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Spatial Analysis of Lymphatic Filariasis Case and Mosquito Resting Place in Rural Area of Brebes Regency, Indonesia

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Abstract

Brebes Regency is an endemic area of Lymphatic Filariasis (LF) and has the highest number of LF cases in Central Java Province, Indonesia. Despite it is located in the coastal region, which is already known as one of the risk factors of LF, the LF case is distributed more in rural areas, away from the shoreline. Adult mosquitoes need a particular site, called a resting place, to rest after and before biting for a blood meal. The purpose of this study was to analyze spatially the distribution of LF cases and mosquito resting places in three subdistricts whose highest LF case number in the Brebes Regency. The three subdistricts are rural areas. The observed resting places were cattle pens, unmaintained bushes, and maintained bushes. The data of LF patients were obtained from the Health Office of Brebes Regency, which stood at 14 patients. Spatial mapping of LF case and mosquito resting place distribution was composed. 4 patients were located in the mosquito flight radius from unmaintained bushes, 3 patients were located in the mosquito flight radius from cattle pen, and 7 patients were located in the mosquito flight radius from both unmaintained bushes and cattle pen. It indicated unmaintained bushes, together with cattle pen, are the favorable resting place contributing to LF transmission.

Introduction

Lymphatic Filariasis (LF) is a kind of disease that is transmitted by various mosquitoes. The mosquitoes inject filaria worm into the human body, then causes blockages in lymphatic nodes, which would cause swelling on the legs, hands, scrotums, breasts, and other body parts. Eliminating LF is one of WHO's global programs currently. LF-endemic countries are mostly located in tropical areas. Indonesia is one of them. Most LF cases in Indonesia are distributed in areas outside Java Island due to their conditions which are more suitable for the breeding of LF-transmitting mosquitoes. However, there are still some areas in Java, endemic to LF. Brebes Regency is an endemic area of LF and has the highest number of LF cases in Central Java Province, Indonesia. Commonly LF is distributed in coastal areas due to its limitation in sanitation because of tidal flood and social-economics issues (Bataille et al., 2009; Al-Abd et al., 2014; El-Zeiny, El-Hefni and Sowilem, 2017; Nurjazuli et al., 2018; Siwiendrayanti et al., 2019; Nurjazuli and Santjaka, 2020; Siwiendrayanti et al., 2020). Poor sanitation allows the emergence of breeding and resting places for mosquitoes. Despite Brebes Regency being located in the coastal region, which is already known as one of the risk factors of LF, the LF case is distributed more in rural areas, away from the shoreline (Siwiendrayanti, Pawenang, Wijayanti, et al., 2020). This unique condition is interesting to study further. Filaria worm is an LF agent injected into the human body by an adult mosquito when it is sucking blood.

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Adult mosquitoes need a certain site, called a resting place, to rest after and before biting for a blood meal. Previous studies found cattle pens, unmaintained bushes, and maintained bushes as important outdoor resting places for adult mosquitoes (Siwiendrayanti, Pawenang and Indarjo, 2017; Khikmah and Pawenang, 2018; Siwiendrayanti, Pawenang, Indarjo, et al., 2020). It is needed to identify what kind of resting place contributes more to LF distribution in rural areas in Brebes Regency.

LF is transmitted by various mosquitoes (Culex, Anopheles, Aedes, Mansonia, and Armigeres). Filaria worm, the agent of LF, is injected into the human body by an adult mosquito when sucking blood. The filarial worm larvae then migrate to the lymphatic vessels, where they develop into adult filarial worms. Adult filarial worms will increase in size so that over time they will clog the lymph channels until swelling arises in the parts of the body that are most affected by the blockage, such as the legs, arms, breasts, and genitals, both in men and women. Swelling that does not get medical attention immediately and lasts a long time will continue to grow and result in permanent disability. Adult mosquitoes need a certain site, called a resting place, to rest after and before biting for a blood meal. Cattle pens and bushes are common resting places in the settlement of rural areas. Both before and after sucking blood, some species rest indoors (endophilic), while others rest outdoors (exophilic) in various shelters, such as among vegetation, in rodent burrows, in crevices and crevices in trees, in under bridges, in termite mounds, in caves and rock crevices, and crevices in the ground (Sapada, Anwar, C. and Priadi, 2015; Nurjazuli and Santjaka, 2020; Siwiendrayanti, Pawenang, Indarjo, et al., 2020).

Most Anopheles are crepuscular or nocturnal in their activity. So blood feeding and oviposition usually occur at night, in the middle of the night, or the early morning around sunrise. Some species, such as An. albimanus bites humans mainly outdoors (exophagic) from around sunset until 21:00. In contrast, in Africa, the species An. gambiae complex species bite mainly after 23:00 until just before sunrise,and are mostly indoors (endophagic). The timing of the bite, and whether the adult mosquito is exophagic or endophagic, is of epidemiological importance. Certain *Anopheles* species transmit the filarial worms *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori*, all of which cause filariasis in humans. *Anopheles*, along with certain culicines (*Culex quinquefasciatus*, various *Mansonia* species, and very few *Aedes* species) are vectors of the nocturnal periodic forms. *Culicines* are vectors of the subperiodic shape. In the nocturnal periodic forms of these two parasites, most of the microfilariae during the day reside in the blood vessels that supply the lungs. At night, especially in the midsection, microfilariae migrate to the peripheral blood and lymphatic systems. Because of this marked 24-hour periodicity, microfilariae are ingested mainly by night-biting mosquitoes such as *Anopheles*. More than 25 species of *Anopheles* are known to be vectors of bancroftian filariasis. The species involved differ by region, and many are also the main vectors of malaria. For example, the nocturnal periodic vector *W. bancrofti* includes *An. albimanus* (tropical America), *An. arabiensis, An. funestus, An. gambiae* (Sub-Saharan Africa), *An. anthropophagous, An. balabacensis, An. director, An. flavirostris, An. letifer, An. leukosphyrus, An. maculatus, An. sinensis and An. subpictus* (India and Southeast Asia), and *An. coliensis and An. punctulatus* (Papua New Guinea). No known animal reservoir host for this nocturnal form of periodic filariasis. The nocturnal periodic *B. malayi* is widespread in Asia, where the disease is primarily a rural disease. Transmission through the culicine mosquito and at least 10 species of *anopheles*, including *An. anthropophagous, An. barbirostris, An. campestris, An. donaldi* and *An. sinensis*. There is no important animal reservoir host, although there may be several. B*rugia timori* is known only from the small islands of Indonesia, such as Alor, Timor, and Flores, and from the low-lying areas of the small islands east of Java. The microfilariae are nocturnal and are transmitted by *An. barbirostris*, and possibly by other species of *Anopheles*. No known animal reservoir hosts. The rate of infective larval infection in the anopheles vector varies according to mosquito species and local conditions but is often around 0.1–5% for

W. bancrofti and about 0.1–3% for *B. malayi.* There is no reservoir host for *W. bancrofti,* but a subperiodic form of *B. malayi,* transmitted by the *Mansonia* mosquito, which is zoonotic. Adult *mansonia* usually bite at night, but some species bite during the day. After sucking, most *Mansonia* rests outdoors, but some species rest indoors. Most adult *Aedes* species bite mainly during the day or evening. Most bites occur outdoors. And adults usually rest outside before and after eating. *Ae. polynesiensis* and related species are the main filariasis vectors, from Fiji throughout the Polynesian islands. Adult *Culex* mosquitoes mainly bite at night. *Culex quinquefasciatus*, and many other *Culex* species, bite humans and other hosts at night. Some species, such as *Cx. quinquefasciatus,* generally rest indoors both before and after eating, but they also take shelter in outdoor resting areas (Philip Samuel et al., 2004; Muturi et al., 2008; Liu et al., 2011; Wilson et al., 2020; Visintin et al., 2022). Mosquitoes will fly from those resting places to settle for blood-sucking. *Anopheles* has a flight distance of 1,000-3,000 meters. *Culex*'s average flight distance is 400-850 m, but *Culex annulirostris* can fly as far as 6,220 m. The average flying distance of *Aedes* is less than 400 m. *Mansonia*'s flying distance is less than 2,000 m (Cui et al., 2013; Verdonschot and Besse-lototskaya, 2014; Genoud, Basistyy and Williams, 2018; Somerville et al., 2019). People located within mosquito-flying distance radius from a mosquito resting place take a higher risk of LF transmission.

WHO declared areas with Mf-rate >1% as filariasis endemic areas. Mf-rate or Microfilaria rate is the percentage of blood samples that are positive for microfilariae from the entire population of blood samples examined during the Finger Blood Survey (FBS). Determination of the Mf-rate is carried out by conducting a Finger Blood Survey on a minimum of 300 population samples. This Finger Blood Survey is carried out by taking blood from a resident's finger and must be carried out at night after 10 PM when the micro filarial worms are in the peripheral blood vessels. Cities and districts with a Mf-rate >1% are required to carry out MDA (Mass Drugs Administration) for 5 consecutive years. The drug must be taken by all residents of the city/district at a dose of 1 time a year for 5 consecutive years. Evaluation will be carried out after the implementation of Filariasis MDA for 5 years. Districts/cities that still have a Mf-rate >1% after 5 years of Filariasis MDA implementation will be required to continue Filariasis MDA until the Mf-rate becomes <1% (Abdul Halim et al., 2022; Aboagye and Addison, 2022; Mendhe et al., 2022; Taylor, Oliver and Garner, 2022).

The objective of this study was to analyze spatially the distribution of LF case and mosquito resting places in three subdistricts whose highest LF cases number in the Brebes Regency. It is needed to identify what kind of resting place which contributes more to LF distribution in rural areas in Brebes Regency. The identification will be needed to arrange strategies to prevent lymphatic filariasis distribution through mosquitoes transmission (Xu et al., 2019; Aisyah et al., 2022; Touloupou et al., 2022).

Methods

It was a spatial analytics study obtained in three subdistricts whose highest LF case number in Brebes Regency in August and September 2020. They were Ketangungan Subdistrict, Paguyangan Subdistrict, and Bantarkawung Subdistrict. There were 14 LF patients in the three subdistricts, spread over 12 villages. They were Taraban, Winduaji, Kretek, Tambakserang, Terlaya, Jipang, Jemasih, Cikeusal Lor, Baros, Karangmalang, Ketanggungan, and Dukuhturi where patient location and resting place would be observed and analyzed spatially. The kind of resting places studied were cattle pens, unmaintained bushes, and maintained bushes. GPS, GIS software, camera, map, and observation sheet were used as instruments in this study. Coordinates of LF patients and resting places were marked with GPS and then processed with GIS software. GIS software was used for overlaying the studied location map with the LF patient map and resting places map. LF patient data (identity and location) were collected from Brebes Regency Health Office. The location and condition of resting places were observed directly on site. Those locations were marked with GPS and documented with a camera and observation sheet. All informations were mapped and integrated with GIS software.

Results and Discussion

Cattle pen, unmaintained bushes, and maintained bushes were observed and mapped together with LF patient locations in Taraban Village, Winduaji Village, Kretek Village, Tambakserang Village, Terlaya Village, Jipang Village, Jemasih Village, Cikeusal Lor Village, Baros Village, Karangmalang Village, Ketanggungan Village, and Dukuhturi Village. The spatial map was displayed in Figure 1-3. Ketanggungan Subdistrict had the most number of LF cases in this study. Figure 1 showed that Ketanggungan Subdistrict had 7 LF cases which were distributed 1 case in Baros Village, 1 case in Jemasih Village, 1 case in Dukuhturi Village, 1 case in Cikeusal Lor Village, 1 case in Karangmalang Village, and 2 cases in Ketanggungan Village. The presence of cattle pens, unmaintained bushes, and maintained bushes in the Ketanggungan Subdistrict was found in Baros Village, Jemasih Village, Dukuhturi Village, and Cikeusal Lor Village. Whereas in Ketanggungan Village were found only unmaintained bushes and maintained bushes. While in Karangmalang Village were found cattle pen and unmaintained bushes. 2 LF cases in Baros Village and Karangmalang Village were in mosquito flight radius from both unmaintained bushes and cattle pen. 3 LF cases in Jemasih Village and Ketanggungan Village were in a mosquito flight radius from both unmaintained bushes. 2 LF cases in Dukuhturi Village and Cikeusal Lor Village were in a mosquito flight radius from a cattle pen. There was 1 LF case in Baros Village, which was almost exactly on the site of a cattle pen.

Paguyangan Subdistrict had 3 LF cases distributed 1 case in each village of Winduaji, Taraban, and Kretek. Cattle pens, unmaintained bushes, and maintained bushes, were found in Winduaji Village and Taraban Village. While in Kretek Village, the potential resting place was only a cattle pen. As shown in Figure 2, 2 LF cases in Winduaji Village and TarabanVillage were in a mosquito flight radius from both unmaintained bushes and cattle pens, whereas the case in Kretek Village was in a mosquito flight radius from a cattle pen. The case in Taraban Village was located almost exactly on the site of a cattle pen, while in Winduaji Village was almost exactly on the unmaintained bushes. Bantarkawung Subdistrict had 4 LF cases distributed 2 cases in Tambakserang Village, 1 case in Terlaya Village, and 1 case in Jipang Village. As shown in Figure 3, 3 LF cases in Tambakserang Village and Terlaya Village were in mosquito flight radius from both unmaintained bushes and cattle pen, while the case in Jipang Village was in mosquito flight radius from unmaintained bushes. 3 LF cases in Tambakserang Village and Terlaya were located almost exactly on the cattle pen site.

Cattle pens, unmaintained bushes, and maintained bushes, were observed as mosquito resting places in the study area. No patient in mosquito flight radius from the maintained bushes, 4 patients in a mosquito flight radius from unmaintained bushes, 3 in a mosquito flight radius from a cattle pen, and 7 in a mosquito flight radius from both unmaintained bushes and cattle pen. There were 5 LF cases located almost exactly on the cattle pen site, and 1 LF case was located almost exactly on the unmaintained bushes site. It indicated unmaintained bushes, together with the cattle pen, are the favorable resting place contributing to the LF transmission. The summary is in Figure 4.

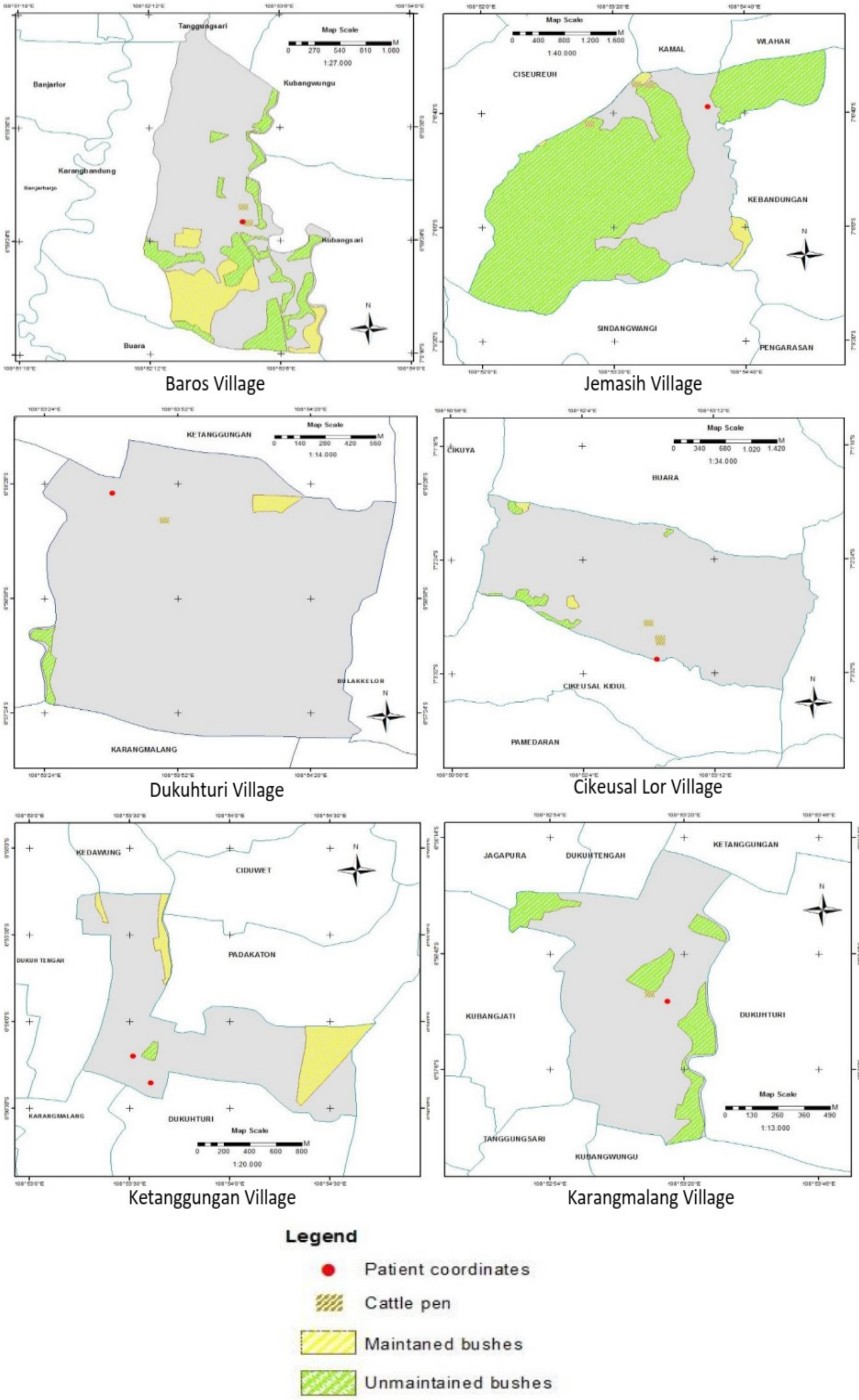

Figure 1. LF Case and Resting Place Distribution in Ketanggungan Subdistrict

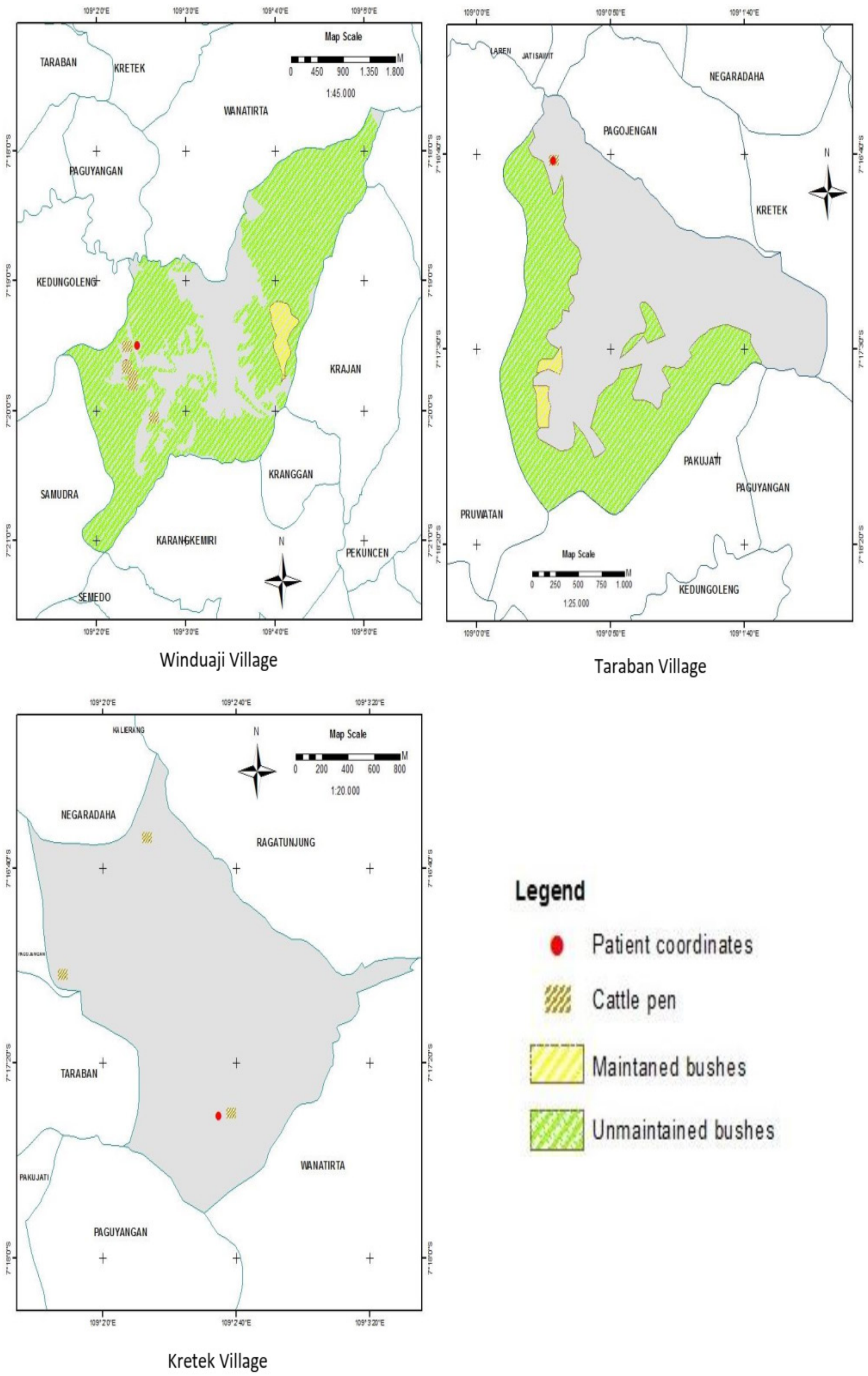

Figure 2. LF Case and Resting Place Distribution in Paguyangan Subdistrict

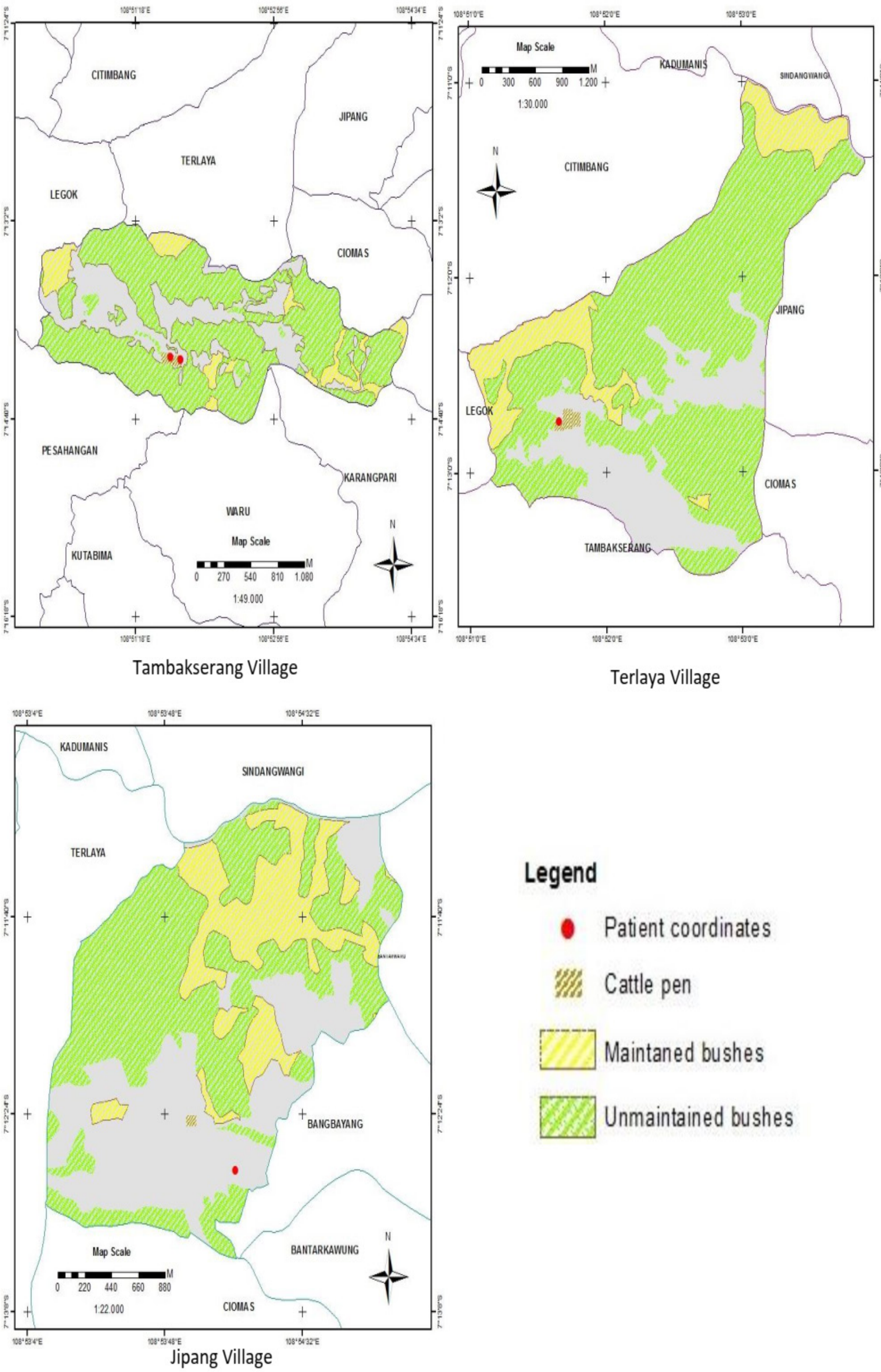

Figure 3. LF Case and Resting Place Distribution in Bantarkawung Subdistrict

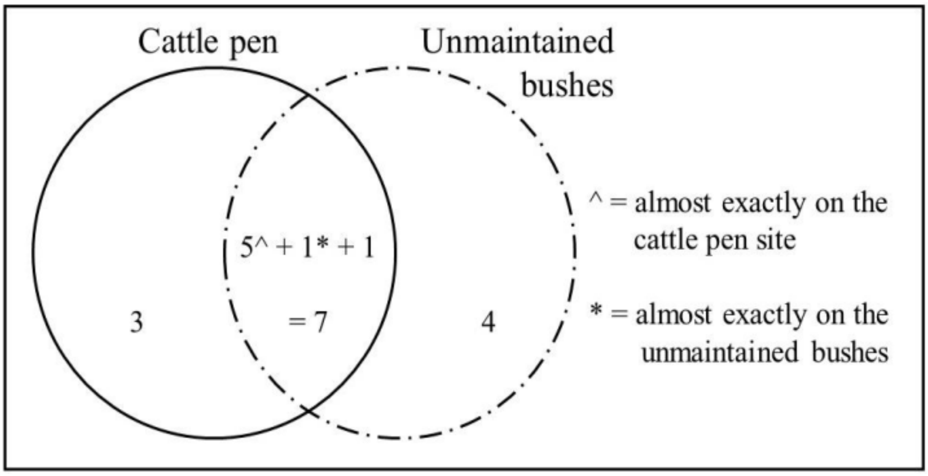

Figure 4. Distribution of Lymphatic Filariasis Cases in Cattle Pen and Unmaintained Bushes Surounding

Cattle pens become a potential resting place for mosquitoes because some mosquitoes prefer to suck animal blood (zoophagism) than to suck human blood (anthropophagism) or like to suck both animal and human blood. The presence of cattle pens will attract more mosquitoes to come. It causes people who live in cattle pens surrounding have a higher risk to be bitten by mosquitoes and infected LF (Siwiendrayanti, Pawenang, Indarjo, et al., 2020). 3 patients were in a mosquito flight radius from a cattle pen, and 7 patients were in a mosquito flight radius from both unmaintained bushes and a cattle pen. There were 5 LF cases located almost exactly on the cattle pen site. It indicated cattle pen is the favorable resting place contributing to LF transmission. Keeping cattle pens away from the dwelling is needed to prevent mosquitoes from easily fly come to people dwelling from cattle pens. However, it is difficult to apply due to space limitations and security issues from cattle thievery. Controlling mosquito population in cattle pens surrounding could refer to the same issues in malaria vector control with applying insecticides in cattle pen areas (Li et al., 2015; Makhanthisa, Braack and Lutermann, 2021; Makhanthisa et al., 2022; Ruiz-Castillo et al., 2022).

Mosquitoes need a particular place to rest. Places with certain objects to perch, low light intensity, and enough humidity become the preferable places for mosquitoes to rest. Bushes have these characteristics and become preferred resting places for mosquitoes. In consequence, people who live in bushes-surrounding areas have a higher risk of mosquitoes bit and infecting LF (Sapada, Anwar, C. and Priadi, 2015; Khikmah and Pawenang, 2018; Nurjazuli and Santjaka, 2020). An ecological study by Alencar et al. (2021), described that *Culex quinquefasciatus* prefers areas with bushes for resting places. *Culex quinquefasciatus* is the primary vector of LF in Java Island. Previous studies proved the contribution of living in bushes areas to mosquito-born diseases like LF and malaria (Chesnais et al., 2014, 2019; Nyasa, Fotabe and Ndip, 2021). No patient was located in a mosquito flight radius from the maintained bushes. 4 patients were in a mosquito flight radius from unmaintained bushes, and 7 patients were in a mosquito flight radius from both unmaintained bushes and cattle pen. There was 1 LF case located almost exactly on the unmaintained bushes site. It indicated unmaintained bushes are also a favorable resting place, contributing to LF transmission. It is necessary to manage unmaintained bushes to be maintained ones to reduce the space of favorable resting places area.

The coastal region is bordering on the shoreline. Mangroves are commonly present on tropical shorelines. In point in fact, the mangrove area meets the criteria of a favorable resting place and also a breeding place for mosquitoes. It contributes to LF transmission in some LF-endemic areas. LF cases are usualy distributed more close to areas bordered by shorelines (Khikmah and Pawenang, 2018;

Nurjazuli et al., 2018; Nurjazuli and Santjaka, 2020). But in reality, LF cases in Brebes Regency were distributed more in rural areas away from shore (Siwiendrayanti et al., 2020). Some studies indicated that the condition of mangrove areas will affect mosquito density (Ismail et al., 2018; Siwiendrayanti, Anggoro and Nurjazuli, 2020). Masela (2012), found that in mangrove forests cut down by humans, there was a reduction in the diversity of mangrove species that grew and tended to be dominated by only one type of mangrove. It resulted in reduced natural predators of mosquitoes and mosquito larvae so that the number and density of mosquitoes there was higher than in mangrove forests where the level of logging by humans is minimal. The research by Ismail et al. (2018), showed that disturbed mangrove areas had lower mosquito densities but irregular biting patterns throughout the day, indicating they consisted of several different types of mosquitoes, making them more difficult to control. Souza et al. (2012), reported that mosquito species caught in disturbed mangrove areas (*Aedes*) are known to play a role in spreading several diseases to humans, while mosquitoes caught in undisturbed mangrove areas (*Wyeomyia*) are known not to be associated with the spread of disease in humans. The Environmental Agency of Central Java Province recorded that in 2015, Brebes Regency had dense and large mangrove areas. It could be the cause of why LF cases in Brebes Regency were distributed more in rural areas away from the shoreline.

Conclusion

Cattle pens, unmaintained bushes, and maintained bushes, were observed as mosquito resting places in the study area. No patient is in a mosquito flight radius from the maintained bushes. 4 patients were in a mosquito flight radius from unmaintained bushes, 3 patients were in a mosquito flight radius from a cattle pen, and 7 patients were in a mosquito flight radius from both unmaintained bushes and cattle pen. There were 5 LF cases located almost exactly on the cattle pen site, and 1 LF case was located almost exactly on the unmaintained bushes site. It indicated unmaintained bushes, together with cattle pens, are the favorable resting place, contributing to LF transmission. It is necessary to manage unmaintained bushes to be maintained, to reduce the main resting places areas. Keeping cattle pens away from the dwelling is also needed to prevent mosquito from easily fly come to people dwelling from cattle pens.

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