supports proliferation of *Anopheles* mosquitos is the temperature of water in the Oesao's rice paddies. The result of measurement showed that the average of water temperature in the arable area is 29.37 °c. The water temperature was measured in the peak of dry season with very hot ambient temperature. The optimum temperature for *Anopheles* mosquitos' proliferation is 26°C up to 30°C[2]. Another reference says that the optimum temperature for the growth and proliferation of mosquitos is 20°C up to 30°C[5]. In addition, pH measurements in the rice paddies also demonstrated nominal values ranging from 6.6 to 6.98. However, according to the book published by Department of Health, 2017, "Ecology Malaria Vector", it is stated that the optimum pH for larvae's development is 6 - 8.

The researcher found another fact that in the ecology of Oesao District there are all types of plants ranging from groups of forages (including grass and shrub), vegetables (mustard, kale, eggplant, sweet potato, cassava), rice crops (rice paddy), high-tree plant species (coconut and banana trees), to forest areas (green fields). Some experts suggest that vector growth is inextricably linked with the number and type of plants. The land and plants area affect the growth and proliferation of *Anopheles* mosquitos. The wider and the more diverse the types of plants, the better for the mosquitos' proliferation than the dry and barren areas.

From the environmental aspect, pH and temperature provide positive contributions to the growth and breeding of mosquitos. Moisture level and adequate rainfall intensity per year also support such conditions to strive. Concerning the book published by UNICEF in 2012, "Malaria, Immunization and Integrated KIA (Maternal and Child Health)", geography and meteorology factors such as temperature, humidity, rain, and altitude are very beneficial to malaria transmission in Indonesia. These are the major factors that explain why malaria case in Oesao district is very high.

Mapping of the Mosquito Breeding Sites (Larvae Habitats)

The illustration of map on larval habitats comprises of 5 habitat types: rice paddies, swamps, rivers, irrigations, and dams. The mosquito breeding sites in rice paddies are the standing water and the water in irrigation canals that flow continuously on edge of the rice paddies. Based on Figure 1 above, the rice paddies become the largest area of the mosquito habitat compared to other larval habitats; the size of rice paddy is 165.03 Ha. The researcher classifies rice paddies into two roles: (1) as plant ecology and (2) as habitat of malaria mosquito breeding sites. In the discussion above, the rice paddy is closely related to the bionomic life of malaria mosquitos.

Previous studies found that the best resting places for adult mosquitos are areas in rice paddies like terraces, and edges. These places are suitable sites for adult mosquitos since they are not far from water puddles, water drains, irrigation canals of rice paddies, so that adult mosquitos can easily put their eggs in water anytime[4]. Beside rice paddies, the other larval habitats are water dams, swamps, irrigation canals, and rivers. Nevertheless, all types of habitats mentioned above are very suitable for the growth and proliferation of *Anopheles* mosquitos.

From the above map, it appears that all potential habitats for the growth and proliferation of *Anopheles* mosquito larvae reside in this region, with a large enough area.

Distribution of Malaria Cases

After combining the data of ecological vegetation with the previous data of the mapping, and mosquito breeding sites (larval habitat), the result revealed that the spreading of malaria patients in Oesao district was distributed evenly. Based on spatial mapping, it is clearly illustrated that the main factors that contribute to the growth and proliferation of larvae and malaria mosquitos are the number and types of plants, the area of arable land, pH and temperature of the malaria mosquitos' breeding sites, and also the types of the breeding sites.

To ensure the relationship or influence of these three factors, a more in-depth analytical research needs to be conducted in the future; 232 such as the analysis based on the demographic characteristics, the mobility of sufferers, etc.[6].

CONCLUSION

Ecology of plants by type consisting of 5 types of plants are dominant, namely: crop rice (paddy), maize crops, vegetable crops, coconut and banana plants, plant shrubs and grass and forest plants. Plant ecology are quite varied in the Village Oesao, as well as extensive areas of the plant that is closely linked to inadequate growth and development of mosquitoes as well as species specific anophelles that kind of *An. vagus* and *An. annularis*.

Conflict of Interest: None

Ethical Clearance Certificate: Ethical Committee of Faculty of Public Health, Airlangga University.

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