

## RESEARCH ARTICLE



## The Potential and Carrying Capacity of Lusi Sidoarjo Island as An Education and Conservation-Based Tourism

Zelen Surya Minata, Deni Ainur Rokhim, Jacky Anggara Nenohai, Nur Indah Agustina, Kafita Krisnatul Islamiyah, Burhanuddin Ronggopuro, Yudhi Utomo

Department of Chemistry, State University of Malang, Indonesia

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### ABSTRACT

The mangrove ecosystem of Lusi Sidoarjo Island has uniqueness and beauty with great potential to be developed as an education and conservation-based tourism. The main step that can be taken in efforts to develop mangrove tourism is identifying regional conditions and potentials through carrying capacity analysis. Carrying capacity analysis is needed to anticipate excess visitors who can potentially cause damage to the tourism environment. This study carried out in June – July 2022, aimed to analyze the potential and carrying capacity of mangrove ecosystems on Lusi Island as an education and conservation-based tourism. The method used in this study is descriptive quantitative by collecting data through observation, interviews, and field surveys. The calculation was made to determine the carrying capacity of the area. The results showed that the area's carrying capacity was 360 visitors/day with a diverse potential for mangroves, flora, fauna, and abundant content of metals and minerals based on XRD and XRF analysis, and literature studies. Based on the results of the analysis, it can be interpreted that Lusi Sidoarjo Island has a great amount of potential to be developed as an education and conservation-based tourism.

## Introduction

Sidoarjo City, which got the nickname Delta City, has a tour called Lusi Island. Lusi Island area is one of the marine tourism destinations in the southeast of Sidoarjo Regency, East Java Province. Astronomically, Lusi Island is located at a coordinate point of 7°33'53.6"S 112°53'16.4"E with an area of ± 94 Ha [1]. Lusi Island is an example of a reclamation island formed from the dredging of Lapindo Mud discharge deposits by the Sidoarjo Mud Management Agency (BPLS) at the mouth of the Porong River [2]. The dredging aimed to prevent silting of the river due to the accumulation of silt deposits. Visitors can access Lusi Island using the crossing boat facilities provided by Tlocor Marine Tourism [3].

Lusi Island is one of the tourist destinations in East Java Province. Most tourists come to Lusi Island to see the beauty of the mangrove forest ecosystem, ponds and to take photos. Most of Lusi Island's vegetation is dominated by various mangrove tree ecosystems [4]. A mangrove ecosystem is typically found along the coast or river estuary influenced by tides [5]. Mangroves have three main types of functions in maintaining environmental balance. The physical function of mangroves is to maintain coastlines, accelerate the formation of new land, and prevent the abrasion of rivers or beaches. The biological function of mangroves is as a shelter and breeding ground for various types of birds, shrimp, fish, and other animals.

Meanwhile, the commercial function of mangroves is as a *wanamina* pond, recreation, salt pond, and wood producer [6]. Very large mangrove vegetation on Lusi Island can help the survival of various biota. However, the area of mangroves on the coast of Sidoarjo is now decreasing. This is in line with the results of research conducted by [7], which shows that the mangrove ecosystem in Sidoarjo Regency has decreased from a total area of 1,236.42 Ha to 1,203.35 Ha. Mangrove damage is mostly caused by illegal logging and the

**Corresponding Author:** Zelen Surya Minata  [zelenminata155@gmail.com](mailto:zelenminata155@gmail.com)  Department of Chemistry, State University of Malang, Indonesia.

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transformation of mangrove ecosystems into ponds. This condition will worsen if the community has low knowledge and awareness of the importance of mangroves for ecosystem balance.

The vast mangrove forest ecosystem and various kinds of biota that live in mangroves strongly support Lusi Island as an ecotourism site. Ecotourism can be defined as a responsible journey to natural areas that can preserve the environment, support the welfare of local communities, and involve interpretation and education where education is inclusive for officers and visitors [8]. Based on the description of the information, Lusi Island is interpreted as a better alternative for ecotourism because it has a focus on preserving the ecosystem and supporting the empowerment of economic, social, and cultural aspects of local residents by involving them in tourism asset management activities to improve the welfare of local residents. The management of Lusi Island tourist assets involves the participation of the local community as the main key holder in resource management so that it can drive the economy [9]. This is in accordance with the principles of ecotourism from [10], which describes some of the main indicators of ecotourism, including being able to contribute to the conservation of diversity, being able to support community welfare, involving the responsibility of tourists and the tourism industry, and involving the participation of the community around tourist attractions.

Many people outside the Sidoarjo Regency area still do not know about the existence of Lusi Island because of the lack of promotion [11]. The potential possessed by this tourist attraction has not been optimized from the aspect of facilities and natural beauty. In 2019 Lusi Island was registered as a nominee in the Anugrah Pesona Indonesia event. However, there is no follow-up in terms of promotion, so that information about Lusi Island tourism cannot be conveyed to the wider community. Currently, Lusi Island is managed by Tourism Awareness Group and controlled by the Ministry of Marine Affairs and Fisheries [1]. Some of the facilities and infrastructure built on Lusi Island are docks, island guard houses, jogging tracks, viewing towers, *wanamina* ponds, prayer rooms, toilets, water tanks, halls, wells, and other facilities.

The preservation of the sustainability of eco-tourism on Lusi Island is the responsibility of the local community, visitors, and the government. Therefore, the community, visitors, and the government must have awareness and understanding of protecting the environment of Lusi Island, including mangrove forest ecosystems and various mangrove biota. Efforts to increase understanding and appreciation of the environment and the sustainability of tourism on Lusi Island can be made by educating tourists and involving them in conservation actions. Furthermore, the number of tourist visits to Lusi Island has reached 88,112 per year. However, no carrying capacity analysis has determined the appropriate number of visitors to the area. Analysis of the carrying capacity of the area is carried out to identify the maximum number of visitors who can visit a tourist area at a certain time without causing disturbances and damage to the physical, economic, and socio-cultural environment to increase satisfaction for visitors and support tourism sustainability [12]. Therefore, it is necessary to research the potential and carrying capacity of mangrove forest ecotourism on Lusi Island. The purpose of this study is to; (1) analyze the potential of the mangrove ecosystem on Lusi Island, (2) analyze the distribution of flora and fauna in the Lusi Island tourist area, and (3) identify the characteristics and perceptions of visitors regarding the ecotourism of Lusi Island based on education and conservation.

## **Method**

### **Study Area**

This research was conducted in the Lusi Island area at the mouth of the Porong River, Tlocor Hamlet, Kedungpandan Village, Jabon District, Sidoarjo Regency. This location was chosen as a research object because Lusi Island is one of the ecotourism destinations that needs to be developed to become a sustainable destination and is known by the wider community. The study was conducted from June to July 2022. The map of the study location can be seen in Figure 1.

### **Data Collection Methods**

This research method is a quantitative descriptive method. Primary data were collected through interviews with tourism management to obtain data on problems in tour management, interviews with visitors to obtain information about tourist attractions), closed-ended questionnaires to obtain visitor profile data, tourism object information, ecotourism understanding, tourism activities, and observation to identify the diversity of mangrove, flora and fauna species, metal and mineral content, visitor data, length of ecotourism paths, visitor time, and time provided for visits. The vegetation analysis was carried out using the quadrant transects method. Plots with different sizes were used to analyze vegetation according to their habitus, i.e., herbs (1x1

m<sup>2</sup>), shrubs (2x2 m<sup>2</sup>), poles (5x5 m<sup>2</sup>), and trees (10x10 m<sup>2</sup>). The plots were placed in the research sites using purposive sampling following the cardinal point directions. Each plant observed in each plot was labeled for easy data collection. Each individual contained in each plot was recorded on an observation sheet. The parameters observed included the number of species, the number of individuals, and the degree of diversity of plants and animals. Next, the number of individuals per species was calculated in each square to determine the index of importance values.

Meanwhile, secondary data was obtained from direct field surveys and literature studies through textbook literacy, journals, and the internet to explore information about the general state of the research location as a basis for determining the carrying capacity of Lusi Island ecotourism. In addition, data on visitors and geographical conditions of the Lusi Island area were used to determine the carrying capacity of tourism. Visitor data was collected using a closed-ended questionnaire that included respondent's profiles, tourist attraction information, eco-tourism understanding, and tourist activities. Respondents were selected using incidental sampling techniques from visitors who were 12 years old or older, assuming they had their mindset and began to be able to think critically [13]. Based on the Slovin formula, the number of respondents was 100.

### Data Analysis Methods

Data analysis techniques use quantitative descriptive analysis using primary data that includes conditions, potential, management of Lusi Island tourism assets, diversity of mangroves, plants, animals, metal content, minerals contents, and efforts to conserve the mangrove ecosystem of Lusi Island obtained from the results of field observations, surveys, and interviews. Meanwhile, secondary data on the ecological carrying capacity of Lusi Island were obtained from literature studies. Data on the potential of flora and fauna, the content of metals and minerals, as well as the characteristics of visitors are tabulated and analyzed descriptively. Quantitative analysis is performed to explain the diversity and structure of plants. Plant and animal vegetation analysis is carried out by calculating the index of importance values as in the method described by [14–15]. Furthermore, the metal and mineral content analysis on Lusi Island was carried out by laboratory analysis using X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) analysis tests and continued with a literature study of relevant previous research. Meanwhile, the carrying capacity was calculated using the following formula found in [16].

$$DDK = K \times \frac{Lp}{Lt} \times \frac{Wt}{Wp} \tag{1}$$

Information:

DDK : Carrying capacity of the destination

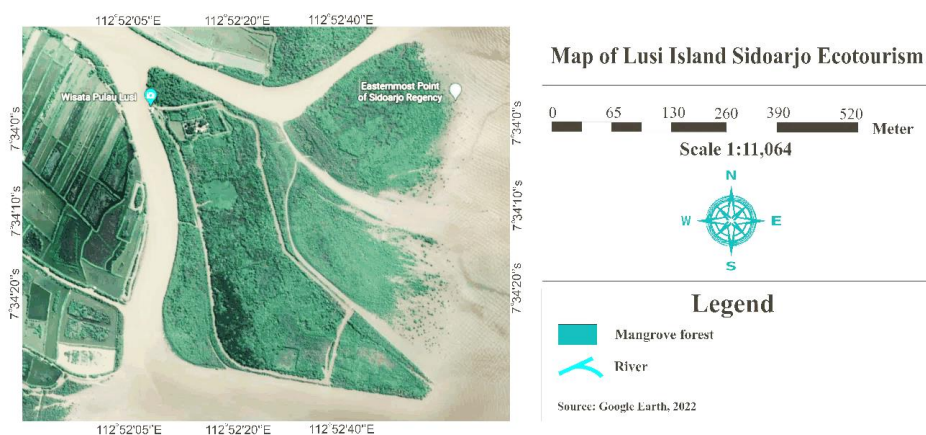
K : Effective capacity of visitors in tourist activities (people)

Lp : Length of the area usable for tourism activities (m)

Lt : Length of the area for mangrove tourism activities (m)

Wt : Time provided by the destination for tourist activities in one day (hours/day)

Wp : Time spent by visitors for each tourist activity (hours/day)



**Figure 1.** Map of Lusi Sidoarjo Island Ecotourism.

## Result and Discussion

Lusi Island has great potential to be developed as an education and conservation-based tourist destination. This is supported by the diversity of mangrove ecosystems, flora, fauna, and the abundance of metal and mineral content that can be an object of information and knowledge for visitors who come. The diversity of resources on Lusi Island needs conservation efforts to be sustainable. The potential of mangrove ecosystems, diversity of flora and fauna, metal and mineral content, characteristics, and visitor perceptions of Lusi Island are described in detail as follows.

### Condition of the Lusi Island Mangrove Ecosystem

Tourism potential is anything found in a tourist destination which attracts people to visit the place. The mangrove forest ecosystem on Lusi Island has an area of 66.42 ha [17]. The soil consisted of sand and mud. The difference in the speed of growth of mangrove plants on sand and muddy land affects the amount of mangrove vegetation. This research found 20 mangrove species on Lusi Island (Table 1).

**Table 1.** Types of mangrove plants on Lusi Island.

No.	Family	Species	Local name	Importance value index			
				North	South	East	West
1	Acanthaceae	<i>Acanthus ebracteatus vahl</i>	<i>Jeruju putih</i>	5.46	-	8.47	10.56
		<i>Acanthus illicifolius L</i>	<i>Jeruju hitam/daruyu</i>	3.37	-	-	4.76
2	Acrostichum	<i>Acrostichum aureum linn</i>	<i>Paku laut</i>	8.36	10.18	4.38	12.96
3	Avicenniaceae	<i>Avicennia alba</i>	<i>Api-api hitam</i>	10.54	8.47	12.45	4.74
		<i>Avicenna marina</i>	<i>Api-api putih</i>	2.97	7.27	10.23	5.38
		<i>Avicenna rumphiana</i>	<i>Api-api bulu</i>	3.77	6.86	3.27	1.48
4	Lythraceae	<i>Sonneratia alba</i>	<i>Pidada/bogem</i>	20.38	5.96	9.52	6.78
		<i>Sonneratia caseolaris</i>	<i>Pidada merah</i>	6.36	-	7.74	-
5	Combretaceae	<i>Lumitzera littorea</i>	<i>Terumtum merah</i>	3.25	12.47	-	14.73
		<i>Lumitzera littorea</i>	<i>Teruntum putih</i>	11.45	15.35	20.28	7.24
6	Aegiceras	<i>Aegiceras floridum</i>	<i>Mange-kasih</i>	7.46	-	11.68	-
7	Rhizophoraceae	<i>Rhizophora stylosa</i>	<i>Bakau</i>	16.72	21.86	34.96	3.56
		<i>Rhizophora mucronata</i>	<i>Bakau kurap</i>	12.25	6.86	-	2.27
		<i>Ceriops zippeliana</i>	<i>Tengar</i>	4.25	7.27	-	4.78
8	Combretaceae	<i>Terminalia catappa</i>	<i>Ketapang</i>	20.92	8.37	29.54	1847
9	Malvaceae	<i>Thespia populnea</i>	<i>Waru pantai</i>	14.70	13.25	8.43	6.86
10	Pandanaceae	<i>Pandanus tectorius</i>	<i>Pandan laut</i>	8.66	-	2.26	8.26
11	Malvaceae	<i>Hibiscus tiliacues</i>	<i>Waru laut</i>	1.54	6.86	14.69	9.32
12	Euphorbiaceae	<i>Hippomale mancinela</i>	<i>Apel pantai</i>	4.76	-	2.35	-
13	Mellaceae	<i>Xylocarpus granatum</i>	<i>Bakau meriam</i>	2.56	6.86	3.86	-

The condition of the mangrove ecosystem is influenced by hydrological conditions, namely the presence of rivers. Mangroves will thrive and dense on beaches close to river estuaries that carry water flows with mud and sand content [18]. Various kinds of flora and fauna can be a tourist attraction in every corner of the Lusi Island area, which is dominated by mangrove ecosystems. Mangrove areas are a combination of terrestrial ecosystems and marine ecosystems, so that they have abundant biodiversity. Mangrove forests also help in maintaining the balance of the ecosystem. The diversity of mangrove species on Lusi Island can be a great potential to be developed as a tourist attraction. Mangrove forest ecosystems have many potentials, including physical potential, ecological and biological functions, economic potential, and tourism potential as ecotourism and educational tourism. Physical potential and ecological function of neutralizing the impact of abrasion on river and sea coasts [19]. Biological function as a place to live marine life such as shrimps, small fish, crabs, and water birds.

Lusi Island, besides being known for its natural beauty, mangrove forests also have a very abundant metal and mineral content as an abiotic component of mangroves. Sludge samples in the field were laboratory tested using X-ray diffraction (XRD) analysis and X-Ray Fluorescence (XRF) analysis. XRD analysis aims to

determine the composition and percentage of minerals from mud. While the XRF analysis aims to determine the abundance of oxide elements and compounds. The results of the XRF analysis of Sidoarjo Mud samples can be presented in Table 2.

**Table 2.** Sidoarjo mud metal content analysis results.

No.	Element symbol	Element name	Abundance (%)
1	Al	Aluminium	9.9
2	Si	Silicon	31.1
3	P	Phosfor	0.44
4	K	Kalium	3.81
5	Ca	Calcium	7.99
6	Ti	Titanium	2.20
7	V	Vanadium	0.087
8	Cr	Chromium	0.11
9	Fe	Iron	36.4
10	Ni	Nickel	0.069
11	Cu	Cuprum	0.16
12	Zn	Zink	0.07
13	Ga	Galium	0.082
14	Pr	Praseodimium	0.09

Source: [20]

The largest abundance of elements in the mud content of Lusi Island is silicon elements, with a percentage of 31.1%. The diversity of this metal element has many potentials and directions of use that are so wide that it can be used as a useful and appropriate product for human life; for example, it is used as a catalyst, heavy metal adsorption, and water purification [20–21]. However, many visitors do not know this potential. The utilization of Sidoarjo sludge deposits based on mineralogy and chemical content can be grouped into five fields, namely health, agriculture, fisheries, industry, and cosmetics [22]. For example, kaolin mineral in the industrial field is used as an additive to the rubber industry, which can increase strength and resistance to damage.

**Table 3.** Sidoarjo mud mineral content analysis results.

No.	Compound formula	Compound name	Percentage of abundance (%)
1	Al <sub>2</sub> O <sub>3</sub>	Aluminum oxide	13
2	SiO <sub>2</sub>	Silicon dioxide	43.3
3	P <sub>2</sub> O <sub>5</sub>	Diphosphorus pentaoxide	1.5
4	K <sub>2</sub> O	Potassium oxide	2.64
5	CaO	Calcium oxide	6.30
6	TiO <sub>2</sub>	Titanium oxide	2.01
7	V <sub>2</sub> O <sub>5</sub>	Vanadium pentaoxide	0.083
8	Cr <sub>2</sub> O <sub>2</sub>	Chromium oxide	0.085
9	Fe <sub>2</sub> O <sub>3</sub>	Iron (III) oxide	25.9
10	NiO	Nickel oxide	0.027
11	CuO	Copper (II) oxide	0.092
12	ZnO	Zinc oxide	0.04
13	SrO	Stronsium oxide	0.46
14	MnO	Manganese oxide	0.35
15	MgO	Magnesium oxide	3.12

Source: [20–22]

Furthermore, the content and percentage of very diverse metals can be knowledge to encourage Lusi Island as educational-based tourism. In addition to having a variety of metal content, the mud of Lusi Island also has a fairly abundant mineral content. This information can be interpreted that the metal and mineral content in the Lusi Island ecotourism area can be a source of knowledge and develop scientific knowledge for visitors, most of whom are dominated by students. This resource can help increase the tourist attraction of Lusi Island

so that tourists who visit not only on vacation but also get useful education. Furthermore, the results of the analysis of the mineral content of mud on Lusi Island that has been tested in the laboratory can be presented in Table 3.

The parts of mangroves that can be utilized are roots, bark, and leaves [23]. Mangrove plants contain flavonoids, polyphenols, tannins, phenolic compounds, chlorophyll, carotenoids, and alkaloids. The content of these compounds in mangrove plants are widely used in the health sector as antioxidants, antimicrobials, and anticancers [23]. For example, *Jeruju* mangroves can be used as chips and medicine for diabetes and shortness of breath. Furthermore, in the culinary field, mangroves can be processed into food; for example, *Jeruju* mangroves can be used as chips [24], *Avicennia marina* mangrove fruit fiber can be used as a natural preservative for fresh tilapia [25]. Meanwhile, fire-type mangroves are used as snacks and *dodol* (typical Indonesian food with the basic ingredients of glutinous rice flour, coconut milk, and sugar) [26].

Processing mangroves into food can help to improve the community's economy. Various potentials and benefits of various types of mangroves on Lusi Island are still not widely known by the community and tourists. People and tourists still have minimal literacy on the potential and benefits of various types of mangroves. This is reinforced by data from interviews with visitors who show that mangroves are only limited to being useful as a deterrent to coastal abrasion. The concept of ecotourism it can provide an understanding for the community and visitors about the importance of environmentally friendly tourism activities by prioritizing aspects of environmental conservation, social empowerment, culture, local community economy, learning, and education aspects.

Ecotourism on Lusi Island is relatively cheap and has adequate accessibility so that it can be one of the alternative tours for the community during holidays. Interviews with Tourism Awareness Group and coral cadets of Lusi Island showed that no special care efforts have been carried out for mangrove ecosystems such as nurseries, mangrove replanting, and identification of various types of mangroves that grow. Meanwhile, interviews with visitors showed that there were no tour guides at the Lusi Island location, so they did not get important information about the types, potentials, and benefits of mangroves for life. Apart from being a refreshing place, Lusi Island can also be used as an educational and conservation-based tour for visitors who come to improve their awareness of and love for the natural environment through mangrove planting activities as conservation efforts. Observations found that visitors to Lusi Island were very diverse, ranging from the age group of children, adolescents, and adults.

Further development of mangrove forests in the Lusi Island area can be used as educational and conservation-based tourism. One of the efforts that can be made to increase tourist understanding of the potential and benefits of mangroves is to implement QR code technology and integrate it into the mangrove's name plate that can be accessed directly by tourists [27]. This can make it easier for tourists to get information about the potential and benefits of mangroves in life. Visitors can get counseling on interesting information about mangroves and how to preserve them. This will be an added value for tourism because visitors can enjoy the beauty of nature and learn about mangroves and their conservation efforts. This is in line with determining the carrying capacity index of tourist areas which can be used as a parameter to identify the sustainability profile of the area by comparing it with the number and activity of visitors. Therefore, visitors who come are expected to maintain the preservation of the mangrove ecosystem on Lusi Island.

### Distribution of Flora and Fauna of Lusi Island

Lusi Island also has diverse plants that live around the mangrove ecosystem. This plant diversity adds to the beauty of the environment on Lusi Island. Some types of plants on Lusi Island include sea cypress (*Casuarina equisetifolia*), tamarind (*tamarindus indica* L.), sea hibiscus or *waru* (*Hibiscus tiliaceus*), Indian camphorweed or *beluntas* (*Plucea indica*), *jambu biji* (*Psidium guajava*), *mengkudu* (*Morinda citrifolia*), *anting-anting* (*Acalypha australis* L.), *putri malu* (*Mimosa pudica*), *wedelia* (*Sphagneticola trilobata*), *meniran* (*Phyllanthus urinaria*), *pucuk merah* (*Syzygium myrtifolium*), cotton (*Gossypium* sp.), *duwet* (*Eugenia cumini*), papaya (*Carica papaya* L.), and *trembesi* (*Samanea saman*). Various types of these plants thrive spreading throughout the Lusi Island area. Based on this distribution, plants that have potential as ornamental plants are *anting-anting* (*Acalypha australis* L.), *wedelia* (*Sphagneticola trilobata*), *meniran* (*Phyllanthus urinaria*), and *pucuk merah* (*Syzygium myrtifolium*). This type of plant is suitable as an ornamental plant because it has an attractive leaf shape, leaf color, and flowers. Some types of fruit-producing plants have potential as food. The types of plants recorded as fruit producers are *duwet* (*Eugenia cumini*), papaya (*Carica papaya* L.), and *jambu biji* (*Psidium guajava*). Then, types of plants as medicines are tamarind (*tamarindus indica* L.), Indian camphorweed or *beluntas* (*Plucea indica*), *jambu biji* (*Psidium guajava*), and *mengkudu* (*Morinda citrifolia*).

Plants that have the potential to produce wood are sea cypress (*Casuarina equisetifolia*), tamarind (*tamarindus indica* L.), sea hibiscus or waru (*Hibiscus tiliaceus*), and trembesi (*Samanea saman*). Furthermore, the herbaceous plants that dominate in the Lusi Island area are putri malu (*Mimosa pudica*). The potential and benefits of this diversity of plant species can be a science for visitors and support Lusi Island as an education and conservation-based tourist area.

Mangroves are one of the living places of various fauna and biota diversity. The mangrove ecosystem fauna community is a mixture of two groups, namely: (1) the terrestrial fauna group which generally occupies the land and air columns; (2) groups of aquatics (aquatic) biota living in the water column, roots and trunks of mangrove trees, as well as mud. The distribution of flora and fauna on Lusi Island is very diverse, which include mammals, aves, reptiles, crustaceans, molluscs, and pisces species. The diversity of animals in the Lusi Island area can provide its own attraction for visitors such as the presence of monkey wildlife attractions, sounds, the beauty of feathers, and the uniqueness of bird behavior. This is supported by [4] show that the existence of animals, especially various types of birds, is very easy to find and can be a tourism potential as bird watching. However, currently in the Lusi Island area, there are still no facilities and infrastructure, such as observation towers equipped with long-distance binoculars, that support such activities. This is reinforced by data from interviews with visitors showing the need for special attention to the conservation of bird animals, whose populations are now declining due to poaching and the destruction of several mangrove ecosystems. The diversity of bird species in the mangrove area of Lusi Island can be presented in Table 4 below.

**Table 4.** Bird diversity in the Sidoarjo Mud Island Mangrove Area

No	Family	Species	Local name	Time	Location found
1	Oriolidae	<i>Oriolus chinensis</i>	<i>Kepodang</i>	7.00 am	North
2	Estrildidae	<i>Lonchura maja</i>	<i>Bondo/emprit haji</i>	14.10 pm	South
3	Columbidae	<i>Streptopelia chinensis</i>	<i>Tekukur</i>	8.35 am	West
4	Columbidae	<i>Geopelia striata</i>	<i>Perkutut jawa</i>	8.40 am	West
5	Zosteropidae	<i>Zosterops flavus</i>	<i>Pleci jawa</i>	9.15 am	South
6	-	-	<i>Cici kembang</i>	8.50 am	South
7	Alcedinidae	<i>Halcyon cyanoventris</i>	<i>Cekakak jawa</i>	8.55 am	North
8	Rallidae	<i>Amaurornis phoenicurus</i>	<i>Kareo</i>	9.30 am	South
9	-	-	<i>Sirdung</i>	7.35 am	West
10	Phalacrocoracidae	<i>Microcarbo niger</i>	<i>Pecuk padi</i>	11.36 am	South
11	Acipitridae	<i>Nisaetus bartelsi</i>	<i>Elang jawa</i>	14.30 pm	North
12	-	-	<i>Pecoh</i>	13.00 pm	East
13	Turdidae	<i>Turdus</i>	<i>Sikatan hitam</i>	11.48 am	South
14	-	-	<i>Blekok lumut</i>	12.27 pm	South
15	Ardeidae	<i>Ardeola speciosa</i>	<i>Blekok sawah</i>	7.37 am	West
16	Scolopacidae	<i>Actitis hypoleucos</i>	<i>Brunul trinil pantai</i>	12.39 pm	West
17	Scolopacidae	<i>Numenius arquata</i>	<i>Gajahan erasia</i>	13.10 pm	North
18	Pycnonotidae	<i>Pycnonotus aurigaster</i>	<i>Kutilang</i>	7.15 am	West
19	Ciconiidae	<i>Mycteria cinerea</i>	<i>Bangau bluwok</i>	13.38 pm	North
20	Cisticolidae	<i>Prinia familiaris</i>	<i>Prenjak jawa</i>	7.20 am	East
21	-	<i>Glaucidium castanopterum</i>	<i>Owl</i>	7.00 am	North
22	Laridae	<i>Larus sp</i>	<i>Camar</i>	13.40 pm	East
23	Laridae	<i>Sterna sp</i>	<i>Dara laut</i>	13 50 pm	North
24	Anatidae	<i>Dendrocygna arcuata</i>	<i>Belibis kembang</i>	15.10 pm	West
25	Ardeidae	<i>Ardea purpurea</i>	<i>Cangak merah</i>	14.46 pm	East
26	Ardidae	<i>Egretta garzetta</i>	<i>Kuntul kecil</i>	7.37 am	West

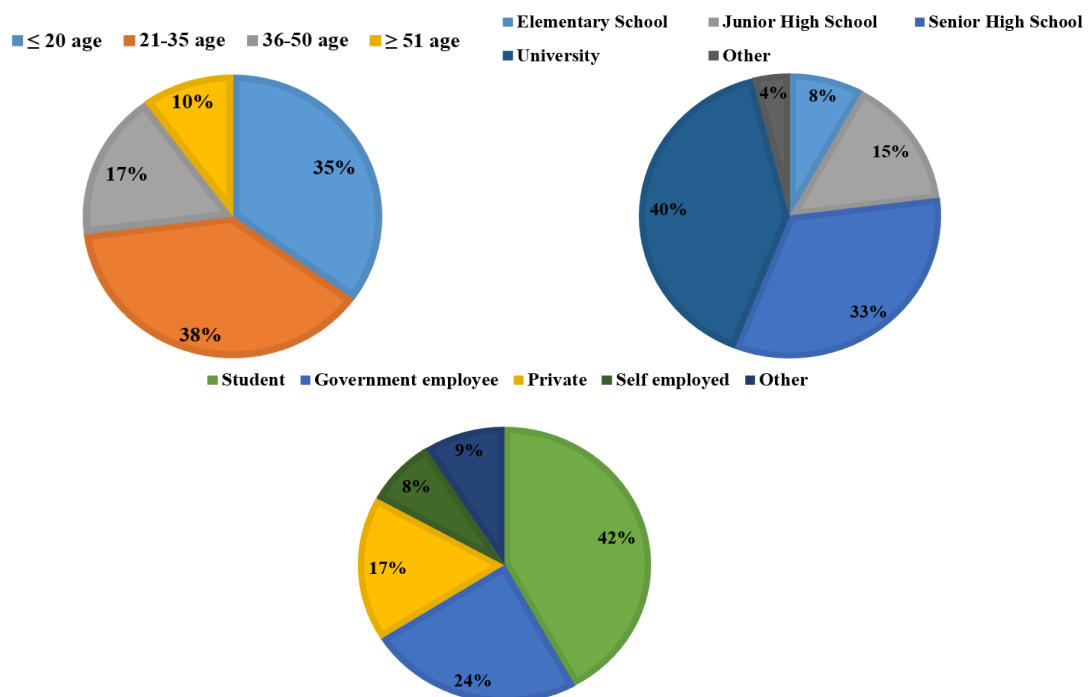
Mangrove ecosystems are habitats for various types of wildlife, such as primates, reptiles, and birds, as well as breeding grounds for various types of waterbirds, fish, and shrimp [28]. In the mangrove area of Lusi Island, the aquatic biota of crustaceae that is commonly found are mangrove crabs (*Scylla serrata*), reborn shrimp

(*Panaeus latisulcatus*), and *jerbung* shrimp (*Fenneropenaeus merguensis*). The most commonly encountered mollusca-type aquatic biota are kupang (*Mytilus edulis*), sand mussels (*Tellina radiata*), and shellfish (*Anadara* sp). Furthermore, the most common types of fish found include mullet fish (*Liza melanopetera*), kakap fish (*Lutjanus* sp.), *bandeng* fish (*Chanos chanos*), and *gelodok* fish (*Periophthalmus* sp.). Furthermore, in the terrestrial zone, the fauna that is often found is long-tailed monkeys (*Macaca fascicularis*), *berang-berang* (*Lutrinae lutrinae*), and squirrel (*Callosciurus notatus*). Furthermore, the most common types of reptiles and amphibian's terrestrial fauna are mangrove lizards (*Emonia atrocostata*), *biawak* (*Veranus salvator*), lizard (*Eutropis multifasciata*), and mangrove snakes (*Boiga dendrophylla*). The diversity of flora and fauna on Lusi Island can also be a very large potential to be further developed as an educational and conservation-based tourist attraction that leads to efforts to preserve the environment and maintain ecosystem balance.

## Visitor Characteristics and Perceptions

### Visitor Profiles

Visitors to ecotourism on Lusi Island are dominated by teenagers to adults (75%) with an age  $\leq 35$  years. This is supported by the fact that the majority of visitors are students and have a tendency to travel to natural environment. Some visitors, such as students and college students, are also often involved in conducting research activities in the Lusi Island area. Visitors who came were mostly from around Sidoarjo and Pasuruan Regencies because, geographically it is considered closer to a shorter travel time of  $\pm 30$  minutes. However, domestic visitors from other regions are still minimal and do not know the existence of Lusi Island, so it is necessary to make further tourism promotion efforts. Profiles of visitors from Lusi Island can be seen in Figure 2 below.



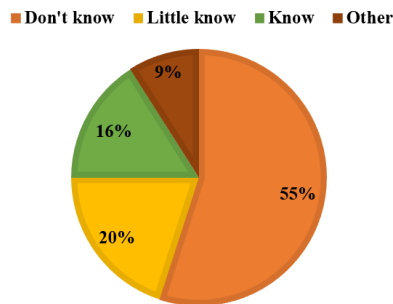
**Figure 2.** Visitor profiles by age (a), education level (b), and employment (c).

### Understanding Ecotourism Based on Education and Conservation

Most visitors to the Lusi Island area do not understand in detail and specifically about the form of ecotourism activities. Therefore, it is necessary to optimize the potential on Lusi Island, such as the potential of mangroves, various types of flora, and fauna as a source of educational information and the importance of conservation efforts that support the concept of ecotourism. Educational programs that have the potential to be further developed are the use of QR code technology as a source of information about the potential and diversity of mangroves, flora, and fauna on Lusi Island and the socialization of appropriate conservation efforts for visitors [27]. Through the development of this further educational program, visitors will be more aware of the importance of ecosystem conservation and be directly involved in conservation efforts supporting sustainability. Therefore, visitors who come are not just recreational and refreshing without



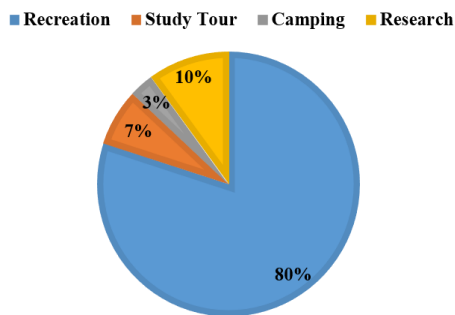
realizing that all mangrove ecosystems on Lusi Island can be used as educational and conservation-based tourist attractions to improve the motivation of visitors to revisit. A profile of visitors' understanding of the level of understanding of Lusi Island as an educational and conservation-based ecotourism can be presented in Figure 3.



**Figure 3.** Ecotourism understanding of Lusi Island visitors.

### Motivation to Visit

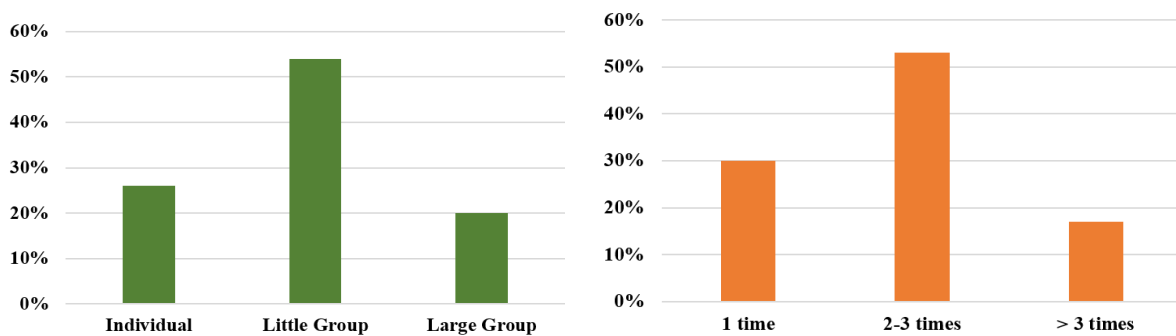
Most visitors who have a motivation for recreation and the type of tourism that is in demand is taking pictures around the mangrove location and enjoying the atmosphere of crossing using a water bus. This is due to the relatively affordable entrance fee and the beautiful scenery owned by the mangrove area on the island of Lusi. Furthermore, visitors can only visit the main region of Lusi Island. However, there are still 80% of mangrove forest land that visitors cannot visit due to lack of supporting facilities and infrastructure. The motivation of visitors to Lusi Island can be presented in Figure 4.



**Figure 4.** The motivation of Lusi Island visitors.

### Forms of Visit

Most visitors visit in groups with a frequency of arrival between 2–3 times a year. The form of visits carried out by the group is dominated by families, while students mostly dominate the form of individual visits. Theoretically, the frequency of arrivals or repeated visits more than once can be interpreted as having a visitor's interest in tourist attractions [29]. A profile of visitor visits by visitors can be presented in Figure 5.



**Figure 5.** Profile of visit form (a) and frequency of visit (b).

## Lusi Island Ecotourism Carrying Capacity Analysis

Carrying capacity analysis is indispensable for utilizing the potential resources on Lusi Island. Carrying capacity is the number of tourists per area and time that can be provided by the tourist area per unit of time without causing a decrease in the level of tourist satisfaction [30]. The concept of carrying capacity was developed to prevent the destruction of natural resources and the environment. The method used in determining the carrying capacity of Lusi Island ecotourism development in this study is the concept of regional carrying capacity [16]. The length of the coastline of the Lusi Island area suitable for mangrove ecotourism ( $L_p$ ) is 4,500 m, with a total mangrove area of 94 Ha.

The length of the coastline suitable for ecotourism is interpreted as a path of ecotourism activity. The ecological potential of visitors ( $K$ ) per unit of mangrove tourism area is one person for a track of 50 m ( $L_t$ ) [16]. The time visitors spend to travel mangroves is 2 hours ( $W_p$ ). The time reserved for visitors in 1 day is about 8 hours ( $W_t$ ), while the number of visitors on Lusi Island is around 150 people per day. So, based on the calculation of carrying capacity, the calculation of the carrying capacity of the mangrove forest ecotourism area (DDK) in the Lusi Island area is 360 people per day. It can be interpreted that the Lusi Island tourist area can accommodate all tourist activities carried out by visitors well without exceeding the area's carrying capacity so that visitor activities and the sustainability of the area are maintained.

Ecotourism is conservation-based tourism with an orientation to minimize negative environmental impacts and be sustainable. To maintain ecotourism to remain sustainable, it is necessary to create conditions for the community that has the authority to make decisions in managing ecotourism, monitor the flow and number of tourists, and develop ecotourism more directly by the goals and targets that have been set. The carrying capacity of ecotourism management is an important aspect that must be managed to support environmental sustainability and ecotourism activities. Carrying capacity can affect the comfort and satisfaction of visitors in enjoying the tourist activities [31]. The results of the carrying capacity analysis can be a reference for tourism managers in developing tourist attractions. Tourism can also be developed by increasing the number of facilities and infrastructure. Possible facilities that are required to support tourism on Lusi Island include bird-watching towers, tour guides, infographic boards, barcode boards containing descriptions of the distribution of flora and fauna, metal and mineral content, and several other facilities that can support comfort and increase visitors' knowledge and insight into the importance of nature conservation efforts.

## Conclusion

Lusi Island ecotourism has an area carrying a capacity of 360 people per day, affecting the sustainability level of ecotourism activities. The carrying capacity index of the area is interpreted as Lusi Island accommodating all tourist activities carried out by visitors well so that the sustainability of the area is maintained. Lusi Island has enormous potential to be developed as an education and conservation-based tourism, which is indicated by the existence of several resources in the tourist area, such as the diversity of mangrove species, flora, fauna, the abundance of metal and mineral content and the direction of its use. Therefore, tourists who come not only on vacation but also get education and awareness about useful environmental conservation efforts. Furthermore, to support the development of Lusi Island ecotourism, additional supporting facilities are needed, such as infographic boards and tour guides.

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