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Dynamics of mangrove community in revegetation area of Karangsong, north coast of Indramayu District, West Java, Indonesia

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Abstract. Gunawan H, Sugiarti, Iskandar S. *2017. Dynamics of mangrove community in revegetation area of Karangsong, north coast of Indramayu District, West Java, Indonesia. Biodiversitas 18: 659-665.* Mangrove along the north coast of Java is heavily degraded due to the conversion of land into fish ponds and human settlement areas. A revegetation program has been initiated by the local community of Karangsong Village, Indramayu District, West Java, Indonesia, supported by PT. Pertamina RU VI Indramayu. Our research aimed to study the population dynamics of the mangrove revegetation in Karangsong. Secondary data was collected from the Fishery and Maritime Services of Indramayu and PT. Pertamina. We carried out on-location field observations and we interviewed key respondents. Data was analyzed to describe trends in the diversity index and population dynamics of the mangrove. It was observed that the revegetation effort in the shoreline of Karangsong had covered ± 69.08 hectares which consisting of six species of mangrove and three tree species of coastal vegetation i.e. *Rhizophora mucronata* Lam., *Rhizophora stylosa* Griff., *Rhizophora apiculata* Blume, *Avicennia marina* (Forssk.) Vierh., *Avicennia alba* Blume, *Sonneratia caseolaris* (L.) Engl, *Terminalia catappa* L., *Casuarina equisetifolia* L., and *Ziziphus mauritiana* Lam. The mangrove population increased dramatically, from estimated 25,000 individuals in 2008 to 690,835 individuals in 2016. *Rhizophora mucronata* was the most dominant species (68.85%), followed by *Rhizophora stylosa* (18.33%) *and Rhizophora apiculata* (9.53%). The Shannon diversity index was fluctuated but tend to be increased from 0.80 to 0.95.

Keywords: Karangsong, mangrove, north coast, re-vegetation

INTRODUCTION

There are roughly 166,876 km^2 of mangrove along the shorelines of the world, with the largest proportion of mangrove occurring in Asia (77,169 km^2) and the Americas (43,161 km^2) (Valiela et al. 2001). Countries with the largest area of mangroves are Indonesia (4.25 x 10^4 km^2) (Spalding et al. 1997), followed by Brazil (1.34 x 10^4 km^2) (Spalding et al. 1997), Nigeria (1.05 x 10^4 km^2) (Saenger and Bellan 1995), and Australia (1.00 x 10^4 km^2) (Robertson and Duke 1990).

Globally, the area of mangrove area is declining rapidly as it is cleared and converted to mariculture, agriculture, urban development, logged timber concessions, and fuel production areas (Fortes 1988; Marshall 1994; Primavera 1995; Twilley 1998; Polidoro et al. 2010). At least 35% of the world's mangrove forest area has been lost in the past two decades (Valiela et al. 2001). It is apparent that maricultural practices are responsible for the bulk of the increasing loss of mangrove worldwide. For example, pond culture has been reported to be responsible for 50-80% of the loss of mangrove in Southeast Asia (Wolanski et al. 2000). Most of the damage is attributable to the direct loss of habitat from the conversion of "cheap" mangrove land to "valuable" shrimp, prawn, and fish ponds (Valiela et al. 2001).

In 1999, Indonesia's mangrove forest covered 8.6 million hectares which consisted of 3.8 million hectares of forest area and 4.8 million hectares of nonforest area. Degradation of mangrove in forest area is 1.7 million hectares (44.73%) and in nonforest area is 4.2 million hectares (87.50%) (Gunawan and Anwar 2005). Indonesia has lost 40% of its mangrove in the last three decades (FAO 2007). The deforestation rate for mangrove in Indonesia is estimated to be 6% or 0.05 million hectares of the total annual forest loss (Margono et al 2014; Ministry of Forestry Republic of Indonesia 2014). The Ministry of Forestry has reported that only 31% of the remaining mangrove is in an intact condition and the rest (69%) is heavily degraded (Ministry of Forestry 2007). FAO (2007) reported that mangrove forest in Indonesia is 3,062,300 hectares or 19% of the world's mangrove and still the largest in the world, followed by Australia and Brazil.

Mangrove forest in Java Island is decreasing as the impact of conversion to mariculture, human settlement and other uses worsens. This impact is due to limited understanding and awareness by surrounding communities of the ecological importance of mangrove and uncertainty about land status (Said and Smith, 1997). In 2011, mangrove in West Java Province was estimated as covering 40,130 hectares which were distributed between forest area 32,314 ha (80.52%) and non-forest area, 7,816 ha (19.48%), including 13 regencies (Forestry Service of West Java Province 2013). The degraded mangrove in this province is 15,276 hectares (38.06%), with the largest occurring in Karawang District 13,181ha (32.85%) followed by Bekasi 10,481ha, Indramayu 8,720ha, Subang 7,346 ha, Cirebon 190 ha, Ciamis 170 ha, Garut 32 ha

and`Sukabumi 9 ha (Ministry of Forestry 2012). The loss of mangrove in the Indramayu District has impacted on the disappearance of Ujung Gebang, Limbangan and Jatinyuat villages (Forestry Service of West Java Province 2016).

Mangrove forest in Indonesia provides benefits for local communities; supporting livelihoods by producing items of food, fuel wood, charcoal, construction materials, and furniture timber, as well as by generating income (Armitage 2002). Mangrove is also important in social-cultural terms in fulfilling various religious, spiritual, aesthetic, and recreational functions that benefit ecotourism (UNEP 2014). Mangrove ecosystems support essential ecological functions such as intercepting land-derived nutrients, pollutants and suspended matter before these contaminants reach deeper water (Marshall 1994, Rivera-Monroy and Twilley 1996, Tam and Wong 1999). Mangroves also perform other important services, such as preventing coastal erosion by stabilizing sediments (Marshall 1994, Tam and Wong 1999), furnishing nursery and spawning areas for commercially important coastal fish and shellfish species (Rodelli et al. 1984, Sasekumar et al. 1992), and providing stopover sites for migratory birds, fish, and mammals (Saenger et al. 1983). Any loss of mangrove forest, therefore, means a loss of their important contributions to subsistence uses, and to ecological, economic, and conservation functions (Valiela et al. 2001).

Based on the essential functions of mangrove for human life, the Ministry of Environment and Forestry has designated mangrove as an essential ecosystem which will be treated as a protected area or conservation area under the Directorate of Essential Ecosystems Management. The Ministry of Environment and Forestry has also launched a National Movement on Forest and Land Rehabilitation (NMFLR) - a national initiative to plant trees in forest land and bare lands - including mangroves - as a commitment to improving the quality of environment for people's prosperity. The total extent of the national program for mangrove rehabilitation during 2010-2014 is 33,394 hectares (Ministry of Environment and Forestry 2015). The rehabilitation program in West Java Province has planted 365 hectares of mangrove in 2008, 50 hectares in 2009, 311 hectares in 2010, 480 hectares in 2011 and 270 hectares in 2012 (Forestry Service of West Java 2013).

The local community of Karangsong village in Indramayu District which is supported by PT. Pertamina Refinery Unit VI Indramayu has initiated a mangrove re-vegetation program on private land (non-forest land) along the north shoreline of Indramayu District. They started planting mangrove species in 2008 and have consistently extended the area of rehabilitation in a project that has involved many stakeholders. They are also developing an ecotourism program and are practicing sustainable utilization of non-timber mangrove products for generating income to raise local people's prosperity. The research described here, aimed to study the population dynamics of this mangrove vegetation that has been planted in Karangsong village, Indramayu District, West Java, Indonesia.

MATERIALS AND METHODS

The study was conducted in Karangsong village, Subdistrict of Indramayu, Indramayu District, West Java, Indonesia located between 6°17'38.52"S - 6°18'17.52"S and 108°22'03.60"E - 108°22'17.94"E. The site is a mangrove habitat combined with coast and the estuary of the Prajagumiwang River which crosses the Karangsong Village and joins with the Java Sea. This area is part of the Cimanuk watershed, with the main Cimanuk River crossing the territory of Indramayu District. Primary and secondary data were collected betweenMay to June 2016.

Figure 1. Study site in north coast of Karangsong village, Subdistrict of Indramayu, Indramayu District, West Java, Indonesia

Data on the mangrove plantation was collected from the Fishery and Maritime Service of Indramayu District and PT. Pertamina RU VI Indramayu. Information collected included the species, the number of plants, the date of planting, an estimation of the site extent, and details of the institutions and community groups involved in the plantation. In-depth interviews with resource persons and key respondents were made to complete and confirm the data and information collected. The point count method was applied for the bird survey (Hill et al. 2005) with an observation radius of 50 m: the result was a list of bird species (van Lavieren 1982). Identification of birds was carried out based on Field Guide to the Birds of Java and Bali (Mackinnon 1991) and Field Guide to the Birds of Borneo, Sumatra, Java and Bali (MacKinnon et al. 1992).

All information and data were analyzed to describe the dynamics of the ecosystem, including the abundance trend, species composition, and diversity and evenness indices of the mangrove population.

RESULTS AND DISCUSSION

National program of rehabilitation on forest and bare land

The Ministry of Environment and Forestry has launched a National Movement on Forest and Land Rehabilitation (NMFLR). It is a national initiative to plant trees in forest land and bare land, including mangroves, as a commitment to improving the quality of environment for people's prosperity. In the period 2010-2014, the NMFLR program planted 2,279,380 hectares. The national program for rehabilitation of degraded mangrove in the period 2010 - 2014 planted 33,394 hectares (Ministry of Environment and Forestry 2015). In the decade 2003-2012, mangrove rehabilitation in West Java Province through the NMFLR program covered 3,681 hectares (Figure 2) (Forestry Service of West Java Province 2012; 2013a; 2013b; 2016). Rehabilitation of mangrove along the north coast of Java is crucial, and not only for ecological reasons; the socio-economic arguments are even more significant, due to the threat that mangrove degradation poses to the surrounding communities who depend on mangrove and the fishery it sustains. Gunawan et al. (2007a) reported that the presence of mangrove can improve the quality of water in fish ponds. Gunawan et al. (2007b) also found that mangrove rehabilitation through a silvofishery program can increase the household income of the adjacent community of Subang District, on the north coast of West Java Province.

Mangrove rehabilitation in Karangsong, Indramayu

The revegetation program to rehabilitate degraded mangrove in Karangsong village was initiated in 2008 through the planting of three species of mangrove (*Rhizophora mucronata*, *R. stylosa, R. apiculata*) covering 2.5 hectares of shoreline in Karangsong Village. The plantation was initiated by a group of fishermen named "Kelompok Pantai Lestari" who were supported by PT. Pertamina RU VI Indramayu through the CSR program. One of the crucial reasons for the involvement PT. Pertamina RU VI, is that the Java Sea to the north of Indramayu is a route for oil tankers transporting refined oil from Balongan Indramayu to Jakarta. The sea has been polluted by oil spills from tankers, which negatively impacts on the local sea-water quality and on the fishery. The suspicion was supported by the research results of Gunawan and Anwar (2008) who detected the pollutants Lead (Pb), detergent (MBAS) and Mercury (Hg) in the waters of Subang, a District on the north coast next to Indramayu District. In this area, Gunawan and Anwar found that the lead (Pb) content and detergent (MBAS) of waters were higher than the threshold for fish culture. They also found that eight species of fishes and a species of shrimp in silvofishery ponds and six species of fishes and a species of shrimp in common ponds without mangrove were contaminated with mercury (Hg), but the concentration of pollutants in the silvofishery pond was lower than that of common pond.

It is believed that revegetation of mangrove can improve the quality of the coastal sea water and in turn restore the habitat of the biota living in the water. As a corporation that produces and transports oil through the Java Sea to the north of Indramayu, PT. Pertamina RU VI has a high commitment to restore the mangrove ecosystem and coastal waters along the north shoreline of Indramayu. The mangrove revegetation program which was initiated by people of Karangsong and PT. Pertamina RU VI was then followed by other community groups and supported by NGOs, private sectors, national government, provincial government and district government. There are 37 community groups and 13 institutions involved in the development and plantation of mangrove at Karangsong. The private sector has a critical role in mangrove rehabilitation at Karangsong (31%) alongside the national government (23 %) (Figure 3). The facts demonstrate that the success of mangrove rehabilitation program depends upon the involvement of all stakeholders. Gunawan and Anwar (2005) similarly found that the success of mangrove rehabilitation on the north coast of Central Java Province is determined by the participation of the local community around the mangrove area.

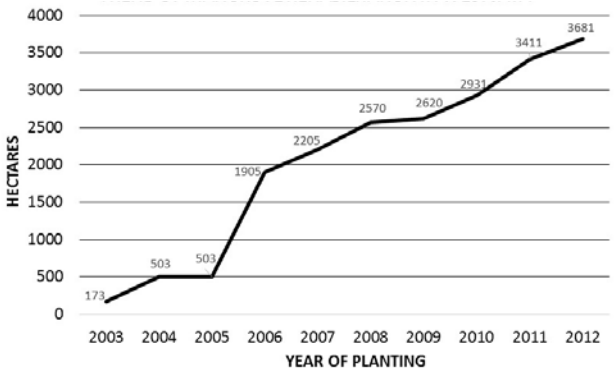

Figure 2. Trend of mangrove rehabilitation in West Java Province, Indonesia. Sources: Forestry Services of West Java Province (2012; 2013a,b; 2016); Ministry of Forestry (2007; 2012; 2014); Ministry of Environment and Forestry (2015)

The extent of the rehabilitated area is increasing from year to year (Figure 4). There has been a particularly significant increase from 2014 to 2016. In the first semester of 2016, the extent of mangrove revegetation in the north shoreline of Indramayu District has covered ±69.08 hectares. Karangsong Village in Subdistrict of Indramayu has the largest area of mangrove revegetation. Mangrove revegetation has been also implemented in other subdistricts i.e. Balongan, Cantigi and Pasekan. The cumulative extent of green belt of mangrove revegetation in the shoreline of Indramayu District is estimated 103.19 hectares. This increase was triggered by national and international events such as International Forest Day, Conservation Day, Environment Day, Tree Planting Day, One Billion Trees Program and One Man One Tree conducted at Karangsong and surroundings.

The increase in the extent of rehabilitated area has been accompanied by an increase in the population of mangrove species (Figure 5). *Rhizophora mucronata* is dominating the plantation (68.85%), followed by *R. stylosa* (18.33 %) and *R. apiculata* (9.53%) (Figure 6). The number of species has also increased from three species in 2008 to nine species in 2016, which consisted of six species of mangrove and three species of coastal vegetation trees (Table 3 and Figure 7). Compared with natural mangrove in Indonesia which consists of trees (at least 47 species), shrubs (5 species), herbs and grasses (9 species), and parasites (2 species) (Kusmana 2011), revegetation at Karangsong still needs to be diversified in terms of the range of species generated in the plantation areas. Increasing the species richness is critical to providing heterogeneous habitat for faunal diversity. The majority of studies have found a positive correlation between habitat heterogeneity/diversity and animal species diversity, although ecological effects of habitat heterogeneity may vary considerably between species groups depending on whether structural attributes are perceived as heterogeneity or fragmentation. Moreover, the effect of habitat heterogeneity for one species group may differ in relation to the spatial scale (Tews et al. 2004).

Although the population number of each species is increasing, the composition is not evenly distributed. This is indicated by the values for diversity and evenness indices. Figure 8 shows the change in values of diversity and evenness indices of mangrove during 2008-2016. The indices have not been continuously increasing. In particular, the mass planting in 2014 - 2016 resulted in a decline in the diversity index as well as evenness index.

Enrichment planting is critically important to increase the diversity of mangrove to enhance quality and heterogeneity of habitats for promoting fauna diversity. Azlan et al. (2015) stressed the importance of diversity and quality of habitat in encouraging the diversity and density of birds in mangroves. Bird species composition in mangroves was closely associated with both plant species composition and configuration of the vegetation structure (Azlan et al. 2015). Habitat structure and floristic characteristics are also closely related to species richness and diversity of birds. Larger areas tend to have more diverse habitats, both structurally and floristically, which bird species can occupy, resulting in greater bird diversity (MacArthur and Wilson 1967; Woinarski et al. 2001). Besides being an important factor in contributing to the increase in species richness and diversity, habitat structure is also an important determinant influencing habitat selection and distribution of species, especially in complex habitats such as tropical forest (Watson et al. 2004). Habitat heterogeneity in mangrove is less pronounced and may limit the number of coexisting species (Ford 1982).

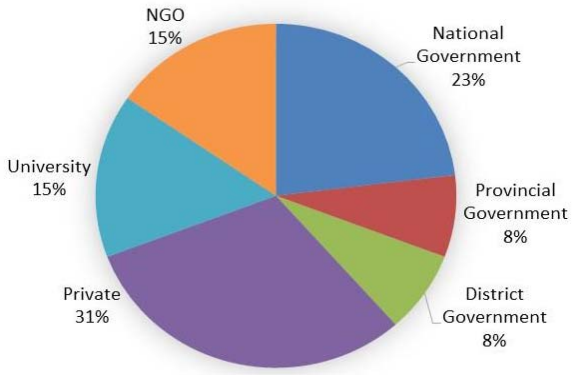

Figure 3. Supporting institutions of mangrove rehabilitation at Karangsong, Indramayu, Indonesia

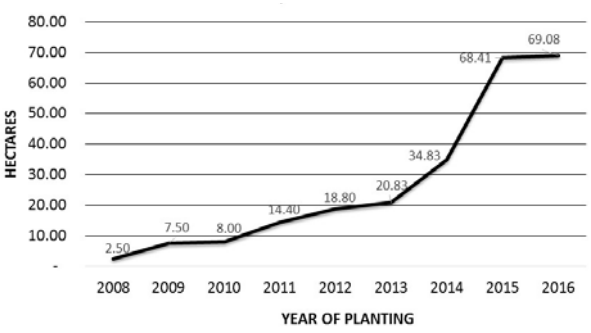

Figure 4. Cumulative extent of mangrove revegetation area at Karangsong, Indramayu, Indonesia

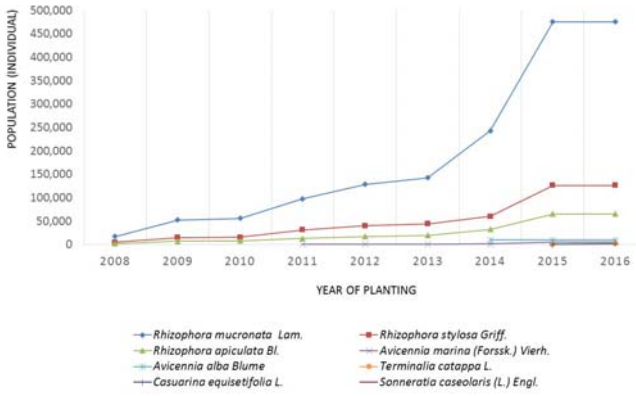

Figure 5. Population increase of mangrove and coastal species at Karangsong, Indramayu, Indonesia

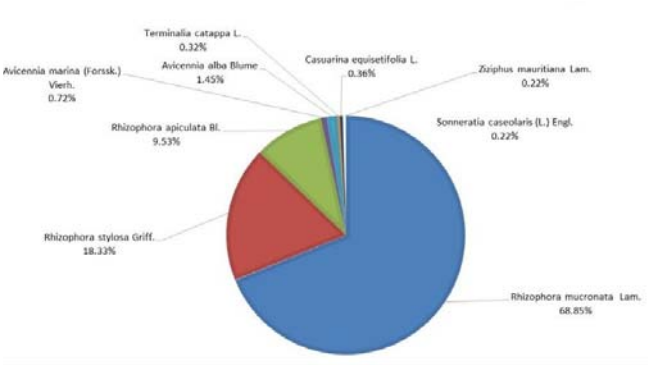

Figure 6. Composition of plant species in the rehabilitation area of Karangsong, Indramayu, Indonesia

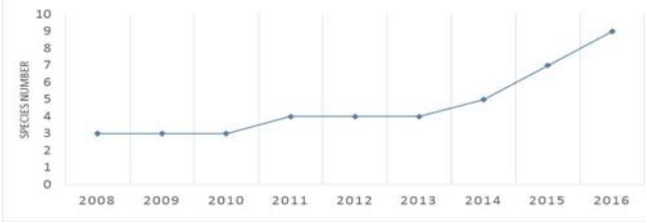

Figure 7. Increase of species number of plant at Karangsong mangrove area, Indramayu, Indonesia

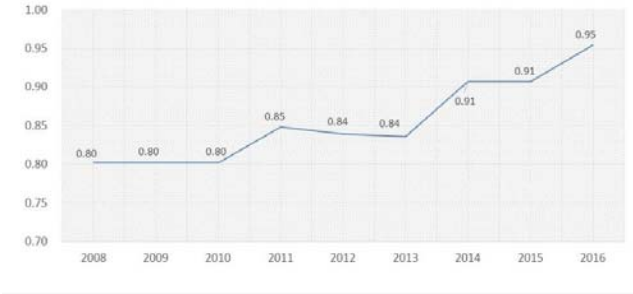

Figure 8. Dynamics of species diversity index of vegetation at Karangsong mangrove area, Indramayu, Indonesia

Enrichment planting should include an increase in species number and a balancing of the proportions among the species, so that the evenness index increases. Some species of mangrove that could be added to enrich the Karangsong mangrove area are Tanjang (*Bruguiera* sp.), Nyirih (*Xylocarpus* sp.), Tengar (*Ceriops* sp.) and Buta-buta (*Excoecaria* sp.) These have not been planted yet in Karangsong. Sandy coastal habitat should also be enriched with coastal species such as Butun (*Barringtonia asiatica* (L.) Kurz.), Nyamplung (*Calophyllum inophyllum* L.), Bintaro (*Cerbera manghas* L.), Ketapang (*Terminalia catappa* L.), Kampis cina (*Hernandia peltata* Meisn.), Waru (*Hibiscus tiliaceus* L.), Waru laut (*Thespesia populnea* (L.) Sol. Ex Correa), Kepuh (*Sterculia foetida* L.), Dungun (*Heritiera littoralis* Aiton), and Malapari (*Pongamia pinnata* (L.) Pierre).

Impact of Mangrove Revegetation

The presence of mangrove vegetation on the north coast of Karangsong Village has gradually encouraged birds and other faunas. Twelve families of birds consisting of twenty species were found in mangrove and coastal vegetation at Karangsong (Table 4). Eight species of water birds were found in the mangrove habitat. These birds are a very common presence in the mangrove of Karangsong and some of them are temporary residents. The area of the North coast of Java still having mangrove is essential habitat for migrant birds. In the north coast of Indramayu, Iskandar and Karlina (2004) reported 15 species of migrant birds. Some of the migrant birds are consumed and sold by local people for additional income (Iskandar and Karlina 2004). The role of mangrove as habitat of wildlife was also demonstrated by Gunawan (2002). Gunawan (2002) found 77 species of wildlife, consisting of three mammals, six reptiles and 68 birds that directly interacted with the mangrove vegetation in Rawa Aopa Watumohai National Park (RAWNP). The mangrove of RAWNP is a secure home for endangered species that depend on mangroves and is the main transit habitat for many seasonally migrant birds.

Table 3. List of species at Karangsong rehabilitation area, Indramayu, Indonesia

Local name	Botanic name	Family	IUCN Red List Category	Habitat
Bakau hitam	*Rhizophora mucronata* Lam.	Rhizophoraceae	LC (ver 3.1)	Mangrove
Bakau kecil	*Rhizophora stylosa* Griff.	Rhizophoraceae	LC (ver 3.1)	Mangrove
Bakau minyak	*Rhizophora apiculata* Bl.	Rhizophoraceae	LC (ver 3.1)	Mangrove
Api-api	*Avicennia marina* (Forssk.) Vierh.	Acanthaceae	LC (ver 3.1)	Mangrove
Api-api	*Avicennia alba* Blume	Acanthaceae	LC (ver 3.1)	Mangrove
Pidada	*Sonneratia caseolaris* (L.) Engl.	Lythraceae	LC (ver 3.1)	Mangrove
Ketapang	*Terminalia catappa* L.	Combretaceae	LR/nt (ver 2.3)	Coastal
Cemara laut	*Casuarina equisetifolia* L.	Casuarinaceae	NE (ver 3.1)	Coastal
Bidara	*Ziziphus mauritiana* Lam.	Rhamnaceae	NE (ver 3.1)	Coastal

Table 4. List of birds species found at Karangsong mangrove area, Indramayu, Indonesia

Local name	Latin name	Family	IUCN Red List Category Ver.3.1
Cekakak sungai	*Todirhampus chloris* Boddaert	Alcedinidae	Least Concern (LC)
Meninting	*Alcedo meninting* Horfield	Alcedinidae	Least Concern (LC)
Walet sapi	*Collocalia esculenta* Linnaeus	Apodidae	Least Concern (LC)
Walet linchi	*Collocalia linchi* Horsfield & Moore	Apodidae	Least Concern (LC)
Kuntul kerbau	*Bubulcus ibis* Linnaeus	Ardeidae	Least Concern (LC)
Kuntul karang	*Egretta sacra* Gmelin	Ardeidae	Least Concern (LC)
Kuntul kecil	*Egretta garzetta* Linnaeus	Ardeidae	Least Concern (LC)
Kuntul perak	*Egretta intermedia* Wagler	Ardeidae	Not Evaluated (NE)
Blekok sawah	*Ardeola speciosa* Horsfield	Ardeidae	Least Concern (LC)
Kokokan laut	*Butorides striata* Linnaeus	Ardeidae	Least Concern (LC)
Cinenen pisang	*Orthotomus sutorius* Pennant	Cisticolide	Least Concern (LC)
Tekukur biasa	*Streptopelia chinensis* Scopoli	Columbidae	Least Concern (LC)
Wiwik kelabu	*Cacomantis merulinus* Scopoli	Cuculidae	Least Concern (LC)
Bondol peking	*Lonchura punctulata* Linnaeus	Estrildidae	Least Concern (LC)
Layang-layang	*Hirundo tahtica* Gmelin	Hirundinidae	Least Concern (LC)
Bentet kelabu	*Lanius schach* Linnaeus	Laniidae	Least Concern (LC)
Gereja erasia	*Passer montanus* Linnaeus	Passeridae	Least Concern (LC)
Cucak kutilang	*Pycnonotus aurigaster* Vieillot	Pycnonotidae	Least Concern (LC)
Kacamata biasa	*Zosterops palpebrosus* Temminck	Zosteropidae	Least Concern (LC)
Kacamata laut	*Zosterops chloris* Bonaparte	Zosteropidae	Least Concern (LC)

The number of mangrove species planted in Karangsong has increased from three in 2008 to nine in 2016, consisting of six species of mangrove and three species of coastal vegetation. The population of each species is increasing, with the dominant species *Rhizophora mucronata* (68.85%), followed by *R. stylosa* (18.33 %) and *R. apiculata* (9.53%). The Shannon's species diversity index was fluctuated but tend to be increased from 0.80 to 0.95. The success of mangrove revegetation depends on the participation of local people and community groups as well as on contributions from the private sectors with support from government at national and local levels. The presence of mangrove has provided habitat for a diversity of fauna, especially for the bird community. Enrichment planting is still needed to increase the diversity of mangrove, which impacts on the diversity of fauna.

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