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Mansaka Baylan, Mindanao, Philippines photo by Jacob Maentz

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Bakera: tradition of medicinal plants utilization for therapy, prevention and recovery of diseases in Jailolo Sultanate custom society, Indonesia

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Abstract. *Syahdar SA, Tamalene MN, Hasan S. 2019.* Bakera*: tradition of medicinal plants utilization for therapy, prevention and recovery of diseases in Jailolo Sultanate custom society, Indonesia. Asian J Ethnobiol 2: 71-77.* Indonesia is well-known as the source of tropical plants that are very useful for treating various diseases. In addition, there is also diverse traditional knowledge of herbal utilization in many societies. The eastern part of North Maluku Utara Province, the Jailolo Sultanate Society of Halmahera Island, consists of four original tribes: Gamkonora, Tobaru, Sahu, and Wayoli, still use traditional medicine to treat diseases. Their tradition called "*Bakera"* is similar to the 'Spa' in modern urban societies. *Bakera*, as one of the local geniuses in the medical field, has become an entrepreneurial interest, especially for those running the spa business. Medically, plants used in *Bakera* have been proven to affect health positively. This data may enrich other data on the wealth, diversity, and knowledge of medicinal plants of Indonesian communities. The research used emic and etic approaches. Data were analyzed descriptively, including presentation, reduction, verification, and validity check. Informants of the study were eight people selected using the Purposive Sampling Technique. *Bakera* can be used in the postpartum treatment and treat sore, malaria, and liver. As a whole, the use of nine different plant species for *Bakera* consists of medicinal and spice plants. There are three plant species found that is often cultivated in the yard. *Bakera* has thermotherapy and aromatherapy effects that contribute to *Bakera* effectiveness. Thermotherapy could alleviate muscle tension, lose weight, increase blood circulation, reduce tension headache, autoimmunity, and relaxation. In addition, plants used have immunostimulant, antiseptic, and antiphlogistic effects.

Keywords: *Bakera*, ethnic, Gamkonora, Halmahera, medicinal plants, Sahu, Tobaru, Wayoli

INTRODUCTION

Societies in developing countries are highly relied on local natural resources, including especially wild medicinal plants, to fulfill their needs on daily primary health treatment (Quave and Pieroni 2014). The diversity of traditional medicine is due to the variety of human societies, languages, and cultures, combined with local ecological diversity Novy (, 1997); Ndoye and Eyebe (1997)**.**

Many ethnic communities in Indonesia have practiced the utilization of medicinal plants. Each ethnic has its knowledge of how to use various medicinal plants. This is a priceless asset, especially for developing the medical and pharmaceutical industry (Noorcahyati 2012). In human civilization, plants as medicine materials have been utilized since the era of gathering. It is inherited from previous generations and lasts until the present day, practiced by modern society. Local knowledge is every generation's heritage. This knowledge is usually owned by traditional healers (the Hattra), who are considered consistent in preserving and practicing local knowledge on utilizing various plants to create many traditional potions. However, many rural societies have become more familiar with modern medication and chemical medicines.

The growing interest in traditional medication cannot be separated from the ever-increasing complexity of diseases among societies and the increasing health expenses. As a result, traditional medicine has become one of the alternatives for people looking to solve health problems.

Supported by available natural resources and inherited knowledge of traditional medication, the interest keeps growing among the Jailolo Sultanate indigenous society in Halmahera Island, North Maluku Province, Indonesia. People's traditional potion processing methods include squeezed, fresh-consumed, boiled, mashed, and vaporization. Jailolo Sultanate indigenous society uses herbal material both in new conditions and after being dried.

There are two ways of processing medicine from plants, either boiled and squeezed or mashed. While there are three ways of serving it: drink it, rub it on the body, or wash it with water. Drinking potion is usually a treatment for inner body part diseases, while the other two are for outer body part treatments (Kusuma and Zaky 2005).

One unique method of traditional herbal medication practiced by the Jailolo Sultanate indigenous society is the *Bakera* or vaporization. *Bakera* is a treatment commonly used by four ethnicities under the Jailolo Sultanate: Gamkonora, Tobaru, Sahu, and Wayoli, who live in West Halmahera District, North Maluku Province. This is the most common treatment for women to keep them fit and fresh during their post-maternal phase. Its method is similar to the sauna and uses aromatic herbs.

Sukenik et al. (1999) stated that a sauna is good for blood circulation. Minerals contained in the potion penetrate through the skin pores. Sauna has many therapeutic functions, including decreasing blood pressure, improving lung function, easing asthma and bronchitis, relieving pain, and improving joint mobility in rheumatic treatment (Hannuksela and Ellahham 2001). Sauna is also suitable for respiration, cardiac disease, hypertension, depression, pain reliever, auto-immunity, and relaxing fatigue (Crinnion 2011). Sauna is ideal for relaxation since it can improve blood circulation and relieve pain. The aroma of the herbal potion used in a sauna can also deliver a sedative effect (Taavoni et al., 2013).

Essential oil used in the sauna plants could evaporate, thus stimulating memory and emotional response. Apart from the inside, the brain, called the hypothalamus, will deliver messages through the whole body, converted to actions to release particular compounds that can make our body relaxed. Relaxation can cause the muscle to relax, thus reducing the production of adrenaline hormone, which in turn decreases blood pressure (Werdyastri et al., 2014).

Aromatherapy from essential oils can easily infiltrate into the blood circulation and then be excreted through the urinal system or exhalation (Maddocks-jennings and Wilkinson 2004). Aromatherapy can treat diseases, balancing and relaxing our body, mind, and soul, as well as stimulating the body immune system to cope with various health problems, such as respiratory diseases, gastroenteritis disease, neural disorder, as well as infection of bacteria and fungus (Alexander 2002; Reichling and Saller 2003, Suwanti et al. 2018).

Inhaling aromatherapy is considered the fastest and most direct healing method. That is because the easy-to-evaporate molecules of essential oil directly react to olfactory organs, resulting in brain perception (Sustrani 2004).

The utilization of medicinal plants is a long-lasting tradition. Traditional knowledge or local genius of Jailolo Sultanate indigenous society in utilizing natural resources, especially medicinal plants, is a cultural treasure to be preserved. As such, authentic Indonesian knowledge will not be eliminated from civilization so that the medicinal plants will be based for utilization by the Jailolo Sultanate indigenous society. The research aims to discover traditional knowledge of Jailolo Sultanate indigenous society in utilizing medicinal plants to prevent (preventive), treat (curative), and recover (rehabilitative) diseases.

MATERIALS AND METHODS

The research was conducted from March to November 2018 at three sub-districts in West Halmahera District areas, North Maluku. Four villages were selected from the three sub-districts (Figure 1).

The research used a qualitative method with *a* phenomenology approach using semi-structured interviews, observation, and documentation. Informants were selected through purposive sampling (Figure 2).

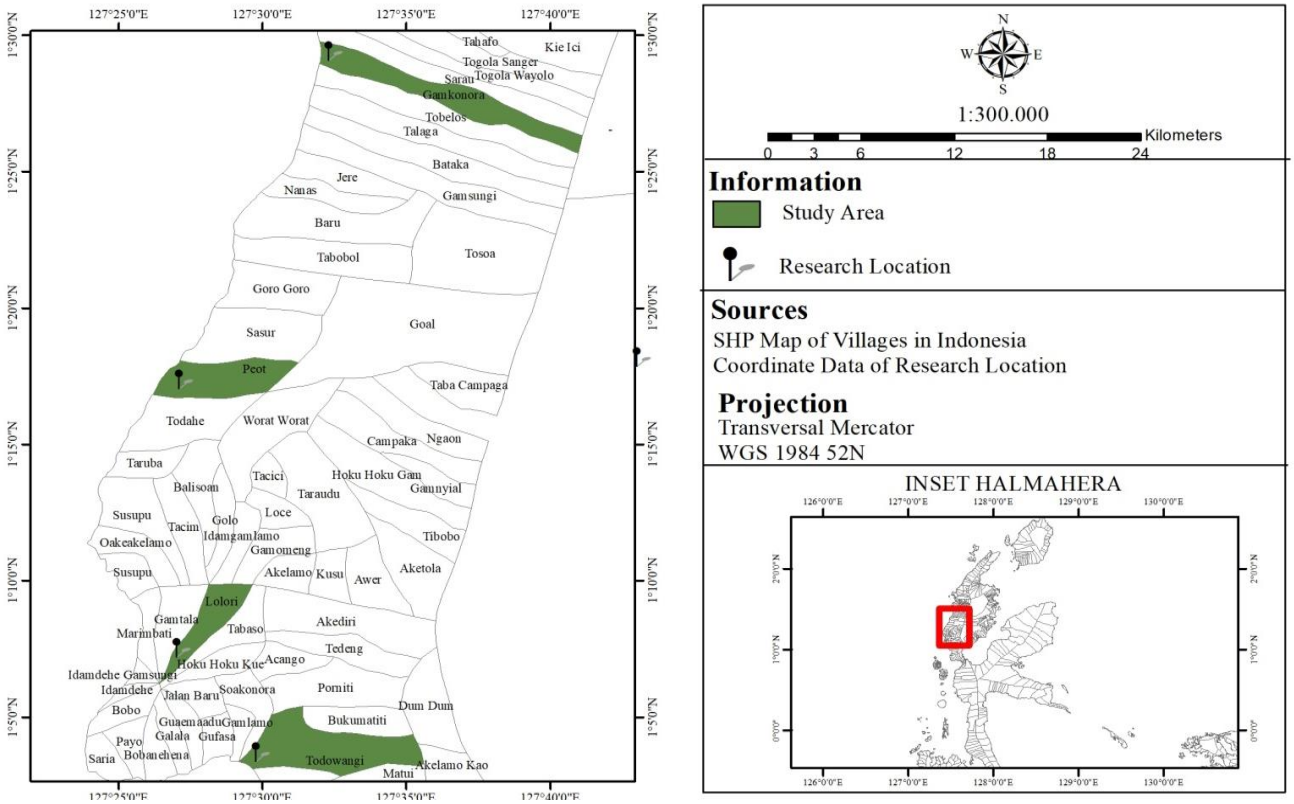

Figure 1. Map of the study area in Jailolo, West Halmahera District, North Maluku Province, Indonesia

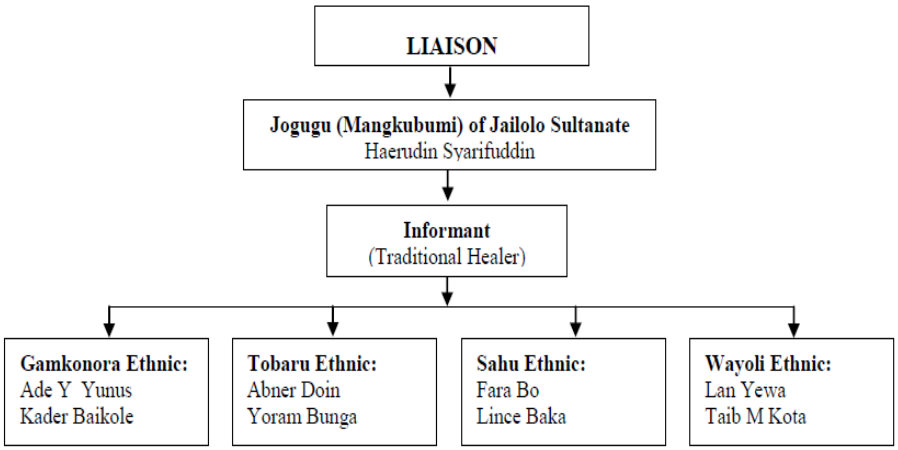

Figure 2. Assignment of Research Informants

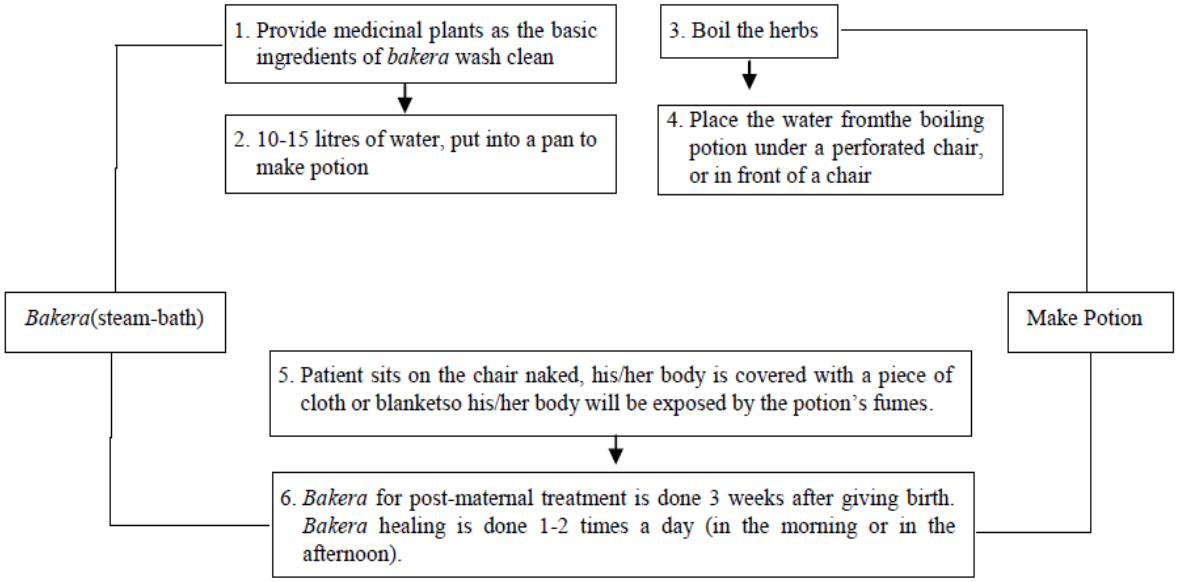

Figure 3. The common process of *Bakera*

The Informants of the research were eight people. The selection was based on 1) Healing period/level of healing practice to represent the level of skill and knowledge; 2) knowledge on medicinal plants utilization, and; 3) already having pupils that will inherit their knowledge. Besides becoming a *hattra* (traditional healer), informants were also peasants. Informants from the Gamkonora Ethnic reside in Gamkonora Village, South Ibu Sub-district. Informants from the Sahu Ethnic live in Lolori Village, Jailolo Sub-district. Informants from the Tobaru Ethnic reside in Todowongi Village, Jailolo sub-district, informants from the Wayoli ethnic reside in Peot Village, Sahu Sub-district. All of them are still practicing traditional medication in their daily life. Informants' age is between 51 and 70 years old with an average level of education is not graduated from elementary school (only one informant who is a high school graduate).

Each informant was asked for information concerning medicinal plants and their utilization and processing method practiced. The identification of plants used in medication was made directly on the field. The identification process was based on the plant's morphological characteristics (root, stem, leaf, flower, seed, and fruit). Plant identification method used plant identification guidebook by the Medicinal Plants Center. Unidentified plants will be identified by matching plants' organs with determination keys using Steenis (2008) book. Results were analyzed descriptively by presenting data in figures and tables. Results are analyzed by data presentation, reduction, verification, and validity check. A map of the research location can be seen in figure 2.

RESULTS AND DISCUSSION

The Jailolo Sultanate indigenous society has an authentic traditional medical treatment method called the *Bakera*. *Bakera* is a traditional way of steam-bathing using the medical plants for healing, recovery, and preventing diseases. The word '*Bakera*' is derived from the Minahasa language of Sulawesi Utara (North Sulawesi), first explained by Watuseke in 1970 (Watuseke 2014). *Bakera* tradition can be considered the "Spa" (Salus per aqum) " in modern societies. Knowing of healing, prevention, and recovery using medicinal plants is inherited hereditary in local medication. From the medical aspect, medicinal plants used in *Bakera we*re proven to positively affect health by simply supporting the body's immune system. *Bakera*, as one of the local knowledge in medical practices in North Maluku, has attracted entrepreneurial interest. Generally, the method used in *Bakera* is presented in Figure 3, and *Bakera* process documentation is shown in Figure 4.

Body treatment is important, not only for women but also for men. The women of Jailolo Sultanate indigenous society have been doing the *Bakera* for generations. This treatment is mainly done by those who have just given birth to a baby (three or four weeks after birth). Yet, *Bakera* is done for post-maternal treatment and many kinds of disease (Table 1.)

Table 1. *Bakera* for medication, recovery, and prevention of various diseases

Ethnic	Disease treated using *Bakera* method	Potion making method	Serving/applying method
Gamkonora	Liver disease	Provide 17 handfuls of clove leaves, 17 handfuls of nutmeg leaves, a piece of dried banana leaf, and 20cm of mangosteen bark. Prepare 10-20 liter of water, put all the ingredients into the water, and boil the potion.	Drink a half glass of boiled potion water, and put the rest under a perforated wooden chair. The patient sits naked on the chair, covered by a piece of the blanket so that their whole body will be exposed to the hot steam coming from the boiling potion. The treatment can be done once a week until the patient feels recovered.
	Post-maternal treatment	Provide 20 handfuls of clove leaves, wash clean; 20 handfuls of nutmeg leaves, 1 dried banana leaf, 20cm of mangosteen bark. Prepare 10-20 liter of water, put all the ingredients into the water, and boil the potion.	Place the boiled potion under a perforated wooden chair. The patient (the mother) sits naked on the chair, covered by a piece of the blanket so that her whole body will be exposed by the hot steam that comes from the boiling potion. The treatment is done twice a day (in the morning and the afternoon) for a month. The treatment can be applied one month after giving birth.
	Treatment of Malaria	Provide 20 handfuls of clove leaves, wash clean; 20 handfuls of nutmeg leaves, 1 dried banana leaf, and 40 cm of the langsat fruit bark. Prepare 10-20 liter of water, put all the ingredients into the water, and boil the potion.	Place the boiled potion under a perforated wooden chair. The patient sits naked on the chair, covered by a piece of the blanket so that their whole body will be exposed to the hot steam that comes from the boiling potion. *Bakera* is practiced in the morning and afternoon until the patient sweats. Treatment is done after the patient recovered from the disease.
Sahu	Post-maternal treatment	Provide 17 handfuls of clove leaves, wash clean; 17handfuls of nutmeg leaves, 1 dried banana leaf, and 30 cm of the langsat fruit bark. Prepare 10-20 liter of water, put all the ingredients into the water, and boil the potion.	Place the boiled potion under a perforated wooden chair. The patient (the mother) sits naked on the chair, covered by a piece of the blanket so that her whole body will be exposed by the hot steam that comes from the boiling potion. The treatment is executed twice a day (in the morning and the afternoon) for a month. The treatment can be performed one month after giving birth.
Tobaru	Post-maternal treatment	Provide 20 handfuls of clove leaves, wash clean; 20 handfuls of nutmeg leaves, 1 dried banana leaf, 30 cm of the langsat fruit bark.1 papaya leaf, 15 handfuls of sea daisy leaves. Prepare 10-20 liter of water, put all the ingredients into the water, and boil the potion.	Place the boiled potion under a perforated wooden chair. The patient (the mother) sits naked on the chair, covered by a piece of the blanket so that her whole body will be exposed by the hot steam that comes from the boiling potion. The treatment is executed twice a day (in the morning and the afternoon) for a month. The treatment can be performed applied one month after giving birth.
Wayoli	Relief pain	Provide 17 handfuls of clove leaves, wash clean; 17 handfuls of nutmeg leaves, 1 dried banana leaf, and 30 cm of mangosteen bark. Prepare 5-10 liter of water, put all the ingredients into the water, and boil the potion.	Place the mixture under a hollow wooden chair. The patient sits naked on the chair, covered by a piece of the blanket so that their whole body will be exposed to the hot steam that comes from the boiling potion. The treatment can be done once a week until the patient feels recovered.

A **B** **C**

Figure 4. A. Tools and materials, B. Ready-to use-potion, and C. *Bakera* process

Table 2. Plants used in *Bakera*

Family	Local name	Commercial name	Scientific name	Habitus	Part(s) used
Asteraceae	Cinga-cinga	Sea daisy	*Melanthera biflora* L. Wild	Bush	Leaf
Caricaceae	Pupaya	Papaya	*Carica papaya* L.	Tree	Leaf
Clusiaceae	Mangustan	Mangosteen	*Garcinia mangostana* L.	Tree	Bark
Convolvulaceae	Loloro	Bayhops	*Ipomea pes-caprae*	Bush	Leaf, stem
Meliaceae	Lansa	Langsat	*Lansium domesticum*	Tree	Bark
Musaceae	Pisang	Banana	*Musa textilia*	Tree	Leaf
Myristicaceae	Pala	Nutmeg	*Myristica fragrans* Houtt.	Tree	Leaf
Myrtaceae	Cengkeh	Clove	*Syzygium aromaticum*	Tree	Leaf

Bakera uses potions made from medicinal plants suitable for disease medication, recovery, prevention and produces unique fragrances. The research found eight plants used in the *Bakera*, from spices to seashore bushes. A complete list of plants used as the ingredients of *Bakera*, along with their local and scientific name, habitus, parts, and family presented in Table 2.

All parts of medicinal plants have medical efficacy. However, the most commonly used part is the leaf, which takes 75% of all components (Figure 5). It is not hard to find those plants in the backyard of the home of Jailolo Sultanate indigenous society since most of their home nearly cannot be separated from those plants. It is just like plants for food and living.

Bakera, or a traditional sauna that uses medicinal plants, was explained in detail for the first time by Zumsteg and Weckerle (2007). Steam-bathing using many kinds of medicinal plants is a traditional method practiced by the people of North Sulawesi, mainly done by post-maternal mothers. Indigenous society believes that steam-bathing positively relaxes the body, improves blood circulation, and reduces body weight.

Bakera is applied one month after giving birth. According to the belief of Jailolo Sultanate indigenous society, a mother who just gave birth to a baby has an 'immature' body and would not be strong enough to take a *Bakera* treatment. That is why it is performed one month afterward. This method is also expected to make the body becomes fitness and healthy.

For Jailolo Sultanate indigenous society, the benefit of *Bakera* can be felt physically and mentally by their mind. These people said that after taking *Bakera*, their body feels more relaxed and fragrant. They feel more comfortable, and their mind also becomes more flexible. *Bakera* is considered to cure, prevent, and recover particular diseases. According to Taavoni et al. (2013), steam-bathing is good for relaxation since it can improve blood circulation and relieve pain.

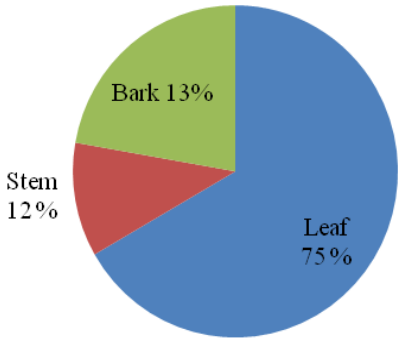

Figure 5. The proportion of medicinal plants' parts used in *Bakera*

The Jailolo Sultanate indigenous society also said that the medicinal plants used and the vaporization in *Bakera* can prevent diseases. Medicinal plants boiled and inhaled by the *Bakera* patient act like medicine for their body. During the vaporization, the patient's body produces sweat. They believe that sweat brings out poisons from inside their body. That is why they feel healthier and fresher after taking *Bakera*.

The utilization of medicinal plants in *Bakera* provides a particular effect. The *Bakera* used plants from the family of Asteraceae (Sea daisy), Myrtaceae (Clove), Convolvulaceae (Bayhops), Meliaceae (*Langsat fruit*), Clusiaceae (Mangosteen), Myristicaceae (Nutmeg), Caricaceae (Papaya), Musaceae (Banana). Almost all ingredients have good effects on healing disease, medication, prevention, and recovery. As presumed by the local society, the efficacy of plants is nearly similar to what has been clinically tested. Studies have been conducted on some of those plants and reported on international journals, such as clove, nutmeg, sea hops, papaya, mangosteen, langsat, and banana.

Secondary metabolite compounds in clove leave act as an antibacterial agent (Nanan 2004). The main content of clove oil is eugenol, eugenol acetate, and caryophyllene. The Eugenol compound is a significant component in clove is an essential oil with antioxidant, antifungal, analgesic, and antiseptic activities. Clove oil has a unique taste and aroma favored by many people. In addition, the oil has stimulant, anesthetic, carminative, antiemetic, antiseptic, and antispasmodic nature (Altman and Marcussen 2001; Nanan 2004; Kumala 2008).

Methanol extract from nutmeg leaves contains alkaloids, flavonoids, terpenoids, acetate, and tannin compounds. At the same time, the ethyl acetate extract contains a flavonoid compound used as an antioxidant and antibacterial. It also has antifungal activity against *Candida albicans*. Nutmeg leaves' acetyl extract has antibacterial activity against *S. aureus* and *E. coli* (Ginting et al., 2017). The essential oil in nutmeg is approximately 5-15% consisting of pinene, sabinene, camphene, myristicin, elemicin, isoelemicin, eugenol, isoeugenol, methoxyeugenol, safrole, dimeric polypropanoate, lignin, and neolignan (Janssens et al. 1990; Sonavane et al. 2001). According to Orita et al. (2003), one of the essential components in nutmeg fruit is myristicin, which has hepatoprotective activity.

Contents of plant langsat that are medically beneficial include essential oil, saponin, tannin, and organic acid. Venkateshappa and Sreenath (2013) suggested that the contents of langsat can be used as a pain reliever, antifungal, anti-inflammatory, tonic, and infection prevention. Phytochemical screening done by Poeloengan and Praptiwi (2010) on mangosteen shows alkaloid, tannin, phenolic, flavonoid, and triterpenoid compounds. Those compounds are known for having an antibacterial nature. The extract of the dry banana leaf contains secondary metabolite compounds of tannin, phenol, and flavonoid (Putra 2014). Tannin is one of the free radical predators (Kumari and Jain 2012).

Papaya leaves contain vitamins such as vitamin A, C, and E and alkaloids as the main antioxidant (Fitria et al., 2013). Antioxidant compounds can prevent damage caused by the free radical on normal cells, proteins, and fat. The utilization of medicinal plants in *Bakera* provides special effects since they contain various kinds of secondary metabolite compounds. This compound is a bioactive substance related to the chemical included. Secondary metabolic is only found in specific organisms and produced under particular conditions (Sudha and Ravishankar 2002).

Generally, secondary metabolite compound has an activity and function as a protector for the plant against pests for the sake of the plant itself and the surrounding environment. A chemical compound resulting from secondary metabolite has been broadly used as a dye, poison, aroma, food, medicines, and so on (Hayati and Fasyah 2010).

Essential oil content in *Bakera* ingredients will evaporate and stimulate memory and emotional responses. A part of the brain called the hypothalamus would deliver messages to the body that will be converted to actions in unleashing compounds that can relax the body. Relaxation can make muscles relaxed as well. This condition will decrease the production of adrenaline, which eventually will be resulted in reduced blood pressure (Werdyastri et al., 2014).

Fresh plants are added to the hot water when the essential oil evaporates. Essential oil concentration resulting from the evaporation process is high enough to induce physiological effects, both from inhalation and skin condensation on infected or inflamed perineum areas (Boer et al., 2011).

The essential oil is inhaled and applied to the skin surface through evaporation. It may also penetrate through women's blood circulation (Bronaugh et al., 1990). Essential oil from plants used in *Bakera* supports the healing process, primarily through tonic effect. It may also prevent infection since it contains antiseptic and antiphlogistic.

Through the evaporated potion, Jailolo Sultanate indigenous society communities believe that *Bakera* will immediately recover their stamina and health, improve the blood circulation of post-maternal mothers, and rejuvenate skin texture from wrinkles after pregnancy. *Bakera* also is believed as a detoxification method after giving birth. It has been reported that steam-bathing can deep-cleanse our skin, enhance body weight, improve blood circulation, enhance muscle recovery, relieve headache, and be good for relaxation (Hannuksela and Ellahham 2001; Iwase et al. 2013; Crinnion 2011).

In summary, the traditional community of Jailolo Sultanate used nine types of medicinal plants for *Bakera* treatment, namely: *Melanthera biflora* L. Wild, *Carica papaya* L., *Garcinia mangostana* L., *Ipomea pes-caprae*, *Lansium domesticum*, *Musa textilia*, *Myristica fragrans* Houtt., and Syzygium *aromaticum*. These plants were used to treat, recover, and prevent diseases such as malaria, liver, soreness, and postpartum treatment using the *Bakera* method. All plants used in the *Bakera* contained secondary metabolite compounds, including eugenol, alkaloids,

flavonoids, terpenoids, tannins, phenolic, organic acids, and vitamins, such as vitamin A, C, and E. The secondary metabolite compounds in *Bakera* plant were used as medicine to treat various diseases. *Bakera* effectiveness contributed to thermotherapy and aromatherapy effects; hence, it could alleviate symptoms such as muscle tension, loss of weight, increased blood circulation, reduce tension headache, autoimmunity, immunostimulant, antiseptic, and antiphlogistic.

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Ethnobotanical study on *Daksina* constituent plants on Lombok Island, West Nusa Tenggara, Indonesia

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Abstract. *Sutraningsih NKA, Sukenti K, Sukiman, Aryanti E. 2019. Ethnobotanical study on* Daksina *constituent plants on Lombok Island, West Nusa Tenggara, Indonesia. Asian J Ethnobiol 2: 78-83.* Lombok Island is located between Bali and Sumbawa Island in Lesser Sunda, Indonesia. About 80% of the population is inhabited by the original tribe called Sasak. Another tribe with a close cultural relationship is Bali, whose various Hinduism traditional rituals still exist, both religious and ancestral beliefs. In carrying out a traditional ritual, the Balinese required several means to support the ceremony, one of which is *Daksina*. *Daksina* is a kind of offerings in Hindu ceremonies composed of various plants. This research aims to explore the ethnobotanical aspects of plants that comprise *Daksina.* The study was conducted in several Balinese-Hindu villages in 5 regions in Lombok Island, i.e., Mataram City, West Lombok Regency, North Lombok Regency, Central Lombok Regency, and East Lombok Regency. Field data collection was done through participatory observation, interviews, and documentation. Informants were selected based on purposive sampling and snowball sampling methods. Reported Use (RU) and Index of Cultural Significance (ICS) were calculated to obtain the cultural importance value of the species. The result records that 46 plant species of 27 families are utilized to compose Daksina used in 13 traditional ceremonial rituals in Balinese-Hindu communities on Lombok Island. In general, traditional rituals have some valuable ethnobotanical aspects that should be revealed to preserve natural and cultural resources and support ecotourism.

Keywords: ethnobotany, *Daksina*, Lombok Island, traditional ritual

INTRODUCTION

Indonesia is a pluralistic society, one of the consequences of such pluralism is that there are a variety of traditional rituals or ceremonies, both religious and ancestral beliefs carried out and preserved by each adherent (Hariyono 2012). The traditional ceremony is a sacred activity carried out from generation to generation, which applies in an area. According to, efforts to explore customs and culture are needed to strengthen the community base in protecting their culture (Handyani 2003 in Purwanto 1999). However, in line with the development of time and modern culture, ancestral wealth is increasingly abandoned and forgotten. A traditional culture that is alleged to have a lot of environmental wisdom has experienced tremendous erosion. Most of the present generation no longer knows and cares about their ancestral heritage. With various ethnic groups, Indonesia has manifold wisdom related to plant utilization (Artha et al. 2016). The progress of science and technology is inseparable from the outstanding contribution of local knowledge owned by traditional communities, which have been applied for generations to survive and develop their culture (Surata et al., 2015).

Ethnobotany is one of the scientific disciplines and is the principle of the community's conception of environmental resources that can be used to protect cultural values. Humans, with their environment, are one entity that cannot be separated with surroundings. Humans can influence and be influenced by the environment. The relationship will describe the level of human knowledge in utilizing and managing plants in the form of garden plants, gardens, fields, or forests that are generally not cultivated (Pramita et al., 2013). The results of ethnobotany studies can be developed and integrated into various aspects of human life to contribute to the development of science and technology and the preservation of local wisdom (Adiputra 2011).

Traditional ceremonies are one element of regional culture and are universal, where each region has its own variety (Rahyuni et al., 2013). They are actions bound by specific rules according to customs, aiming to maintain the continuity and harmony between living things and their environment. Traditions in cultural ceremonies continue to exist, guarded, and passed down from generation to generation (Rohmah et al., 2014). In carrying out a traditional ritual, local people required several facilities to support the implementation of the ceremony. Some parts of plants, such as stems, leaves, flowers, and fruit, can be used as a means of the ceremony, referred to as *upakara*, and plants used as a complement of this ceremony are called *upakara* plants (Yaniasti 2015). There are hundreds of plant species used in various traditional ceremonies in Bali, of which 14.1% are included in the category of rare or protected plants (Mustaid et al. 2004).

One of the facilities in Hinduism traditional ceremonies that are routinely used is *daksina*. *Daksina* means Brahma, or Brahmana, which means *Sang Hyang Widhi* (God) and is composed of various plants (Sudarsana 2010).

Most Hindus in Lombok Island always use *daksina* in traditional rituals at certain times, for example, in marriage ceremonies, cutting teeth, and other major holidays. Various plant species are involved in daksina making, but scientific study has not been done. The utilization of plants as *upakara* (offerings) in various traditional ceremonies is a reminder for humans to preserve natural resources, which is indirectly related to the continuity of the implementation of these traditional ceremonies (Darma 2012). This research needs to reveal ethnobotanical aspects related to daksina that could be essential data in supporting wise efforts in preserving natural resources and culture.

MATERIALS AND METHODS

The study was conducted in March-May 2019 in several Balinese-Hindu villages in 5 regions in Lombok Island, i.e., Mataram City, West Lombok Regency, North Lombok Regency, Central Lombok Regency, and East Lombok Regency (Figure 1). The selected areas were based on the consideration that those areas have Balinese-Hindu communities that routinely use daksina for their religious ceremonies. This study was descriptive exploratory research using qualitative and quantitative methods in ethnobotany; data were obtained through direct observation, participatory-observation, interview, documentation, and literature review (Cotton 1996; Martin 2007). Semi-structured and open-ended interviews were directed to informants who have knowledge related to *Daksina*, which was chosen through purposive and snowball sampling methods (Endraswara 2006). Quantification was based on the calculation of Reported Use (RU) and Index of Cultural Significance (ICS) by Turner 1988 (Hoffman and Gallaher 2007). All data was analyzed holistically related to ethnobotanical data that revealed plant diversity, utilization, social-cultural, and other aspects.

RESULTS AND DISCUSSION

Role of *Daksina* on Lombok Island

Daksina in Lombok Island is a means in a Hinduism ceremonial ritual that is composed of various plants that has meaning as *linggih* (place) for Ida Sang Hyang Widhi (God) who will bless His people (Figure 2a). A *daksina* consists of some parts or components that made from plants and other materials, for example, *canang sari* (lotus-shaped symbol made from young coconut leaves) (Figure 2b), *bedogan* (container made from *Cocos nucifera* leaves) (Fig.2c), *tapak dara* (cross symbol made from *C. nucifera* leaves), *porosan* (symbol made from *Piper betle* leaf), duck eggs wrapped in coconut leaves, *gegantusan* (symbol made from plant parts wrapped in corn leaves), *papeselen* (rolled leaves made from five plants species), yarn or cotton, coins, *sampyan payasan* (triangle symbol made from young coconut leaves), and *tadah sukla* (square-shaped symbol made from young coconut leaves, filled with beans, bulbs, and others).

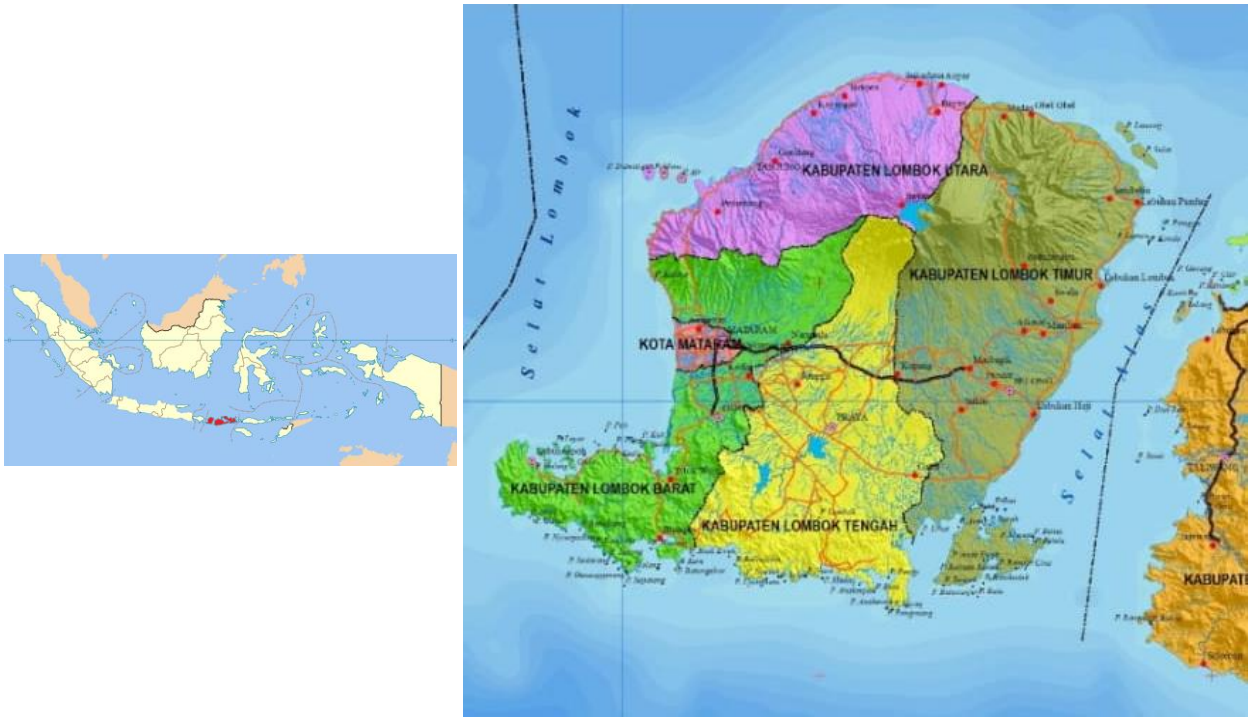

Figure 1. Research area. West Nusa Tenggara Island mark in red-colored (*left*). Map of Lombok Island (*right*)

A **B** **C** **D**

Figure 2. A. Daksina, B. Canang sari, C. Bedogan, D. Tadah sukla

Table 1. Plants species used in preparing *Daksina* based on highest *Index of Cultural Significance*

Local name	Species	Family	Plant part	ICS
Pinang	*Areca catechu* L	Arecaceae	fruit	1220
Nyiuh	*Cocos nucifera* L	Arecaceae	fruit, leaf	1220
Gumitir	*Tagetes erecta* L	Compositae	flower	1220
Daun kayu	*Codiaeum variegatum* (L.) Rumph. Ex A. Juss.	Euphorbiaceae	leaf	1220
Kapas	*Gossypium herbaceum* L	Malvaceae	fruit	1220
Pudak	*Pandanus amaryllifolius* Roxb.	Pandanaceae	leaf	1220
Base	*Piper betle* L	Piperaceae	leaf	1220
Padi	*Oryza sativa* L	Poaceae	seed	1220
Jagung	*Zea mays* L	Poaceae	seed, fruit skin	1100
Pacar Air	*Impatiens balsamina* L	Balsaminaceae	flower	1028
Biu	*Musa paradisiaca* L	Musaceae	fruit	988
Kedele	*Glycine max* (L.) Merr.	Leguminosae	seed	976
Bambu	*Schizostachyum silicatum* Widjaja	Poaceae	stem	876
Nusa Indah	*Mussaenda pubescens* Dryand.	Rubiaceae	leaf	732
Bawang	*Allium cepa* L	Amaryllidaceae	bulb	706
Jambu biji	*Psidium guajava* L	Myrtaceae	fruit, leaf	641
Talas	*Colocasia esculenta* (L.) Schott	Araceae	bulb	626
Kesune	*Allium sativum* L	Amaryllidaceae	bulb	622
Jepun	*Plumeria alba* L	Apocynaceae	flower	588
Salam	*Syzygium polyanthum* (Wight) Walp.	Myrtaceae	leaf	584
Belimbing Bintang	*Averrhoa carambola* L	Oxalidaceae	fruit	582
Kacang Mentik	*Vigna unguiculata* (L.) Walp.	Leguminosae	seed	566
Kacang Komak	*Lablab purpureus* (L.) Sweet	Leguminosae	seed	556
Kemiri	*Aleurites moluccanus* (L.) Willd.	Euphorbiaceae	fruit	553
Tabie	*Capsicum annuum* L.	Solanaceae	fruit	553
Laos	*Alpinia galanga* (L.) Willd.	Zingiberaceae	rhizome	553
Kunyit	*Curcuma longa* L	Zingiberaceae	rhizome	553
Cekuh	*Kaempferia galanga* L	Zingiberaceae	rhizome	553
Jahe	*Zingiber officinale* Roscoe	Zingiberaceae	rhizome	553
Ketan	*Oryza sativa var. Glutinosa*	Poaceae	seed	542
Tingkih/pangi	*Pangium edule* Reinw.	Achariaceae	fruit	539
Sandat	*Cananga odorata*	Annonaceae	flower	372
Sabo/Sawo	*Manilkara zapota* (L.) P.Royen	Sapotaceae	fruit	329
Jambu Air	*Syzygium aqueum* (Burm.f.) Alston	Myrtaceae	leaf	316
Kompyong	*Hydrangea macrophylla* (Thunb.) Ser.	Hydrangeaceae	flower	300
Mangga	*Mangifera indica* L	Anacardiaceae	leaf	218
Enau	*Arenga pinnata* (Wurmb) Merr.	Arecaceae	leaf	218
Manggis	*Garcinia mangostana* L	Clusiaceae	leaf	218
Buluan	*Nephelium lappaceum* L	Sapindaceae	leaf	217
Bunga Terompet	*Allamanda cathartica* L	Apocynaceae	flower	170
Duren	*Durio zibethinus* L	Malvaceae	young fruit, leaf	149
Ceruring	*Lansium domesticum* Corrêa	Meliaceae	leaf	141
Tebu	*Saccharum officinarum* L	Poaceae	stem	122
Tal	*Borassus flabellifer* L	Arecaceae	leaf	114
Bunga Kertas	*Bougainvillea spectabilis* Willd	Nyctaginaceae	flower	74
Salak	*Salacca zalacca* (Gaertn.) Voss	Arecaceae	leaf	28

Based on research and interviews conducted with 45 informants in 5 areas in Lombok Island (Mataram City, West Lombok Regency, North Lombok Regency, Central Lombok Regency, and East Lombok Regency), there are similarities in the ceremonial process and plants species used in preparing *daksina* to be served in 13 reported uses (RU) or ceremonial rituals. The rituals are *ngaben* (cremation ceremony), *odalan* (birthday of a Hindu temple), *pawiwahan* (marriage ceremony), *otonan* (traditional birthday ceremony), *purnama* (full-moon ceremony), *ngelungsur tambe* (healing ceremony), *ngaturang pemangku* (preliminary ceremony/ask for permission before the main ceremony), *mayah munyi* (votive paying ceremony), *mecaru* (praying for the harmony of nature and living things), *mepandes* (teeth cutting ceremony), *ngadegan merajan* (ceremony for an establishment of a holy site), *melukat* (sacred bathing), and *mepiuning* (ceremony for asking blessing and salvation).

Botanical aspects of *daksina*

46 plants belonged to 27 families used by the local Balinese-Hindu communities to prepare *daksina* as a means in 13 traditional ceremonies (Table 1).

Based on ICS values calculation, 8 species have the highest value (1220), i.e., *C. Nucifera, Gossypium herbaceum, P. betle, Oryza sativa, Areca catechu, Codiaeum variegatum, Tagetes erecta*, and *Pandanus amaryllifolius*. This indicates that these species have high intensity of use (i) and have a high priority and preference (e) in the community. The ICS value of a species is also influenced by the fact of reported use (RU), where the more RUs owned by a species, the higher its ICS value. In this study, the RU for all plant species was relatively similar because almost all plant species were utilized in nearly all of 13 ceremonial types in all 5 study areas. An exception is *Salacca zalacca* which is only used in the East Lombok Regency in 12 traditional ceremonies. This causes *S. zalacca* to have the lowest ICS value, but it is more due to local preference. In general, the community has no difficulty providing plant species for arranging *Daksina* because they have cultivated plants used in *daksina* in the yard or garden around their house. This is a kind of implementation of knowledge that the community understands that the sustainable use of plant resources in daily life will depend on how they manage and preserve it. The community's ability informs biodiversity and reflects local communities' life experiences and lifestyles with the norms contained therein (Tupan 2011).

Table 1 also shows that plant species used in *daksina* are dominated by Poaceae, Arecaceae, and Zingiberaceae. Besides being widely cultivated in community yards, plants in these families are easily found growing in the surrounding forests and traded on the local market. The most commonly used plant part is leaves and fruit. Apart from being a constituent of *Daksina*, leaves are also widely used as ingredients for *daksina* containers.

Socio-cultural aspects of daksina and community conservation efforts

Daksina plays an important role because it is always used in various traditional rituals that must be carried out routinely and continuously. Ritual is a mechanism for maintaining the ecological balance in the local environment and/or for redistributing food (Mintz and Du Bois 2012). Most Hindus in Lombok Island learn how to make *daksina* from generation to generation from their parents. In some places like Mataram City, the composition of *daksina* has begun to change due to the limitations of plant species because it is hard to find, for example, the *pisang keladi* (taro banana). In today's life, most people start replacing them with other bananas, such as *pisang ketip* (other varieties of *Musa paradisiaca*). This indicates that efforts are needed to maintain the preservation of certain species, especially those that play an important role in the routine activities of the community.

Some species of plants are prohibited from making *daksina* based on myths believed by local people. An example is the *pisang kepok* (*M. paradisiaca* var. Kepok), which is believed to be produced from Dewi Durga's milk. Goddess Durga in Hinduism is dualistic with seemingly conflicting characters. Meanwhile, from the aesthetic aspect, *M. paradisiaca* var. Kepok has a large box-like fruit shape so that it does not look good enough when arranged in a means container. This causes *M. paradisiaca* var. Kepok has never been used in making ceremonial facilities such as *daksina*.

Regarding the use of *daksina*, the community has conservation efforts and preserve the surrounding environment. Communities in the Sekotong Barat sub-district (West Lombok Regency) replanted *C. Nucifera* used in *daksina* in their yard. This more or less affects the availability of coconuts in the region, which, according to the community, purposed to make *daksina*. Meanwhile, most Hindu communities in Bayan, Gangga, Tanjung, and Kayangan (North Lombok District) regions have gardens to grow various plants to compose *daksina*, especially coconuts and fruits. In addition to fulfilling the personal needs of making *daksina*, this garden is also used to complement the needs of Hindu fellows. It is also to be sold to supplement the family income, such as coconut leaves (*C. Nucifera* L) and palm leaves (*Arenga pinnata* L). Another tradition is to bury *daksina* that has been used under a tree. In addition to respecting the sacred value of *daksina*, biologically, this can contribute to the fertility of the surrounding soil because it can act as an organic fertilizer. Compost or organic fertilizer made from leaves accelerates the decomposition process in the ground to increase soil fertility (Sulistyorini 2005). These actions and behaviors of the community show that the community utilizes plants for their daily needs and takes responsibility for protecting the environment so that the availability of plants is well maintained. The use of plants in *daksina* aims to instill the value of preserving nature for the welfare of nature and humanity. With all the socio-cultural norms and values, local wisdom allows humans to balance the environment's carrying capacity, lifestyle, and needs.

Preservation and development of the Daksina tradition as support for Ecotourism

Ethnobotany tradition can be interpreted as plant utilization activity, carried out for generations and maintained by a traditional community since ancient times. The tradition is created from combining the community's social culture with the plant's diversity in each region. Each tribe in an area has a unique plant utilization system and is different from other regions. Therefore, the variety of plant species is essential in the ethnobotany tradition (Setyowati and Wardah 2007).

Ecotourism is defined as tourism activities that prioritize the principle of nature conservation, providing economic benefits, increasing the empowerment of local communities, and maintaining the integrity of the local culture (Sastrayuda 2010). In its development, ecotourism is widely accepted by the global community and is increasingly perspective because ecotourism sells attractions and offers local philosophy or culture. Balinese tribe has a wide variety of cultures, as stated in their traditional ceremonies. Most of the Balinese in the Hindu community uphold the traditional ritual culture. Each ritual ceremony always uses plants believed to connect humans with God. This belief teaches humans to treat nature, plants, water, and animals like humans. *Daksina* as an offering at Balinese tribal ceremonies can develop ecotourism, especially in plant utilization and preservation and cultural preservation.

The Balinese ethnobotany tradition uses *Daksina* to harmonize human interaction with plant diversity. By developing the concept of ethnobotany ecotourism, the ethnobotany tradition, which was previously a routine in meeting daily needs, can become an activity that has economic, social, and environmental benefits. As one of the essential parts of ecotourism, ethnobotany tradition has principles that are inseparable from conservation efforts, empowering local communities, potentially providing economic benefits for local communities, and encouraging high appreciation of indigenous cultures. The ethnobotany tradition of the local community is a distinctive native culture. It is expected to be a competitive service product because it has high originality and specificity value (Ramadhan et al., 2017).

Regarding the use of *daksina*, ethnobotany ecotourism will encourage preserving the plant's diversity that composes *daksina.* In the concept of ethnobotany ecotourism, the availability of plant diversity in a sustainable manner is a requirement for continuing the tradition. In addition, the ethnobotany tradition also creates a sense of concern for local people towards the preservation of natural resources, including in the forest environment. Many plant species used in *daksina* grow naturally in the forest, for example, *Borassus flabellifer* L. and *A. pinnata* (Wurmb) Merr. On spiritual tourism, Tourists will enjoy religious places that provide a sense of peace and spiritual satisfaction (Aggarwal 2008).

Figure 3. Sacred bath at Suranadi Village, Lombok Island, Indonesia

This is what distinguishes spiritual tourism from other types of tourism alone. One of the potential tourist attractions in developing and preserving the *Daksina* tradition is the sacred bathing ritual at Suranadi spring, Suranadi Village, West Lombok Regency (Figure 3). In this area, tourists can enjoy sacred bathing, which is believed to clean themselves physically and spiritually. In this ritual, the tourist must use one of the ritual facilities: daksina. This causes *Daksina* to be sold around the bathing location by the local community and used as an income source. Besides, tourists are also presented with natural and clean forest conditions, storing high biodiversity. Forest areas in this area are also widely planted with *daksina* constituent plants by local communities, for example, *Allamanda cathartica* L., *A. catechu* L, *C. Nucifera* L, *S. zalacca* (Gaertn.) Voss, *Garcinia mangostana* L., *C. variegatum* (L. Clump. ex A.Juss., *Durio zibethinus* L., *Lansium domesticum* Corrêa, *Nephelium lappaceum* L., and *Manilkara zapota* (L.) P. Royen.

Another thing that can be a tourist attraction in this area is the activity of making *Daksina* by the sellers and artisans, from the preparation process, the selection of materials and plants, the arrangement, and its use in sacred bath rituals in the area. The tourists will benefit from spiritual tourism and additional knowledge related to biodiversity and culture. In general, the preservation of *daksina* traditions will contribute to preserving biodiversity and conserving traditional culture. Based on all ethnobotanical aspects revealed in this study, it can be concluded that *Daksina* stores information on the diversity of plant species and the richness of Indonesia's traditional culture and information about the local wisdom of the community in managing natural resources and environment to remain preserved and sustainable.

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Importance of indigenous communities' knowledge and perception in achieving biodiversity conservation: A case study from Manobo tribe of Southern Mindanao, Philippines

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Abstract. *Salvaña FRP, Arnibal SLT. 2019. Importance of indigenous communities' knowledge and perception in achieving biodiversity conservation: A case study from Manobo tribe of Southern Mindanao, Philippines. Asian J Ethnobiol 2: 84-91.* Indigenous communities play a relevant role in setting biodiversity management and conservation. This study aims to determine the knowledge and perceived importance of the Manobo tribe toward biodiversity. A total of 100 Manobos were included in the study to assess indigenous communities' ability and perception, particularly the Manobo tribe towards biodiversity. A semi-structured survey questionnaire was used to determine responses on knowledge and importance perception/ Our study found a consistent significant difference in the mean responses on knowledge and perception across gender and education attainment. Interestingly, traditional knowledge is significantly associated with the biodiversity importance perception of Manobos. Our findings suggest involving indigenous communities is equally important in achieving balanced biodiversity conservation and protection. Thus, strengthening collaborations among local government sectors and community leaders must develop conservation priorities and protection.

Keywords: Biodiversity, conservation, knowledge, Manobo, perception

INTRODUCTION

Biodiversity supports the health of ecosystems and the services they provide to society. However, biodiversity is in rapid decline globally, despite commitments by governments to reduce the rate of loss (Butchart et al., 2010). Monitoring is an essential part of biodiversity conservation, allowing governments and civil society to identify problems, develop solutions, and assess the effectiveness of actions and progress toward meeting the Convention on Biological Diversity (Secades et al. 2014). The Philippines' biodiversity heritage is globally essential due to high species endemicity and concentration of threatened species (Myers et al. 2000; Garrity 2001; Posa et al. 2008). However, the establishment of protected areas alongside the implementation of policies towards limiting biodiversity threats, yet human activities (e.g., deforestation, agricultural expansions) remain to persist in many country regions. The protection of species and habitats provides the essential backdrop to existing biodiversity conservation management strategies and policies globally (Bille et al., 2012). Traditionally, conserving nature has been equated with protecting charismatic and rare species or protecting their habitats and spectacular landscapes (Shafer 1990; Home et al. 2009). However, one of the current challenges in decision-making is the limited and inadequate human and financial resources to protect particular species or invest in the management and protection of habitats that are of substantial biological value (Jaisankar et al., 2018).

Considering that ancestral lands and territories contain 80% of the planet's biodiversity, indigenous people can play a crucial role in conserving and sustainable management of natural resources (IFAD 2014; Garnett et al. 2018). Indigenous people play an essential role in regenerating their natural resources and ancestral environments and systems (Russell et al., 2015). Indigenous people often inhabit territories rich in minerals and natural resources; thus, they have in-depth, varied, and locally rooted knowledge systems of the natural world. Local people are increasingly being recognized as partners in more comprehensive efforts towards sustainable management; an approach generally termed as 'community-based conservation' (Mehta and Kellert 1998). The approach is based on the principle that conservation strategies should emphasize the role of local communities in decision-making towards conservation (Adams and Hulme 1998), and indigenous communities can be involved as active partners in protected area management (Murphree 1995; Songorwa et al. 2000). Community-based conservation programs could effectively achieve its goals by (i) allowing people living in and around protected areas to participate in land-use policy and management decisions, (ii) giving people proprietorship or ownership over wildlife

resources, and (iii) providing local people with economic benefits from wildlife conservation (Hackel 1998).

Moreover, there is evidence that indigenous people's role as nature conservationists can be easily undermined by counter-examples such as species extinction due to human hunting in the prehistoric past and giving grants on extensive timber cutting or mining concessions on their lands. Indigenous people have a variety of reactions to these claims (Cunningham 2001). Some studies adopt a more pragmatic stance that stresses the practicality and urgency of coordinating local communities and conservationists (Orlove and Brush 1996).

In the Philippines, Manobos are the largest ethnic group based on the relationships and ethnolinguistic branching and distribution. The group occupies a wide range of distribution but is localized in some regions and has assumed the character of distinctiveness as a separate ethnic grouping such as the Bagobo or the Higaonon and the Atta (Elkins 1964). These tribes are typically forest-dwellers and reside near protected areas. They usually live on timber and non-timber forest products. Although their cultural background is well explored, the knowledge and perception of the Manobo tribe on biodiversity conservation are not well understood. Thus, this study aims to determine the knowledge and perception of this indigenous group on biodiversity conservation, which is necessary to evaluate the various perspectives of indigenous people on this matter. Traditional knowledge and perception towards diversity can be a helpful foundation in developing adaptive management strategies. Moreover, this will be an excellent basis to develop and implement community-based conservation management with the involvement of indigenous people since most of these communities live within or in the vicinity of protected areas and biodiversity hotspots.

MATERIALS AND METHODS

Location of the study

The study was conducted in Brgy. Bentangan, Carmen, North Cotabato (Figure 1). Bentangan is one of the twenty-eight barangays of Carmen, North Cotabato, Philippines, located at 7.3250 N and 124.6941 E. The area is inhabited by the Tri-people group composed of Christians, Muslims, and Arumanen-Manobo ethnic group. The area belongs to a type III climate wherein seasons are not very pronounced, relatively dry from November to April, and wet during the rest of the year. Karstic hills bound the area with fertile soil utilized mainly for agriculture. There are forest patches along valleys and river banks with reported wildlife. Most settlement areas are located near agricultural lands. There are no major roads near the site, and farm-to-market roads are not concrete.

Respondents and sampling procedure

Prior informed consent was sent to barangay (Filipino term for the lowest government unit in the Philippines) and community leaders. The study's rationale was presented as part of the requirements for securing a survey permit. We surveyed a total of 100 randomly selected individuals belonging to the Manobo tribe to interview. Respondents were validated by barangay officials and tribal leaders as members of the Manobo tribe.

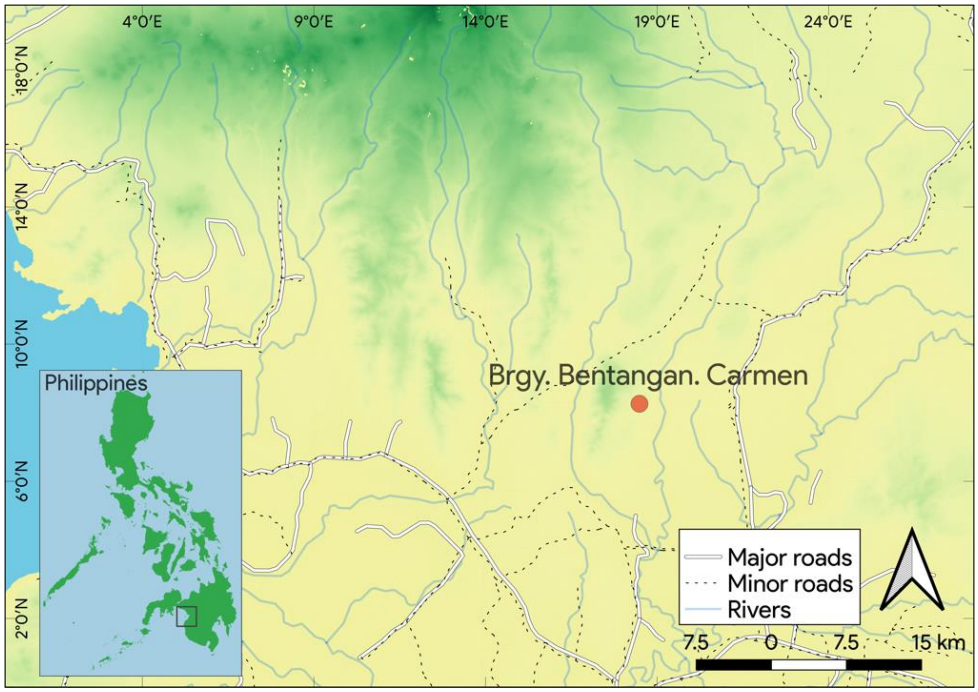

Figure 1. Map of the sampling site showing the relative distance to nearest roads. Map was generated using QGIS 3

Table 1. Summary of reliability test across indicators of biodiversity knowledge and overall perception of biodiversity importance

Variables	Cronbach's α
(1) Knowledge of Biodiversity	0.8589
(2) Understanding of threats to Biodiversity	0.8574
(3) Understanding the role of Biodiversity in sustainable development	0.8636
(4) Efforts and policies are important for Biodiversity conservation	0.8485
(5) Traditional knowledge is important for biodiversity conservation	0.9066
(6) General Perception of the Importance of Biodiversity	0.9159

Using a validated semi-structured questionnaire adapted from Turner-Erfort (1997) and Halim et al. (2012), modifications, levels of knowledge, and perception were measured. The questionnaire consisted of three parts: (i) sociodemographic profile of each respondent (e.g., gender, age, religious affiliation, years of residency, and educational attainment); (ii) Part 2 of the questionnaire consisted of ten statements regarding respondent's knowledge on biodiversity aspects (e.g., Biodiversity can be understood as biological in nature) and respondents' indicated strongly agree, agree, disagree or strongly disagree with each statement; and (iii) Part 3 of the questionnaire consisted of ten statements regarding respondent's perception on the importance of biodiversity (e.g., Maintaining biodiversity is needed for the sustainable utilization of natural resources) and respondents indicated very important, important, slightly important or not important with each statement.

A face-to-face interview was conducted with each respondent. Clarification on each statement on knowledge and perception towards biodiversity was done when needed.

Of the 100 respondents, sixty percent 60%) were female and forty percent (40%) were male respondents. Most of the respondents belonged to the age group of <20 years old (52%). Other respondents were >20-40 years old (31%) and >40 years old (29%). Regarding their religious affiliation, 83 % of the respondents were Langkat (religious movement of the Manobos); 10% were Roman Catholic; 3% were UCCP; 2% were Protestants, and 2% were Muslims. Fifty (50%) of the respondent were residents in the area for 10-19 years. Others were residents in the area for 1-9 years (20%) and 20-29 years (20%) in the area. In terms of educational attainment, 60 (60%) out of 100 were high school level, 21 (21%) were elementary level and 7 (7%) were college level.

Statistical analysis

Before statistical analyses, categorical responses were transformed to numerical scales (4= Strongly Agree/Very Important - 1= Strongly Disagree/Not Important). Some statements on biodiversity were lumped to develop a more reliable statistical model. Using Cronbach's alpha coefficient was employed to test the reliability and internal consistency of the items in the questionnaire. Based on the reliability test, the overall alpha-value is 0.896. This indicates that all indicators of biodiversity knowledge and general perception of biodiversity importance (Table 2). To determine the significant difference in responses across demographic scales, a non-parametric Kruskal-Wallis test was used. Categorical classifications of sociodemographic remained the same except we transformed "Age" into three categories (A=<20, B=>20-40, and C=>40). A stepwise general linear regression was to determine tpublicrminants of public perception on the importance of biodiversity using local understanding variables to predict biodiversity (e.g., Sakurai et al. 2013). We used the open software JASP (version 0.11) statistical to perform all reliability and statistical tests. All significance was set at p=0.05.

Ethical note

Before the personal interviews, each respondent was briefed on the purpose of the research Respondents were informed of their rights to discontinue the interview if deemed necessary. All responses provided by the respondents were kept in an envelope, and only an authorized person could access it.

RESULTS AND DISCUSSION

Results

Based on the computed mean responses (Figure 2), it was observed that female respondents have greater knowledge on biodiversity ($\bar{x}$=3.43), perceived that traditional knowledge ($\bar{x}$ =3.53) and related policies ($\bar{x}$ =3.35) are important for biodiversity conservation ($\bar{x}$ =3.53), and overall perception on the importance of biodiversity ($\bar{x}$ =3.54). They also have a better understanding of the relationship between biodiversity and sustainability ($\bar{x}$ =3.56). It was also observed that female respondents have a better understanding on possible threats to biodiversity ($\bar{x}$ =3.4). According to age category (Figure 3), category B (>20-40 years old) have greater knowledge on most aspect of biodiversity including threats to biodiversity (3.02), on the importance of related policies (3.22) and traditional knowledge (3.48) on conservation, and overall perception towards biodiversity importance (3.59). While, computed mean response according to religious affiliation (Figure 4) showed that respondents from United Christian Church of the Philippines, Inc. (UCCP) have greater knowledge on biodiversity (3.44), better understanding of biodiversity threats (3.0), the link between biodiversity and sustainability (3.67), and perceived that policies related to biodiversity (3.17) and traditional knowledge (3.67) are important for conservation. However, protestants have higher mean response in terms of overall perception of the importance of biodiversity (3.65). In terms of educational attainment

(Figure 5), respondents with higher educational attainment have tended to have college graduates have greater knowledge on biodiversity (3.93), threats to biodiversity (3.9), and perceived that policies towards biodiversity (3.8) and traditional knowledge (4.0) are important for conservation. In terms of overall perception of the importance of biodiversity, respondents who are elementary graduates have higher mean response (4.0).

Based on the result of Kruskal-wallis test (Table 2), there was a significant difference on the mean responses towards biodiversity according to gender and educational attainment. In terms of the general perception of the importance of biodiversity, there was a significant difference in the mean response according to gender.

Furthermore, general multiple regression model showed that independent variables are associated with overall importance perception of respondents (R^2=0.34, $F_{(9,90)}$ =5.6935p<.0001) but only "importance of traditional knowledge biodiversity" conservation showed strong positive association (β=0.32, p<.01).

Table 2. Non-parametric Kruskal-Wallis Test on the significant difference across sociodemographic scales in different indicators of biodiversity knowledge and overall perception of biodiversity importance. (*P* values with ** indicates significance)

	Statistic	df	p-value
(1) Knowledge of Biodiversity			
Gender	19.272	1.000	0.001**
Age	5.542	2.000	0.063
Religion	0.958	4.000	0.916
Educational Attainment	37.492	5.000	0.001**
(2) Understanding of threats to Biodiversity			
Gender	48.736	1.000	0.001**
Age	1.080	2.000	0.583
Religion	1.139	4.000	0.888
Educational Attainment	39.187	5.000	0.001**
(3) Understanding on the role of Biodiversity in sustainable development			
Gender	13.570	1.000	0.001**
Age	4.940	2.000	0.085
Religion	1.090	4.000	0.896
Educational Attainment	36.214	5.000	0.001**
(4) Efforts and policies are important for Biodiversity conservation			
Gender	39.674	1.000	0.001**
Age	3.572	2.000	0.168
Religion	2.802	4.000	0.592
Educational attainment	32.150	5.000	0.001**
(5) Traditional knowledge is important for biodiversity conservation			
Gender	4.940	1.000	0.026**
Age	1.662	2.000	0.436
Religion	4.732	4.000	0.316
Educational attainment	11.357	5.000	0.045**
(6) General Perception on the Importance of Biodiversity			
Gender	5.187	1.000	0.023**
Age	3.901	2.000	0.142
Religion	2.124	4.000	0.713
Educational attainment	6.192	5.000	0.288

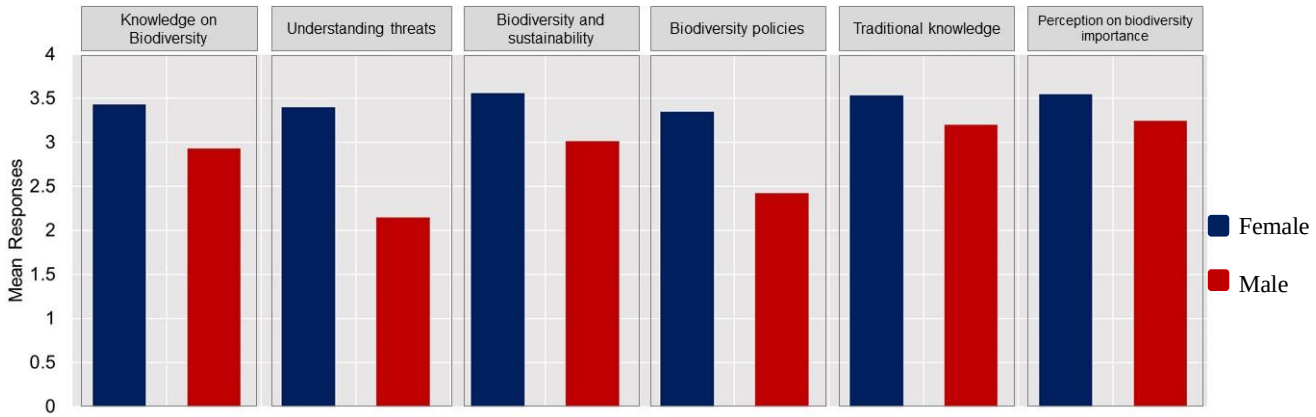

Figure 2. Levels of knowledge and perception importance on biodiversity according to gender (expressed in $\bar{x}$ values where 4 as "strongly agree")

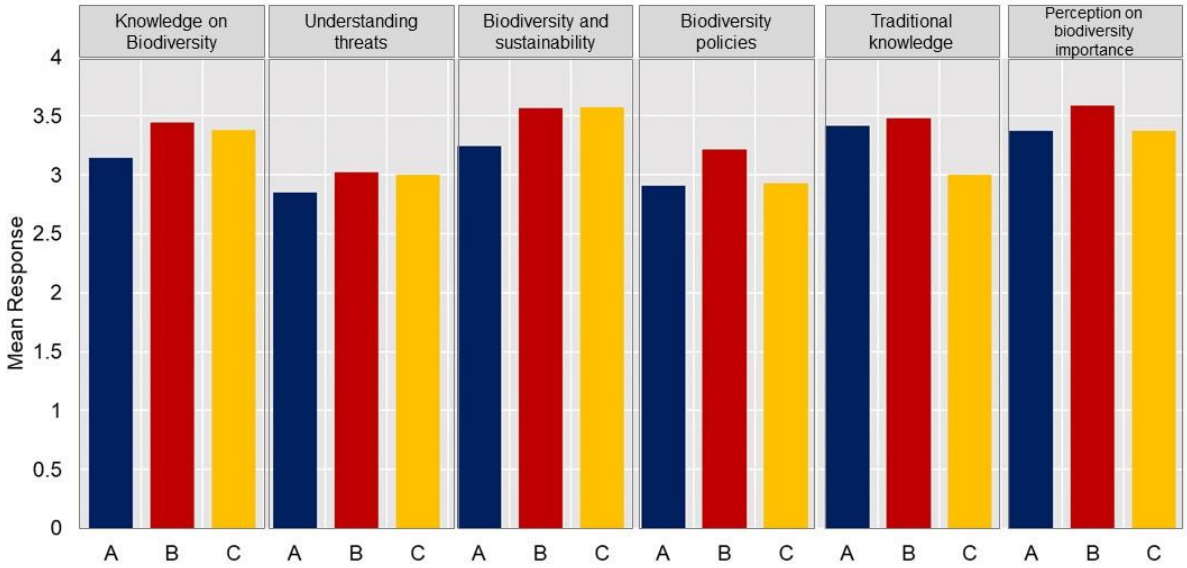

Figure 3. Knowledge on biodiversity and perception on biodiversity importance according to age category (A- <20 years old; B- >20-40 years old; C- >40 years old)

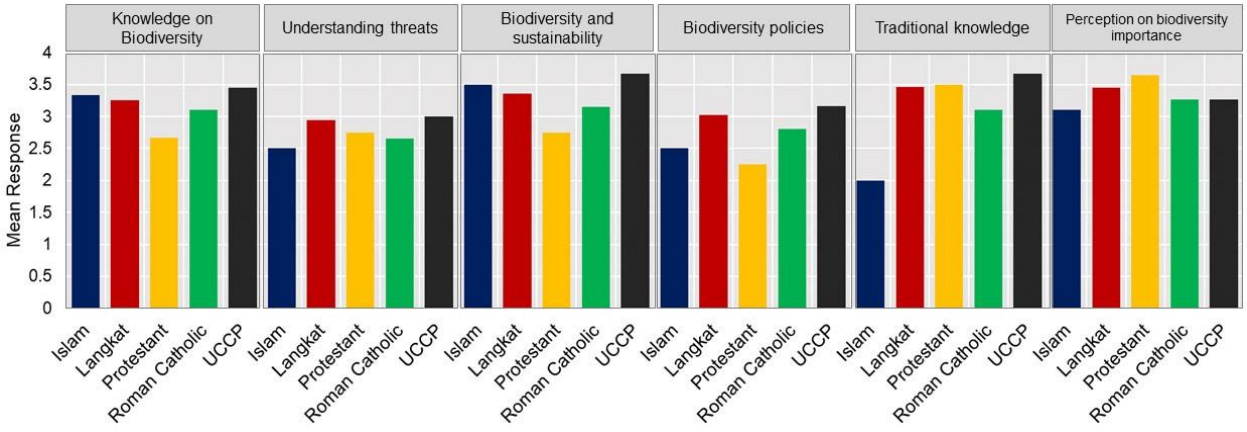

Figure 4. Knowledge of biodiversity and perception of biodiversity importance according to religious affiliation

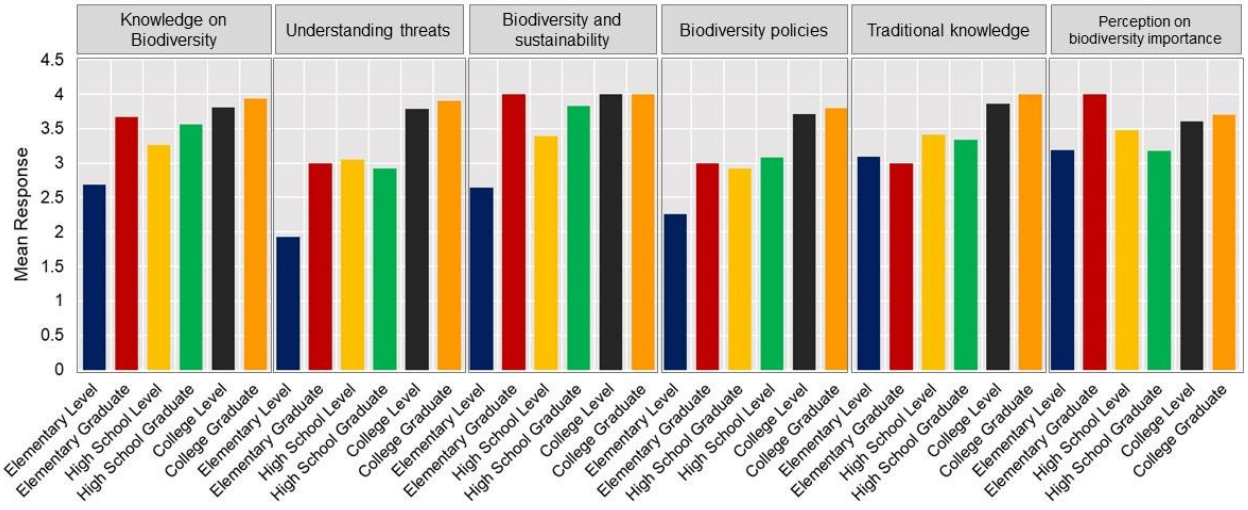

Figure 5. Knowledge of biodiversity and perception of biodiversity importance according to educational attainment.

Table 3. General multiple linear regression on the association of local biodiversity understanding to general perception on the importance of biodiversity. (*P* values with ** indicates significance. R^2=0.363, *Mean square*=1.3418, *F*=5.6935. Note: β= standardized coefficient, SE=Standard Error)

	β	SE	t	p-value
(Intercept)		0.51	3.27	0.01
Gender	-0.04	0.18	-0.25	0.80
Religion	-0.05	0.06	-0.54	0.59
Age	0.12	0.00	1.37	0.17
Educational attainment	-0.15	0.05	-1.27	0.21
Knowledge on biodiversity	0.35	0.30	1.21	0.23
Understanding of threats to biodiversity	0.17	0.15	0.74	0.46
Understanding the role of biodiversity in sustainable development	-0.34	0.20	-1.49	0.14
Efforts and policies are important for biodiversity conservation	0.25	0.18	1.09	0.28
Traditional knowledge is important for biodiversity conservation	0.32	0.09	3.03	0.01**

Discussion

There was a significant difference in the mean responses on knowledge and perception towards biodiversity according to gender and educational attainment. It was observed that female respondents have higher mean responses on both knowledge and perception towards biodiversity. This result is in agreement with the study of Lim and Wilson (2019) wherein females significantly viewed the importance of bats in fruit production compared to males. Murphy (2004) also added that females are more knowledgeable and tend to have more positive attitude towards environment. In terms of educational attainment, respondents with higher educational attainment were more knowledgeable and have better understanding of the aspects of biodiversity. Increased ecological and biodiversity knowledge can be acquired through formal education which can be used in developing educational programs related to biodiversity (Pinheiro et al. 2016). In the case of Kenya, compulsory biology courses possibly increase positive attitudes towards biodiversity, like perception towards bats (Prokop and Tunnicliffe 2008). Among the respondents, those who were elementary graduates have higher mean response on the overall perception of the importance of biodiversity. This result indicates that even at the lower educational level, the importance of biodiversity has been discussed and taught. In addition, respondents with lower educational levels have been involved in some activities related to biodiversity conservation which may have contributed to their perception. It is also possible that perception of the importance of biodiversity is a result of traditional knowledge transfer from elder Manobos.

It is interesting to note that traditional knowledge of Manobo tribe significantly affects their perception of the importance of biodiversity. This can support the aforementioned statement on the perception of Manobo on the importance of biodiversity. This indicates that Manobo tribe believes that their traditional knowledge has a big contribution to preserving biodiversity which they can use as a source of basic needs. In the study of Ruddle and Johannes (1990), many indigenous people are dependent on traditional knowledge and practices in caring for their traditional territories, and for the harvesting of wild food and animals, medicines, water, and other basic needs to preserve their environment and biodiversity. There are traditional activities conducted by the Manobo tribe that balance ecological cycles. It indicates that biodiversity is very important for them since it is also part of the survival of the present and future generations aside from being the source of their basic needs. This result is in agreement with the study of Elder et al. (1998) which stated that the indigenous people's meaning of biodiversity is not connected to scientific definitions but anchored to the respondents' daily practices, experiences, knowledge, and emotions.

Perception of the importance of biodiversity can be associated with biodiversity conservation and according to Jordan (1988), conservation has a critical role to play in maintaining biodiversity. However, it is not an adequate strategy in conserving biological diversity. Eventually, there is a need for a way of putting pieces back together when something has been altered, damaged, or even destroyed as what Manobo does to conserve their biodiversity. Biodiversity is of global importance for humanity as a whole, for the maintenance of ecosystem services.

The results of this study indicate that biodiversity and culture can be related. Most discussions on the complex relationship between the conservation of biodiversity and cultural diversity center on the argument that cultural diversity can sustain a wide variety of practices that promote conservation of natural resources (Posey 1999). An example is how different 'indigenous' groups around the world have protected those species and habitats related to their cultural beliefs which provide an insight into the relationship and role of human diversity in the conservation of biodiversity. Manobos perceived that forest ecosystem and protection of species and habitats are important aspects that linked to cultural beliefs which provide insights on the connection and role of humans in biodiversity conservation. This is related to the statement of Posey (1999) wherein different cultures perceived and appreciate biodiversity in different ways because of their distinct heritage and experiences. As stated by the ASEAN Centre for Biodiversity (2010), the abundance of these diverse biological resources also ensures the continuous flow of goods and ecosystems services for the benefit of the present and future generations which can be done through

community-based conservation management. Some studies revealed that many indigenous communities depend directly on natural ecological systems for their sustenance. In Sabah, Malaysia, indigenous people have developed their unique indigenous systems for a sustainable livelihood (Halim et al. 2012). However, indigenous communities have scanty resources and few options to adapt (financially, technically and socially) by themselves where most adaptive strategies constitute local knowledge. Studies revealed that many indigenous communities depend directly on natural ecological systems for their sustenance. In this context, Geronimo et al. (2016) stressed that biological diversity and natural ecosystems are closely linked to the economy, identity, cultural and spiritual values, as well as the social organization of indigenous people.

Implementation of biodiversity conservation measures is often challenged through fierce debate and resistance to specific management approaches (Stoll-Kleemann 2001; Miller 2005; Lindström et al. 2006; Marshall et al. 2007). This lack of support at the local level has been linked to the seemingly inadequate knowledge of the general public about biodiversity, suggesting that the public might not have enough insight to appreciate the benefits of biodiversity and its conservation (DEFRA 2002; Hunter and Brehm 2003). Some studies examined this phenomenon describing individuals' understanding of biodiversity as an isolated concept.

In general, the result of this study indicates that traditional knowledge has a significant role in the perception of Manobo tribe on the importance of biodiversity, thus, conservation as well. Practices and beliefs that have been embedded in the indigenous knowledge among indigenous communities, particularly the Manobo tribe are good examples to establish biodiversity conservation and environmental obligations. The community of Brgy. Bentangan is the best venue for implementation of community-based conservation management since it is one of the vicinity of protected areas and biodiversity hotspots.

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Review: Local wisdom of Baduy people (South Banten, Indonesia) in environmental conservation

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Abstract. *Arifiani KN, Wijaya CKW, Irfan AN, Septiasari A, Iskandar J, Iskandar BS, Partasasmita R, Setyawan AD. 2019. Review: Local wisdom of Baduy people (South Banten, Indonesia) in environmental conservation. Asian J Ethnobiol 2: 92-107.* Baduy people live in Kanekes Village, Leuwidamar Subdistrict, Lebak District, Banten Province, Indonesia. Baduy people is a group of people who firmly adhere to the traditions of their ancestors where the entire social system is rooted in their religious system. The tribe that lives depends on nature and always maintains the balance of nature. This review is intended to find out the current state of life of the Baduy people in environmental conservation, the ability to utilize local wisdom (traditional ecological knowledge) to meet their needs and the possibility of sustainability in the future their way of life. This research was conducted by studying literature based on journals or other information media. The results showed that the Baduy people still hold strong beliefs and customs and day by day with great wisdom. Beliefs and customs that become *Pikukuh* (rules) have always been the philosophy of life and daily of Baduy. Traditional rules and *Pikukuh sapuluh* are the basis of life guidelines and produce Baduy culture both in thinking, acting and behaving. Mores as part of local wisdom still beholder firm considerably by Baduy people, and the mores have come to the self fortress for Baduy people in the face of modernization, included in matter preserve its environment. The forms of local wisdom behavior that are a form of sustainability of environment and conservation conducted by Baduy people, for example: (i) agricultural systems, (ii) residential systems, (iii) forestry systems, and (iv) conservation practices.

Keywords: Baduy people, beliefs, conservation, local wisdom, traditional customs

INTRODUCTION

Indonesia is a large unitary state in the form of a republic (Azhari and Negoro 2019). The Republic of Indonesia is located on the equator between Asian Continent and Australian Continent and Pacific Ocean and Indian Ocean. According to the Ministry of State Secretariat of the Republic of Indonesia (2013), Indonesia has 17,504 islands included in the sovereignty of the Unitary State of the Republic of Indonesia. The territory of the State of Indonesia, which is separated by the sea and is located between the Australian Continent and the Asian Continent, makes Indonesia diverse (Gunawan and Sulistioningrum 2016). The diversity of the Indonesian state can be seen in the diversity of ethnicities, races, languages, and religions. The diversity of cultures and customs that are owned is a treasure in enriching national culture, of course also rich in abundant natural wealth in several regions in Indonesia. In essence, this archipelago is regulated and managed from generation to generation by customary law, followed by hundreds of belief systems and religions (Sinapoy 2018). According to the Central Statistics Agency or BPS (2010), the Indonesian state has 1,340 ethnic groups. The diversity of ethnic groups in Indonesia adds to the wealth and blessings of the Indonesian people. The factors that influence the emergence of ethnic diversity are geographic location, foreign cultures, and various climatic and natural conditions in Indonesia (Hidayah 2015). The benefits of cultural and ethnic diversity for a nation can be seen from various aspects, namely economic and social (Sutardi 2007). The benefits of diversity are an asset to the nation's wealth in the economic aspect. In total, cultural diversity is the country's identity (Ridwan 2015).

The biggest problem for Indonesia's cultural diversity is modernization (Ahimsa 2014). Modernization is changing in society regarding social norms, social values, the structure of existing institutions in society, patterns of social behavior, and all aspects of social life (Ritzer 2014). The main factor causing modernization is the rapid development of science and technology. The existence of science and technology or science and technology makes people dependent on science and technology. Over time, the cultural values that become life guidelines begin to

erode and fade (Rosana 2011). Culture, a life guideline replaced by science and technology, can cause dissonance between society and nature as places and providers of human needs (Syah 2013). The characteristics of modernization can be seen from society's attitudes, where individualism is more dominant in modern life (Rosana 2015). In addition, people's dependence on science and technology will lead to a culture of hedonism and a consumptive society (Sudarsih 2011). Thus, the environment will be damaged due to the consumptive lifestyle and hedonism (Eddy et al. 2017). Environmental damage as a provider of human life will cause imbalance. This will have an impact on human life (Rochwulaningsih 2017).

The Baduy people isolate themselves from outside life to remain firm in carrying out their customs and reject the development of science and technology and modernization (Andriana et al. 2017). According to their beliefs, the Baduy claim to be descended from *Batara Cikal*, one of the seven gods or Batara who were sent to earth (Permana 2003). The origin is often associated with Prophet Adam as the first ancestor. According to their belief, Adam and his descendants, including the Baduy people, have an ascetic (*mandita*) duty to maintain world harmony (Permana et al. 2012). The essence of this belief is indicated by the existence of absolute customary provisions that are adhered to the daily life of Baduy (Judhistira 1998). The most important content of the Baduy *'Pikukuh'* (compliance) is the concept of "without any changes" or changes as little as possible. The embedded motto is "*lojor heunteu beunang dipotong, pèndèk heunteu beunang disambung*" (Zidny and Eilks 2018). It means that what's long cannot be cut, what's short cannot be joined (Iskandar and Iskandar 2017).

The most important object of belief for the Baduy people is Arca Domas, whose location is kept secret and is considered the most sacred (Permana and Eka 1996). Baduy people visit this location to perform worship once a year in the month of Kalima (Mustomi 2017). The Baduy people have a culture and beliefs that lead to sustainable living. This study is expected to find out the trust in managing the Baduy people environment by carrying out this study. And it is hoped that they will be able to know the customary provisions of the Baduy people as local wisdom in environmental conservation patterns. This research was conducted by studying literature based on journals or other information media.

BADUY PEOPLE

Homeland

The Baduy region is located at 6°27'27"-6°30'0" S and 108°3'9"-106°4'55" E. The Baduy people are an ethnic group that lives side by side and depends on nature. The Baduy people are also known as the Kanekes people (*urang Kanekes*), the indigenous peoples of the Banten. They live in Kendeng Mountains, i.e., Kanekes Village, Leuwidamar Sub-district, Lebak District, Banten Province, Indonesia (Figure 1). Especially in Kaduketug hamlet (*kampung*) for Outer Baduy and Cibeo hamlet for Inner Baduy. Its territory is arranged and connects between hills and valleys. Baduy settlements are usually located in hilly valleys, in flatter areas near groundwater sources or rivers. The total area as a whole is around 5,136.58 hectares Kanekes Village Index Book (2009). Figure 2 shows the environmental conditions and activities of the Baduy people.

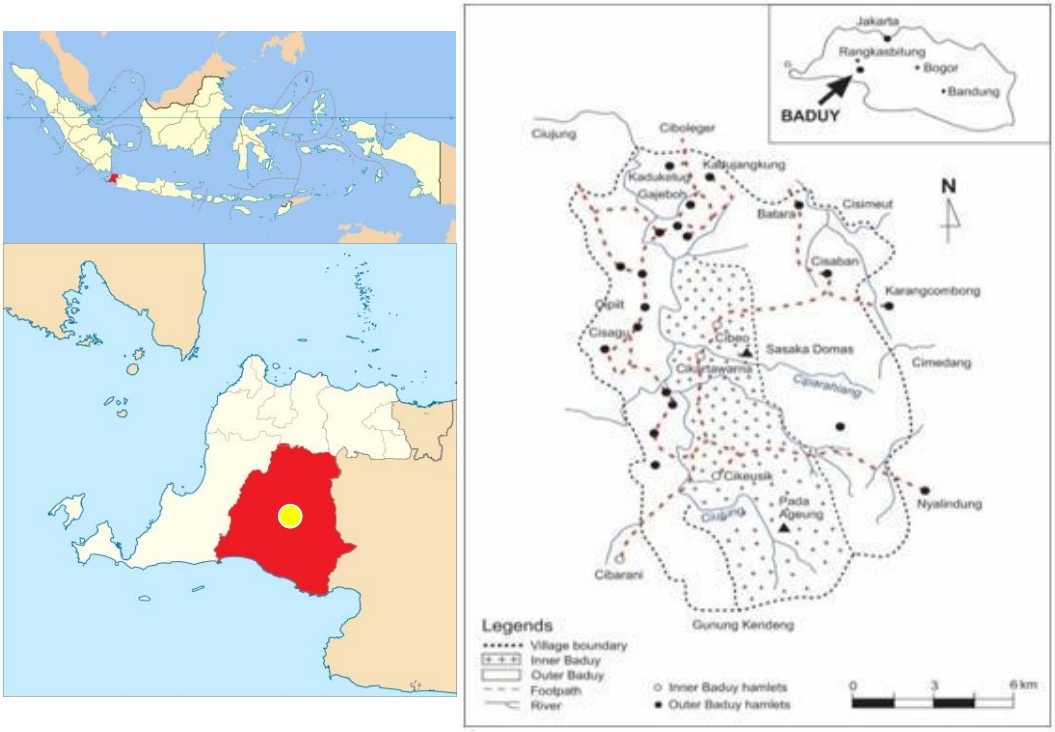

Figure 1. Location of Baduy area, Kanekes Village (), Leuwidamar Sub-district, Lebak District, Banten, Indonesia

Table l. Hamlets in the Baduy area, Kanekes Village, Lebak District, Banten, Indonesia in 2009

A.	**Baduy-Dalam Village**				
1.	Cikeusik				
2.	Cikartawana				
3.	Cibeo				
B.	**Baduy-Luar Village**				
1.	Cigoel (Kaduketug 3)	21.	Cigula	41.	Cibagelut
2.	Cipondok (Kaduketug 2)	22.	Cicatang	42.	Batubeulah
3.	Kaduketug 1	23.	Cicatang 2*)	43.	Cibogo
4.	Kadukaso	24.	Kadukohak	44.	Pamoean
5.	Cihulu	25.	Cisaban	45.	Cipaler
6.	Balingbing	26.	Babakan Cisaban	46.	Cipaler
7.	Marengo	27.	Cijanar	47.	Cicakal Muara *)
8.	Gajeboh	28.	Leuwihandam	48.	Cicakal Tarikolot *)
9.	Kadujangkung	29.	Cicangkudu	49.	Cicakal Girang
10.	Babakan Karakal (Kadugede)	30.	Cisagu Landeuh	50.	Cicakal Girang 2
11.	Karakal	31.	Cijengkol	51.	Cicakal Girang 3 (Leuwibuleud)
12.	Kaduketer 1	32.	Cikadu 1	52.	Cijangkar
13.	Kaduketer 2*)	33.	Cikadu 2*)	53.	Ciranca Kondang *)
14.	Cikopeng	34.	Cipiit 1	54.	Kanengai *)
15.	Cibongkok	35.	Cilingsuh	55.	Cikulingseng *)
16.	Ciwaringin	36.	Cisagu pasir		
17.	Binglugemok (Cibitung)	37.	Cipiit 2		
18.	Batara	38.	Ciranji		
19.	Sorokokod	39.	Babakan Eurih		
20.	Panyerangan	40.	Cisadane (Leuwigede)		

Source: Kanekes Village Index Book (2009).

Administration system

The Baduy area is divided into two main areas: Inner Baduy (*Baduy Dalam*, *Baduy Jero*, or *Tangtu*) and Outer Baduy (*Baduy Luar* or *Panamping*). The number of hamlets in Baduy area (Kanekes village) in 2009 was 58 hamlets, i.e., 3 in Inner Baduy, namely Cibeo, Cikartawarna and Cikeusik, and 55 hamlets in Outer Baduy. In 2002, there were 50 hamlets in Baduy (Senoaji 2003). Within 7 years there were 8 additional hamlets, namely Cicatang 2, Kaduketer 2, Cikadu 2, Cicakal Muara, Cicakal Tarikolot, Ciranca Kondang, Kanengai, and Cikulingseng. The boundaries of the northern Baduy area (Kanekes village) is bordered by Bojongmenteng Village, Cisimeut Village, and Nayagati Village of Leuwidamar Sub-district; to the west it is bordered by Parakanbeusi Village, Keboncau Village, and Karangnunggal Village of Bojong Manik Sub-district; to the south it is bordered by Cikate Village of Cijaku Sub-district; and in the east it is bordered by Karangcombong Village and Cilebang Village of Muncang Sub-district. While the natural boundaries to the north are the Ciujung River, the south of the Cidikit River, the west of the Cibarani River, and the east of the Cisirneut River (Pemda Kabupaten Lebak 2001). Besides these two Baduy, there are also *Dangka* Baduy, they are Baduy descendants who embrace Islam, do not practice ancestral customs, receive education and technology, and live outside the traditional territory of the Baduy people. They generally live in two hamlets, i.e., Padawaras (Cibengkung) and Sirahdayeuh (Cihandam) (Permana 2001).

Population

The number of Baduy residents in 2019, recorded a total of 11,699 people, consisting of 3,413 heads of families (BPS, Leuwidamar Sub-district 2019). 90% of the total population are Outer Baduy and the remaining 10% are residents of Inner Baduy. They are one of the Sundanese indigenous communities who practice a life isolated from the outside world. They limit themselves to being in touch with modernization and culture they perceive as external culture. The main occupation of the Baduy people is farming or *ngahuma* (Ichwandi and Shinohara 2007; Jamaludin 2012; Suparmini et al. 2013; Iskandar and Iskandar 2017a). Almost all Baduy people work as farmers and agricultural laborers. Farming for the Baduy people is considered an obligation in their religion, called Sunda Wiwitan. Based on Baduy customs, working on the fields applies various taboos or taboos, such as abstinence from using modern rice seeds, synthetic inorganic fertilizers and manufactured pesticides, and trading in field rice. They also don't work on the fields, raising buffalo, cattle, and sheep, cultivating commercial crops in monocultures, such as cloves, cocoa, rubber, teak, etc.

Socio-education system

The language used by the Baduy is Sundanese (Adimihardja 2014). The Kanekes or Baduy people do not know written culture, so their ancestors' customs, beliefs, religions, and stories are only stored in oral speech. The Baduy people do not know schools because formal education begins with their customs (Widowati 2014).

They think that formal education in schools makes them smarter and can potentially destroy nature (Saleh et al., 2019). As a result, most Baduy people cannot read and write (Ahidin et al. 2018). The approach to education in Baduy is non-formal, which is carried out in homes and the field directly. The non-formal education taught is very simple. One of their Jaro (leaders) told them that they educate their people not to be smart but to be honest (Bintari 2012).

Social classification: tangtu, panamping, and dangka

The Baduy people is divided into three groups, namely the *tangtu* of *Baduy Dalam* (Inner Baduy), *panamping* or *Baduy Luar* (Outer Baduy), and *dangka* (Muslim Baduy) (Permana 2001). Although divided into three groups, the status of relationship with each other is very close. The group structure of the isolated Baduy people is divided into two major groups, namely the Inner Baduy people (Baduy *Tangtu*) and the Outer Baduy (Baduy *Panamping*). The Outer Baduy area is 1,975 hectares with 1,083 people (281 families) spread over three hamlets. Meanwhile, the Inner Baduy area covers an area of 3,127 hectares with a population of 10,089 (2,667 households) spread over more than 55 hamlets (Prihantoro 2006). The difference between the two area can be seen from the distinctive clothes and the shape of the house. Outer Baduy is characterized by wearing black clothes and headbands (Erwinantu 2010). Meanwhile, the Inner Baduy wears its distinctive white clothing and headband. Then the difference in making a house where the Outer Baduy uses nails to connect the house's frame, while the Inner Baduy only uses ropes to connect the wood to make the house's frame. The type of baduy house is a house on stilts made of woven bamboo (cubicle), a house made of shape according to the existing morphology, if the land is sloping, adding stones is done to make the land flat (Suparmini et al. 2013). The *panamping* group or Outer Baduy people, has a place to live around the Inner Baduy people. This group is the people who have left Inner Baduy because of their wishes or have violated customary regulations. This community group has the characteristic of clothing and headbands colored dark or *tarum* (Senoaji 2010). The *Dangka* group is a Baduy people that lives outside the Baduy area. They leave the Sunda Wiwitan belief to embrace Islam, and have a lifestyle like the majority of Sundanese people. Due to outside influences, Kampung Dangka functions as a buffer zone (Permana 2003).

Belief system

Humans are very dependent on the presence of the universe. This causes the concept of a belief system to grow from human understanding of the universe. This also happened to the Sundanese *buhun* (original/ancient), where their belief system was built on their dependence on nature (Miharja 2015). The belief of the Baduy people is referred to as the Sundanese Wiwitan teachings, ancestral teachings that are rooted in reverence for *karuhun* or ancestral spirits and worship of spirits of natural forces (animism). Although most aspects of this teaching are original from hereditary traditions, this ancestral teaching was also slightly influenced by several aspects of Hindu, Buddhist, and later Islamic teachings in later developments. Sunda Wiwitan also has elements of ancient monotheism, namely above the gods and hyangs in their pantheon there is a single supreme, almighty, intangible God called *Sang Hyang Kersa* who is likened to God Almighty (Prawiro 2013). Broadly speaking, people's belief in a matter, condition, location, grave, and belief in ancestors reflects the meaning of mutual respect, between humans and nature and the environment. This situation is part of local wisdom/environmental wisdom (Sufia et al. 2016).

The animist belief system adopted by the Baduy people is Sunda Wiwitan. Where to believe and believe in one power, namely *Batara Tunggal*, yarrs cannot be seen with the eye but can be touched with the heart, omniscient knows who moves and acts in this world. Sunda Wiwitan has the most significant influence on the life of its people. The core of his belief is indicated by absolute customary provisions or *Pikukuh* (customary regulations) which are called the concept of no change at all or without any changes (Sugiwa 2015). The pattern of religious relations and activities of the people of Kanekes Village regarding the supernatural in the context of the Sundanese Wiwitan Religion is manifested in various activities of daily life (Supriatna 2012). The highest power of the Sundanese Wiwitan belief is in *Sang Hyang Kersa* (the Almighty) or *Nu Ngersakeun* (The Willing). He is also called *Batara Tunggal* (God Almighty), *Batara Jagat* (Lord of Nature), and *Batara Seda Niskala* (The Invisible). He resides in *Buana Nyungcung*. All gods in the Hindu concept (Brahma, Wishnu, Shiva, Indra, Yama, etc.) are subject to *Batara Seda Niskala* (Ahmad 2013).

Sang *Hyang Kersa* lowered seven *Batara* at *Sasaka Pusaka Buana*. One of the seven *Batara* is *Batara Cikal*, the oldest who is considered the ancestor of the Baduy people. Other descendants are *Batara*, who rule in various other areas in the land of Sunda. The meaning of nurunkeun (lowering) *Batara* is not giving birth but creating or creating. In Sundanese Wiwitan teachings, prayers are delivered by singing rhymes, songs, and dance movements. This tradition can be seen in the rice harvest thanksgiving ceremony and the New Year celebration, based on the Sundanese calendar known as the *Seren Taun* Festival. In various places in West Java, *Seren Taun* is always lively and is attended by thousands of people (Adisaputri and Widiastuti 2015). *Seren Taun* celebrations can be found in several traditional villages such as in Kanekes, Lebak, Banten (by Baduy people), Ciptagelar Kasepuhan Banten Kidul, Cisolok, Sukabumi, Kampung Naga, Tasikmalaya and Cigugur, Kuningan.

The holy place or place of worship that is considered sacred or sacred in the Sundanese Wiwitan is *Pamunjungan* or *Kabuyutan*. *Pamunjungan* is a punden with terraces usually found on a hill and in *Pamunjungan* there are usually menhir, arca, cengkuk stone, bowl stone, flat stone and others. There are many *Pamunjungan* or *Kabuyutan* in Tatar Sunda such as Balay Pamujan Genter Bumi, Cengkuk Site, Mount Padang, *Kabuyutan* Galunggung, Kawali Site, etc (Saringendyanti et al. 2018). At that time, the biggest and most luxurious *Pamunjungan* was *Pamunjungan*

Kihara Hyang which was located in Leuweung (forest) Songgom, or Balay *Pamunjungan* Mandala Parakan Jati (Sabri and Musyahidah 2015). This form of respect for the spirit of natural forces is manifested through the attitude of protecting and preserving nature; namely taking care of the surrounding environment (mountains, hills, valleys, forests, gardens, springs, rivers, and all the ecosystems in them), as well as giving the highest respect to nature, by caring for and maintaining prohibited forests as part of an effort to maintain the balance of the universe (Sucipto and Limbeng 2007).

The essence of this belief is indicated by the existence of *Pikukuh* or absolute customary provisions that are adhered to in the daily life of the Baduy (Garna 1993). The most important content of the '*Pikukuh'* (compliance) Baduy is the concept of "without any changes", or changes as little as possible: *"lojor heunteu beunang dipotong, pèndèk heunteu beunang disambung"*. It means that what's long cannot be cut, what's short cannot be joined. The religious harmonization in the Baduy area is due to their strength in holding the principle that they originate from one descent or family (Hakiki 2015). The nobility of the community is seen in behavior, ethics, beliefs, customary laws which are adhered to in the routine of life (Nurislaminingsih et al. 2019).

HUMA: SWIDDEN AGRICULTURAL SYSTEM

The main livelihood of the Baduy people is *huma* rice farming, a swidden agroforestry model. In addition, they also get additional income from selling the fruits they get in the forest, such as durian and tamarind, and forest honey. There are various traditions and customs of the Baduy people that function as food security. The Baduy people are a group of people who live separately from the outside environment and their life is still very traditional (Bintari 2012). The Baduy people are essentially studious people with their daily activities. The working practice of the Baduy people means learning. Therefore, the Baduy indigenous people are prohibited from studying like city people (Sutoto 2017).

The Baduy ethnic group still prioritizes their lives and is with nature. They live in Kendeng Mountains with diverse habitat types, natural potential, and a high level of biodiversity (Khastini et al. 2019). Based on the Baduy category, the Baduy landscape can be divided into four types: forests, fields, gardens, and settlements. This type of landscape has been traditionally managed based on Traditional Ecological Knowledge and Beliefs. As a result, the Baduy people can continue to practice traditional swidden/shifting cultivation, even though the population is growing and the forest around them is thinning (Iskandar and Iskandar 2017b).

The Kendeng Mountains are dominated by forests, both protected and production forests (Permana 2010). The main livelihood of the Baduy people is the development of rice cultivation on dry land (*huma* or *ngahuma*) (Sutoto 2017). For five years, the Baduy farming system changes land with a fallow period (resting the land). The existence of local wisdom of the Baduy people in farming shows a form of environmental conservation and concern for the environment embedded in community life. While waiting for the harvest or spare time, side jobs are making handicrafts from bamboo (*asepan*, *boboko*, *nyiru*, etc.), making *koja* (packages made of bark), going to the forest looking for rattan, bananas, *ranji*, taking fruit and *medu* (Iskandar 2012).

Baduy people have culturally maintained the *pranata mangsa* (referred to Baduy as *pananggalan*) for the annual practice of swidden cultivation (*ngahuma*) based on the traditional calendar. Baduy rice farming cycle is fixed annually with reference to an agricultural calendar. The various environmental perturbations have slightly affected it because the Baduy people have developed several strategies, such as organizing a traditional calendar and implementing traditional agroforestry whose production can be used for subsistence and commercial purposes (Iskandar and Iskandar 2016).

The *huma* has been culturally managed by the Baduy based on moral and interest purposes and managing a high diversity of crops/plants. In the swidden agroforestry of Baduy was recorded 41 species of food crops consisting of 9 species of carbohydrate food and 32 species of non-carbohydrate food (Iskandar and Iskandar 2015). By applying strategy to cultivate various local rice varieties (landraces), which are prohibited from trading for moral purposes, are mixed cropped with harmonious with non-rice crops/plants that are not prohibited from trading. The swidden agroforestry *huma* has been an important role in conserving local crop/plant diversity, including food crop diversity. In addition, conserving crops variety in the swidden agroforestry *huma* has been very useful in supporting and maintaining the food security of Baduy. With more intensive economic market penetration to Baduy village, the food consumption pattern of the Baduy household has dramatically changed. However, by the rapid economic market development, the Baduy people have properly adapted, such as selling non-rice crops and household handicrafts. As a result, Baduy has got cash and can be used to buy various household needs of the Baduy, such as sawah husked rice (*beras sawah*) to supplement the swidden rice. Moreover, the swidden rice production can be stored in rice barns (*leuit*) for more than fifty years, and food security of the Baduy can be maintained (Iskandar and Iskandar 2015).

In addition, the Baduy people also hunt animals, make roofs from kirai leaves, and make agricultural tools, such as blades and kored. In their spare time, the role of Baduy women, apart from encouraging their partners in the fields, they also make handicrafts by weaving. They weave materials using basic equipment that they make themselves (Permana 2001). For the Outer Baduy, apart from carrying out these activities, the job that distinguishes the inner Baduy is tapping sap or palm flower bunches to make sugar. Occasionally, the Outer Baduy people cultivate agriculture with seasonal crops, such as harvesting coffee and cloves, planting sengon wood, exchanging, and becoming laborers (Iskandar et al. 2019). The work is carried out exclusively for a decent living and is prohibited

from overproducing. Some of the agricultural products of the Baduy people are sold and some are only for personal use. Agricultural products in the form of rice are only for their own interests, they don't sell it. Usually, after harvest the rice is dried, it is directly put into a rice barn called *Leuit*. The rice barn (*leuit*) is woven bamboo strung together with large woods and has a *kirai* (coconut husk) roof. Each Baduy family has one or more *leuit*. Rice stored in the granary is used for daily food needs and is preferably used during traditional ceremonies, such as weddings or circumcisions.

The Baduy people have long practiced a form of swidden farming based on traditional ecological knowledge and beliefs about the cosmos. Therefore, Baduy have prohibited wet rice field cultivation on their lands. Moreover, in conserving their traditional swidden farming system, the Baduy people have resisted using modern rice varieties, inorganic fertilizers, and synthetic pesticides. Based on Baduy culture, their swidden-produced rice is not sold, and for at least the past 50 years, the harvested rice has not been stored away in barns but has been mainly used for daily home consumption and various traditional rituals. Nowadays, Baduy swidden farming is affected by many new pressures – particularly by population increase and increasing food demand – but the forest land used for practicing their swidden farming is limited. Therefore, to maintain the sustainability of their swidden farming system, the Baduy people, particularly the Outer Baduy, have developed cultural strategies that include temporary out migration (*nganjor*) to neighboring, non-Baduy areas where Muslim value-systems provide the main cultural dynamic. The Outer Baduy have maintained the sustainability of their swidden farming, by various means, especially by conducting contemporary out migration to non-Baduy areas in Muslim majority territory. They plant swidden rice in a way that fulfills multiple traditional rituals, and by diversifying their non-rice-trading options that include growing a variety of mainly tree crops in their swidden land (*huma*) and other anthropogenic lands. This involves occasional negotiated out-migration to non-Baduy areas for temporary swidden farming in surrounding Muslim majority territory. This has enabled the Outer Baduy to maintain long-term swidden farming system (Iskandar et al. 2018a).

The Outer Baduy people rely heavily on swidden cultivation for subsistence. They grow rice in the uplands every year, according to their calendar. Planting calendars and social events calendars are often closely related. There is also traditional ecological knowledge for land and forest conservation, such as zoning land-use systems. The productivity of the Outer Baduy swidden cultivation area is mainly determined by the period the forest is fallow relative to plants. The long-term success of the Outer Baduy swidden cultivation depends on how well the fallow period restores or maintains soil fertility. The Outer Baduy classifies soil based on color, water content, stoniness or rock parent material, and humus content. To maintain soil fertility in swidden cultivation, the Outer Baduy people have developed several strategies, such as determining the right fallow period, implementing no-tillage, and planting legumes both in the swidden fields and in the fallow land. Traditionally, because the Outer Baduy are prohibited from using inorganic fertilizers, the length of the fallow period and the type of vegetation succession have an important role in maintaining soil fertility (Iskandar et al. 2018b).

Suparmini et al. (2013) said the prohibitions that must be obeyed in agriculture are as follows: (i) It is prohibited to use hoes when cultivating the land, (ii) It is prohibited to plant cassava, (iii) It is prohibited to use chemicals to eradicate pests. Pest eradication and crop fertilization are carried out traditionally, (iv) Going to the fields is prohibited on Monday, Thursday and Saturday, (v) It is prohibited to open fields in Leuweng or forest cover and it is prohibited to clear land in the village forest.

ENVIRONMENTAL MANAGEMENT OF BADUY PEOPLE

The Baduy people living in Kanekes Village have a close life and depend on the environment. In essence, the main activity of the Baduy people is to save and protect the prohibited land that has been mandated by their ancestors (Senoaji 2011). Kanekes Village, where the Baduy people group or the Baduy people is located in the foot of the Kendeng Mountains with an altitude of 300-600 m asl., which has a hilly and undulating topography with an average slope of up to 45%, which is volcanic soil (in the north), sedimentary land. (in the middle), and mixed soils (in the south), the average temperature is 20°C. The Baduy people have customary land of approximately 5,108 hectares, they have the principle of living in peace, do not want conflict, and obey traditions and customary laws. The environmental conditions in Kanekes Village, where the Baduy people live, have a good environmental quality, characterized by a high diversity of biodiversity. There are many types of flora and fauna in Baduy but not found in other areas. Some of the animals that live there are classified as wild and rare, so they are protected by the Indonesian government. So that good environmental management needs to be done by the Baduy people. There are many types of flora and fauna in Baduy but not found in other areas.

Environmental management is a conscious effort to maintain and preserve and improve the quality of the environment to best meet human needs (Manik 2018). Environmental management aims to realize sustainable development that is environmentally sound in developing the whole Indonesian people and the development of all Indonesian people who believe and have devotion to God Almighty (Maryana and Rachmawati 2013). The goal in sustainable environmental management is the creation of harmony, harmony and balance between humans and the environment (Effendi 2003). Second is realizing humans who have attitudes and actions to protect and foster the environment. Third, ensuring the interests of present and future generations. Fourth, creating environmental functions and controlling the wise use of resources there. Environmental management is based on responsibility, sustainability and the principle of benefits (Purnaweni 2014).


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Figure 2. A-C. Face of Baduy people: adult males (A), young girls (B), boys (C), white clothes for Inner Baduy and black/blue clothes for Outer Baduy. D-F. The position of the Baduy settlement in side the forest. G-L. Upland rice farming, as the most important production of the Baduy: Swidden farming (G-H), Drying of the rice, prior to store in *leuit* (I), pound rice (J). K. Honey, the most important non-tree forest product od Baduy. L. Durian, one of the most valuable agroforestry products. M-Q. Typical house and housing of Baduy. R. *Leuit*/rice storage house. S-T. Several model of bridges, as many rivers flow in the Baduy area (U). V-X. Weaving is a skill that must be mastered by Baduy female. Y-AA. Several handicrafts made and sold by Baduy people. AB-AD. Several types of Baduy musical instruments: *angklung* (V), *sitar* (W) and *seruling*/flute (X). AE-AG. *Seba*, the most colossal traditional ceremony where thousands of Baduy men face government officials with harvested gifts

Incorrect environmental management can cause damage to the environment (Atmojo 2013). Environmental damage can occur due to the dynamic activities of nature and human activities. Human or anthropogenic activities in managing the environment can cause environmental damage. One of the human activities that can damage the environment is development activities that ignore the environment. The human perspective on nature greatly influences environmental awareness and how to manage the environment and natural resources (Dharmawibawa 2019). An environmentally sound development needs to be carried out (Dahuri 2003). Environmentally sound development is implemented to be able to process natural resources wisely. This is so that the implemented development can sustain sustainable development to improve the quality of life of the people, from generation to generation throughout the ages. So that with environmentally sound development, it can support a sustainable and harmonious environment. Finally, development can be carried out sustainably that continuously improves humans' quality and the environment (Mukono 2005).

Sustainable environmental management activities have been reflected in the local wisdom or local wisdom of the Baduy people Group. Local wisdom is the attitudes, views, and abilities in managing its spiritual and physical environment, which gives the community resilience and strength to grow in the community's area. In other words, local wisdom is a creative response to a geographic, political-historical and situational situation that is local (Dahliani et al. 2015). Local wisdom becomes a view of life and knowledge and various life strategies manifested in local community activities in responding to challenges and fulfilling life. Local wisdom is considered very valuable and has its own benefits in people's lives. The system was developed because of the need to live, maintain, and live in accordance with the situation, conditions, abilities, and values that are lived in the community concerned. In other words, local wisdom then becomes part of their wise way of life to solve all life problems they face. Thanks to local wisdom they can continue their life, even develop sustainably.

One of the local wisdom still firmly held by the Baduy people group or the Baduy people is the *Pikukuh*. *Pikukuh* is divided into two, namely *Pikukuh* sapuluh and *Pikukuh* karuhun. *Pikukuh* sapuluh (dasa sila) are ten guidelines of life that the Baduy people must implement. *Pikukuh* karuhun is a hereditary rule made for the Baduy people and outsiders who visit Baduy, this rule regulates the procedures for carrying out life in Baduy (Suparmini et al. 2013). *Pikukuh* teaches honesty and always maintains the truth and goodness for the benefit and safety. *Pikukuh* means not changing something or it can be interpreted as accepting what already exists. *Pikukuh* or customs and norms are not only references for all their behavior, but also guidelines as well as social control over their behavior. The Baduy people consider land or land to be ambu or mother, land is ambu rarang, the upper part of the land or sky is ambu luhur, while the world where humans live is the middle world controlled by ambu Tengah. Respect for land is on par with that of the mother, demonstrating the close bond that a mother has with her children. Ambu is all the sources of life for humans, and the source of the three worlds, the sublime world, the middle world, and the handap world.

Pikukuh sapuluh contains: (i) Moal megatkeun nu lian life (not killing other people); (ii) *Moal mibanda pangaboga nu lian* (not taking other people's things); (iii) *Moal linyok moal lying* (not denying and not lying); (iv) *Moal mirucaan kana inuman nu eye drunkenness* (not involving oneself in intoxicating drinks); (v) *Moal midua ati ka nu sejen* (not double-minded to others / polygamy); (vi) *Moal goods dahar dina when kungkung peting* (eat at midnight); (vii) *Moal make development of jeung seuseungitan* (do not use flowers and fragrances); (viii) *Moal ngageunah-geusan sare* (not slumbering); (ix) *Moal nyukakeun ati ku igel, gamelan, kawih, or tembang* (displeasing with dancing, music, or singing); and (x) *Moal made gold or salaka* (not wearing gold or jewels).

Pikukuh karuhun includes: (i) It is prohibited to enter the forbidden forest (*leuweung kolot*) to cut trees, open fields or take other forest products; (ii) It is prohibited to cut down any types of plants, such as fruit trees, and certain types of trees; (iii) It is prohibited to use chemical technology, such as using fertilizers, and drugs to eradicate pests and plant or poison fish; and (iv) Farming must comply with customary provisions, etc.

The Baduy people divides the Kanekes area into three zones: the lower, middle, and upper zones. The area in the valley of the relatively flat hill is the lower zone used by the Baduy people as a residential zone. The Baduy people call this zone the "*dukuh lembur*" zone which means village forest. They set up houses in this zone in groups (Suhartini 2009). The traditional Baduy house is in the form of a simple and traditional stage. The materials used are obtained from the natural surroundings, such as wood for poles, bamboo for walls and coconut leaves for the roof. Their settlement is at an altitude of 250 m asl (above sea level), with the lowest area at 150 m asl while the highest is up to 400 m asl. The second zone or the middle zone is above the village forest. This land is used as intensive agricultural land, such as garden fields and mixed gardens. Their way of farming is still traditional, namely by clearing forests to be used as agricultural land and gardens (Laily 2017). Forest cleared for fields is a type of secondary forest or production forest. The land for farming is used for one year, after which the land is left to become forest again for at least 3 years. The third zone or the upper zone represents the hilltop area. This area is a conservation area that is not allowed to be made for fields, it can only be used for limited timber extraction. The Baduy people refer to this area as "*leuweung kolot*" or "*leuweung titipan*" which means old or *titipan* forest to be preserved.

In addition, the Baduy people groups differentiate forests based on their function and location. Based on its function, forests are divided into three types: forbidden forest (*leuweung kolot*), *dudungusan* forest, and arable forest (*leuweung reuma*) (Senoaji 2011). Protected forest prohibited forest that cannot be entered by anyone, even Baduy people or traditional leaders. Dudungusan forest is a

protected forest because in the upper reaches of a river, or in it there is a sacred place or Baduy ancestors, and arable forest is a forest that can be used as a field or *huma*. Forbidden forest is located in the south of the Baduy *Tangtu* settlement, located in the deepest and highest location of the forest area in Baduy. In the forest there are many types of tall wooden stands with shady canopies or canopy, there are also perennials and trees under them. Palm, ferns, vines, shrubs, lubrication, and other inferior plants cover the forest floor (Senoaji and Simon 2011). In the forbidden forest, various animals, insects, and microorganisms can also be found that complement the forest ecosystem. The denser the forest, the richer the potential for stored air reserves and the richness of biodiversity. It is respected as the source of the power of the forest that supports, supplying nutrients to the excess forest below, gardens, fields, and yards around the house. From this forbidden forest, the Ciujung and Cisemeut rivers flowed. Baduy Forbidden Forest is treated with special care, so that its integrity, integrity and health are maintained. Anyone who is prohibited from entering, is prohibited from disturbing him, taking anything from him, even a piece of leaf, twig, or even a drop of honey is not taken from the forbidden forest. This is a forbidden forest, not because it is haunted or sacred, but because the Baduy people really respect and value nature based on an understanding of the potential it contains (Iskandar 2012).

Protected forest is basically like a forbidden forest that must be maintained for its integrity, sustainability and health. So that the original potential is not disturbed and is maintained. The difference between protected forest and prohibited forest is that the Baduy people around it are allowed to take and utilize protected forest products but on a limited basis. Arable forest is a forest area that functions as a field or *huma*. A kind of perennial land for intercropping, or food crops, namely rice and garden commodities. Baduy people think that their territory is the core of the universe, with the right to remain nurtured and not disturbed by changes, because the disturbance will create an imbalance in the universe including ourselves. The Baduy see the universe as 'a sky distance, a weak one'. The obligation of the Baduy people for prohibitions is to maintain them as best as possible according to the will or message of the karuhun (ancestors) (Iskandar 2012).

ENVIRONMENTAL CONSERVATION AND PRESERVATION BASED ON LOCAL WISDOM OF THE BADUY PEOPLE

Local wisdom is an unwritten rule of thumb that becomes a reference for the community covering all aspects of life (Ahmad 2010). Local wisdom can be understood as ideas, values, and local (local) views that are wise, full of wisdom, good values that are embedded and followed by members of the community (Koentjaranigrat 2010). Local wisdom can also be interpreted as a view of life and various life strategies in the form of activities by local communities in responding to various problems covering all elements of life; religion, science, technology, social organization, language and communication, and arts. Permana et al. (2011) state that there is a link between local wisdom and local communities. The local wisdom of Sundanese culture is contained in the idea, activities and artifacts that are always used as guidance in relationships with others, the environment and the Creator (Saleh et al. 2013). The local Baduy people in Kanekes Village generally applies their daily local wisdom in protecting and preserving the environment. In addition, they also carry out conservation efforts that play a role in supporting sustainable development in the life of the community itself. Sustainable development emphasizes the economic income system alone and prioritizes the community's socio-cultural system and environmental sustainability efforts for the future (Akbarini 2016). The application of a sustainable development system in society can be applied by integrating local knowledge of the community and scientific knowledge in managing their environment. This is expected to understand better certain systems owned by the community (Taylor and Loë 2012). Local wisdom inherent in the community in protecting the environment is attractive for further investigation to maintain customs without reducing conservation efforts so that it becomes an object of special attraction and can be developed to increase the economic income of local communities. The local wisdom about protecting the environment they use indirectly emphasizes rules that are physically material in the form of environmental processing procedures and emphasizes psychological changes to form good and praiseworthy human character (Satriadi 2018).

The Baduy people and other Sundanese people view the natural environment as not something that must be subdued, but must be respected, nurtured and cared. Human life is closely related to the natural environment because it depends on ecosystems that ensure survival (Niman 2019). In essence, the attitude of the Sundanese people in relation to nature is more adaptive to nature (Indrawardana 2012). The attachment of humans or Sundanese people to the surrounding environment sometimes positions humans "as if they are submissive" to nature. In fact, the Sundanese people who work as farmers must adapt to nature so that nature indirectly forms the mentality of Sundanese people (farmers of the past). Understanding local communities in using natural resources wisely and realizing that humans are part of the natural spectrum to preserve sustainability is a concept of ecological awareness that must be adhered to (Anshoriy and Sudarsono 2008). Changing the paradigm and behavior of society towards nature is very important for environmental balance. This principle leads to limiting the exploitation of nature by considering the conservation of biological resources (Ardan et al. 2015).

The role of the Baduy people related to their local wisdom lies in three dimensions of local wisdom, namely: (i) local values, they maintain their attitudes and behavior by the teachings given by their parents and convey it in the form of knowledge to tourists; (ii) local resources, they still fulfill the obligation to cultivate and use every available resource as best as possible without exploitation and commercialization; and (iii) solidarity with local groups,

they uphold tolerance and continue to work together to maintain good relations with fellow members of the Baduy people and outside communities (Firdaus et al. 2019). Examples of forms of local wisdom in the Baduy people in agriculture, forestry and settlement are described as follows.

Local wisdom of the Baduy people *regarding the agricultural system*

The agricultural system of the Baduy people is an agricultural system. Baduy people cultivate rice in a field system based on local ecological knowledge and beliefs (Iskandar and Iskandar 2018). In agriculture, they do not recognize modern agricultural facilities and infrastructure and only recognize the cultivation system. The Baduy people really respect their environment while maintaining the balance of their ecosystem. They have the principle that if the balance is not maintained, then calamity will come and will befall them too. Some of their farming activities that show the values of local wisdom include having reliable knowledge of astrology. The Baduy people still use the manual farming system because they follow the rules of their ancestors which do not allow the use of modern fertilizers. Baduy people use fertilizers from nature, such as leaves. In addition, Baduy people do not use modern agricultural tools, but use traditional tools in accordance with the rules of their ancestors (Putri et al. 2019). When starting rice planting in the fields, the Baduy people don't forget to stick the stems or branches of pelah leaves with a distinctive smell. This is done to prevent attacks from pests and rodents. The Baduy people uses plant fertilizers and prevents plants from being attacked by pests and diseases. Fertilizers and pesticides are made from a mixture of various leaves that are finely ground and mixed with kitchen ash. The ingredients for making natural pesticides are *Pinanga coronata* fruit, *Zingiber cassumunar* rhizome and water sand are mixed and while chanting the tawa kungkang spell (Iskandar and Iskandar 2017c). All these materials are very environmentally friendly and the materials are available in their environment. This shows their independence in farming as well as their wisdom towards nature. They have recognized and applied integrated pest management, which is highly recommended in modern agriculture today. Meanwhile, the type of rice planted is local rice, which results from self-selection. This is another form of their independence in agriculture.

The fields applied in Baduy are mobile. Every year the rice harvest is only once. The length of the rice planting period is five to six months. Land left behind by a cultivator must be left on before other residents make land to maintain its fertility. The time lag before the soil can be planted again is getting shorter. Changing fields is generally done after one to two harvests, although there are also residents who have just moved their fields after four harvests. Yields on the same land will continue to decline every year. Every time you open a new field, three jobs are done: cutting existing plants, burning plants, and clearing the soil from objects that disturb the cultivation. Land is not plowed to maintain the strength of the land in Baduy land. After the soil is ready, start planting rice, known as ngaseuk. Before starting to plant rice, the Baduy people holds a ceremony to praise Dewi Sri, known as the rice goddess, for protecting their land. In this ceremony, there are mantras accompanied by the strains of angklung and small drums (dog-dog). And angklung players are in charge of reciting spells. This ceremony must be held in every village and residents who can hold this ceremony for each of them. The ceremony held by each family is not mandatory because for this ceremony the host must provide food and other necessities. The rice planting period in Baduy villages began when *Puun* had planted rice. After *puun*, residents started planting (Sutisna 2019).

Some residents have good days which they use as a guide to start planting rice. After the planting period, the Baduy people no longer regularly take care of their *huma*. They only clear the fields of plants that can reduce rice production. Irrigation of fields is carried out without irrigation and only relies on rain. In general and broadly speaking, the work stages of farming in the fields of the Baduy people are clearing and clearing land areas, then cutting down large trees using an ax, patik or baliung (a type of large ax), then burning the forest that has been cut down for accelerate the decay process. After burning the seeds are planted in the form of grains and other grains. This activity is carried out by men and women, this job is called ngaseuk, which is to make a hole in the ground to plant the seeds with an aseuk (a wooden stick about one and a half meters long with a slightly pointed tip). Apart from rice, nuts and seeds are also planted on land, such as maize, and even in Banten, people have started to plant tree crops, such as coconuts and fruits. The last stage is harvesting. Women usually carry Harvest work in mutual cooperation, while men are tasked with transporting the harvest to their respective homes. Harvesting activities are always accompanied by a celebration ceremony so that the agricultural business does not experience disruption or attack by pests. The ceremony manifests belief in the supernatural in human life, as part of a culture of animism and dynamism (Suparmini et al. 2014).

Local wisdom on agriculture of the Baduy people related to Baduy food security is carried out by maintaining agricultural cultivation procedures and maintaining foodstuff management by still following the ancestors' rules (Iskandar and Iskandar 2015). The Baduy people have a customary law structure that is subject to and obedient to the *Puun* as the highest leader of the customary government and religious leaders in Cikeusik Village, Cibeo Village, and Cikartawana Village. The customary legal structure system of the Baduy people plays an important role in protecting all its citizens both in the community sector and in managing the natural environment (Senoaji 2012). The community must carry out local wisdom which has become the norm, the rules for a long time. Community businesses related to food security in Baduy, carried out by carrying out the concept of self-Koran, pamali culture and mutual cooperation. The concept includes agricultural regulations, foodstuff management and views on the resilience of the cultural views of mutual cooperation in Baduy so far there has been no change in

local wisdom because people still adhere to the mandate conveyed by their ancestors (Iskandar 2012).

Local wisdom of the Baduy people *in settlements*

Baduy people's settlements are determined by *puun*. *Puun* is the highest leader of the Baduy people. In his life, *Puun* is a descendant of Batara and is considered the ruler of the Sundanese Wiwitan religion who must be obeyed by all his commands and words (Suparmini et al. 2013). The building to be erected must be in accordance with the soil structure and topographical location of the area. The house's condition, shape, and arrangement of the rooms have been adjusted according to customary provisions. All customary rules are always related to the existence of orders from ancestors which the Baduy people continue to care for. The settlement of the Baduy people follows the Sundanese settlement pattern, which is centered and surrounds the square or field. The Baduy settlement is in the form of a stage with a height of about 0.5-1 meters. This aims to reduce the effects of the earthquake because the surrounding area is hills and mountains (Pratiwi 2017). The form of residential buildings for the Baduy people has the same shape, namely the house room is divided into three parts, namely the terrace (sasoro), the living room (depas), and the kitchen (imah). The architectural form of houses and other buildings is associated with environmental conditions such as roofs made of palm leaves (kirey) and palm fibers, which function to prevent water from entering the house and facilitate the entry of direct sunlight so that the house is protected from moisture. The poles are made of mahogany, because mahogany is the strongest wood so it is anticipated that the house does not collapse quickly and is resistant to natural disasters such as wind, rainwater, and earthquakes. The house walls are made of bamboo (in woven form). Its function is resistant to wind and provides a cool effect in the house. The use of building materials in general uses materials from bamboo (building frames, roof trusses, and booths) and kirai roof coverings (ateup) suggest a very strong Sundanese and offering styles (Khamdevi and Andrey 2018). Besides that, the buildings of the Baduy people have the same shape, this shows simplicity in the community. The form of settlement of each house is grouped according to the existing topography.

Local wisdom of the Baduy people *on forestry*

According to Sahlan (2012) forests have important functions for the lives of surrounding community members, especially in state forests with a processing system that aims to empower local communities without disturbing their main functions. For people who live and live in the vicinity of the forest, the existence of the forest with all the potential natural resources contained in it is very important for the survival of the community. Forest is interpreted as a source of food, drink, medicine, fulfillment of life necessities, protection and comfort, a place for rituals and institutions of belief, as well as a place to develop social solidarity for members of the local community. The Baduy people in Kanekes Village use non-timber forest products for their daily needs, one of which is forest honey. Non-timber forest products are a natural resource that is still widely available in Indonesia and its existence is used for livelihoods by the community. One of the non-timber forest products is generally collected from natural forests and only a small portion is harvested from the forest. One of the potential non-timber forest products, namely forest honey, is a beekeeping product that has been recognized by the public around the world, including Indonesia. Non-timber forest products are all products or products produced from forests. One of the potential non-timber forest products, namely forest honey, is a beekeeping product that has been recognized by the public around the world, including Indonesia. Non-timber forest products are all products or products produced from forests. One of the potential non-timber forest products, namely forest honey, is a beekeeping product that has been recognized by the public around the world, including Indonesia. Non-timber forest products are all products or products produced from forests.

Given the importance of the function of forests for the survival of these communities, local wisdom is formed and developed to preserve environmental functions. Among the local wisdoms that result from the adaptation experience of the community with its environment, particularly forests, is the concept of"prohibited forest" which is derived from the views and knowledge of the community (traditional knowledge) in traditional environmental management efforts. Through the concept of prohibited forest, the community applies norms to control attitudes and behavior in forest management by conducting forest management, utilization, development, maintenance, restoration, supervision and control (Iskandar 2012). A social intermediary that is friendly to nature, Indigenous peoples have sufficient capacity to carry out rehabilitation and restore forest damage in concession areas. The role of indigenous peoples in forest management in the future, among others, indigenous peoples have a strong motivation to protect forests compared to other parties, indigenous peoples have indigenous knowledge how to maintain and utilize forest resources in their habitat, indigenous peoples have customary laws that are enforced, and indigenous peoples have customary institutions that regulate the harmonious interactions between them and their forest ecosystem.

The Baduy people's view of life towards the forest is that they consider mountains and forests to be the source of livelihood for the Baduy people, nature is not only for the Baduy people but for the wider community. The Baduy people think that nature is not a resource that must be exploited to get the maximum benefit, but that nature is a gift from God to be protected by humans so that it can be used by future generations. Baduy people are aware that the inhabitants of the world and the duty to care for nature is not their own task, but the task of all human beings on this earth, because all humans have the same status, namely they need the goodness and generosity of nature as a source of life (Kesum 2013). The Baduy people believe that they were created to protect the prohibited land, the center of the earth. They are required to save the entrusted forest by implementing a simple lifestyle regulated by customary

norms. Among the various customary laws scattered in Indonesia, the Baduy customary law is one example of the customary law that has been in effect regulating the Baduy indigenous people for hundreds of years from generation to generation. Until now, the law in Baduy is still binding on each member of the community (Fathurokhman 2010). Therefore, the main activities of the Baduy people essentially consist of land management for agricultural activities (*ngahuma*) and forest management and maintenance for environmental protection. Work is not a livelihood, but also a form of worship that is part of the pillars of Baduy. Farming activities are considered sacred because they married the rice goddess or Nyi Pohaci Sanghyang Asri. Farming activities will always be followed by ceremonies led by traditional leaders.

Local wisdom of the Baduy people in conservation practices

The concept of sustainability that is implemented by the Baduy people clearly originates from their belief and derived from customary law which they adhere to. The rules for avoiding changes to the form of nature in all aspects of life are forms of preserving nature between generations. The structure of government and custom is combined to maintain the existence of customary law and remain part of the external environment. The economic principles that are applied are also the key to the sustainability of the Baduy people, namely that activities aim to meet daily needs which are primary needs such as clothing, food and shelter. Baduy people perceive needs outside the primary as fulfilling their lust or desire and the desire to trigger the exploitation of natural resources and social inequality. If depicted in the form of a triangle, nature is the pinnacle of the Baduy people order. People must serve nature, as a form of service so they always worship nature as their life provider. This relationship between humans and nature creates a high respect for the environment to create a sustainable life. Conservation practices carried out by the Baduy people can be realized in terms of: (i) For the Baduy people, the forest is considered sacred so the indigenous people respect their forest area. (ii) The concept of environmental management with a zoning system has been known and practiced by the Baduy people from generation to generation. Through local wisdom, both traditional ceremonies and the concept of environmental management, which have been a practice of hereditary life and have been preserved, confirm that the Baduy people can exist. These life values are still actual and necessary for everyone in their present and future lives (Nadroh 2018). The traditions and customs of a community can act as an attraction for an area itself (Henri et al. 2018).

MODERNIZATION AND BELIEF SHIFT IN BADUY PEOPLE

The beliefs held by the Baduy people are often referred to as Sunda Wiwitan which are based on ancestor worship (animism). The essence of this belief is indicated by the existence of *Pikukuh* or absolute customary provisions that are adhered to in everyday life. *Pikukuh* is divided into two, namely *Pikukuh sapuluh* and *Pikukuh karuhun*. *Pikukuh* teaches honesty and always maintains the truth and goodness for the benefit and safety. Even though the Baduy people still believe that obeying their religious beliefs will lead to community integrity, prosperity, and peace, Baduy people are also aware and believe that with changing times, changes will occur around the Baduy people. It would be impossible to deny it. The symptoms of change show a higher frequency in the *panamping* Baduy (Outer Baduy) than the *Tangtu* Baduy (Inner Baduy) people. Changes in the social dimension, including the beliefs of the Baduy people, can be caused by several factors such as modernization and outside influences. Changes in the beliefs of the Baduy people can be exemplified by the change in animist beliefs (Sundanese Wiwitan) to Islamic, Buddhist and Hindu beliefs. The influence of modernization also affects changes in farming systems, religious activities, changes in the use of clothing and language, and various other living systems (Maftuh 2018).

The outside world also affects the lives of the Baduy people. The traditional way of life of the Baduy people is simple and full of tolerance and sees life further into the future, so that their life remains sustainable. Protection of the environment is carried out to maintain the life of the Baduy people so that it remains intact and can continue to meet their needs. Management and utilization of the natural environment is an effort that has been prepared since humans occupy certain lands so that the sustainability of natural resources can be enjoyed by future generations (Fahmi 2017). They assume that environmental damage or changes to the shape of the environment will threaten their livelihoods resulting in hunger and economic deprivation. The destruction of life due to environmental damage will lead to the extinction of the Baduy people. Therefore they also prohibit and even fight against outsiders who try to damage their environment. Because the influence from outside can shift the socio-economic life of the Baduy people (Bintari 2012). The presence of outsiders can have both good and bad effects. The good impact of the arrival of newcomers or tourists for the Baduy people is that it can increase family income. The bad impact is disruption of culture to the Baduy people. The impact is the way of life of the Baduy people, especially the Outer Baduy, which is becoming contaminated with the times. The social and cultural dynamics of the Baduy people impact the management of forests, land and the environment (Senoaji 2010). The community maintains this culture because immigrants must obey and obey the rules applicable in the Baduy people, and this is done without exception.

To protect the environment from outside influences, many of their efforts are repressive or preventive (Sugiwa 2015). Some of the preventive efforts that have been carried out are by not accepting development assistance from any party which is thought to damage their environmental conditions or social structure. In addition, they also continue to urge both local and national governments to make their area a protected area and are supported by regulations issued by the government so that it is binding for people outside Baduy. Repressive efforts

are made firmly by directly taking action against anyone who tries to damage their environment. To control land use by the community, Baduy has no land ownership. The existing land is customary land which is used collectively. In addition, there is no system of buying and selling or renting land. With such a system, adat can control land and its allocation. The land that can be used as agricultural fields is used in rotation by the families there. For the Outer Baduy area, there is a land rental system. Rent is done for agricultural land with a production sharing system. The family who rents the land pays with their agricultural produce to the land owner, the amount is determined by agreement at the beginning of planting. The form of environmental conservation and conservation behavior carried out by the Baduy people is reflected daily. This high awareness of the relationship between the sustainability of life and the natural environment is what shapes Baduy people's behavior to be very environmentally friendly. In making decisions about new problems that arise, it is always based on the interests of the environment as a priority.

CONCLUDING REMARKS

Baduy people are peoples who always apply their traditional customs and beliefs in their daily lives. The Baduy people is a society that is known to have full authority in regulating the natural environment and customs. The Baduy people has strict customary rules and is carried out with full regulating their natural environment and traditional customs. The belief held by almost all Baduy people is Sunda Wiwitan. In Sundanese Wiwitan belief, protecting nature is an obligation from the foundation of the pillar of religion. The rules or laws that apply in the life of the Baduy people are *Pikukuh*. *Pikukuh* is divided into two, namely *Pikukuh sapuluh* and *Pikukuh karuhun*. *Pikukuh* has become a philosophy of life and social control over the behavior of the Baduy people. In essence, the main activity of the Baduy people is to save and protect the forbidden land that has been sacred by their ancestors. Therefore, the behavior of the Baduy people is always directed at managing the forest and its environment and managing land for agricultural activities (*ngahuma*). Through a system of beliefs, traditions, and traditional customs, as a form of local wisdom to maintain the balance of nature, the Baduy people are proven to support themselves, protect their environment, and preserve nature. The behavior of local wisdom which is a form of environmental conservation and conservation carried out by the Baduy people includes: (i) agricultural systems, (ii) residential systems, (iii) forestry systems, and (iv) conservation practices.

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Human activities outcomes on the composition of woody plant species of Ngarama Southern Forest Reserve in Kilwa District, Tanzania

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Abstract. *Jilala ZJ, Mwakalukwa EE, Chamshama SAO. 2019. Human activities outcomes on the composition of woody plant species of Ngarama Southern Forest Reserve in Kilwa District, Tanzania. Asian J Ethnobiol 2: 108-118.* This study evaluated the effects of human activities on the composition of woody plant species of the Ngarama Southern Forest Reserve (NSFR) in Kilwa District, Tanzania. Vegetation research was conducted in 40 systematically arranged rectangular test plots, aligned in five transepts over 2,070 ha forest. Information recorded in each plot included: species name, diameter at breast height (DBH), the height of selected timber species with a diameter ≥ 5 cm, and various indicators of human disturbance. Landsat TM and ETM+ images from 1995, 2000, and 2011 were used to locate and quantify the land cover change in the NSFR over the past 20 years. Inventory data was analyzed using Microsoft Excel and R software, while Landsat images were analyzed using the academic software ILWIS 3.0. About 126 plant species belonging to 34 families have been identified. Trees contributed 63% (28 families), and shrubs 37% (17 families). The Shannon-Wiener index and Simpson's diversity indices were 3.95 and 0.03, respectively. In addition, a mean stem density of 667 ± 19 stems ha^{-1} and a basal area of 13.11 ± 0.34 m^2 ha^{-1} were obtained. Twenty-three stumps (7 ± 3 ha^{-1} stems) with a mean baseline area of 0.24 ± 0.09 m^2 ha^{-1} stumps were removed, indicating ongoing anthropogenic disturbances in the forest. Other indicators of disturbance recorded were damage from fire (50%), paths / roads (13%), silage (8%), lumber/planks/pile harvesting (8%), cultivation (5%) and logging (8%). Although NSFR has a decent species richness and is well-diversified, there has been a consistently negative change in forest cover concerning low trunk density, average tree height, average DBH, and basal area, indicative of anthropogenic disturbance. Conservation measures are recommended to improve governance and accountability regarding accountability for intensive forest resource management.

Keywords: Composition, human activities, Ngarama Southern Forest Reserve, woody plant

INTRODUCTION

Tanzania has about 48.1 million hectares (ha) of forest cover, of which 93% is forest and only 7% is classified as forest (mangroves, coastal forests, montane rainforests, and plantations) (NAFORMA 2015). About 3.5% is coastal forest covering an area of 0-150 km along the Indian Ocean coastline, and 0.3% is mangrove covering the area along the Indian Ocean coastline (FAO 2007, 2012; IPPC 2011). Currently, statistics show that in Tanzania, there are at least 70 000 hectares of coastal forest scattered on the inland coastal strip from 0 to 150 km from the Indian Ocean (Burgess et al. 2003). Coastal forests are generally 0-50 m and 300-500 m above sea level, but other locations are more than double this upper limit, where they begin to transition to submontane forests (Burgess et al. 2003, 2011; Sumbi et al. 2003).

In Tanzania, along with these areas, more than 66 coastal forests come under different forms of protection (Kibet 2011). There is currently only one coastal forest in a national park and 41 forests managed by Tanzania Forest Services and the local government (Burgess and Clarke 2000; Dickinson et al. 2010). Two forests are under the game reserve, and three are under private land (Burgess and Muir 1994). There are 21 forests that do not have a formal status; although some have started to publish a participatory forest management program, their total number is not well known. (Howell and Msuya 2002).

Clarke et al. (2011) reported that pressure on fresh farmland, along with an ever-increasing demand for charcoal, stakes, firewood, and uncontrolled bushfires, pose a threat to the existence of these forests, particularly those in southeastern Tanzania and most of the remaining areas of the East African coastal forest as a whole. Consequently, these disturbances have contributed to the loss of biodiversity, as well as the emission of greenhouse gases such as carbon dioxide, which over time contribute to global climate imbalance and, ultimately, climate change (Paavola 2003; Dallu 2004; Dickinson et al. 2010; Godoy et al. 2011).

Efforts to conserve these forests have been hampered by the lack of reliable data on flora and fauna present in these areas. In addition, most biological surveys conducted in coastal forests have been highly uneven and selective. For example, in Tanzania, most of these surveys have been conducted on the country's northern coast, leaving much of the forest in southeastern Tanzania almost unsurveyed, despite the available evidence that these areas have levels of floristic endemism higher than any other. Along the coast (Prins and Clarke 2006). *Erythrina schliebenii* is a good example of endemism detected in the coastal forests of Tanzania. Formerly classified as extinct in 1998 (Lovett et al. 2006), it was rediscovered in 2001 and confirmed in

May 2011 in the Namatimbili forest in Kilwa, in the Lindi region of Southern Tanzania (Clarke et al. 2011).

The objectives of this research were (i) to determine the species richness and diversity of NSFR. (ii) Determination of NSFR vegetation structure in basal area and stem density. (iii) Assess the intensity and distribution of human activities within the NSFR. (iv) Assess land cover change in the NSFR over the past 20 years.

MATERIALS AND METHODS

Description of the study area

This study was conducted in the Ngarama Southern Forest Reserve (NSFR), located in the Kilwa District of the Lindi region of Southeastern Tanzania (Figure 1). The forest reserve was established with the Government Notice n. 300 of 12/09/1955. It is located between latitudes 9°3'S-9°33'S and 39°23'E-39°26'E with an area of 2,070 hectares (Prins and Clarke 2006; Howell et al. 2012). It borders the village of Kiranjeranje on the northeast side and the village of Makangaga on the southwest side (Burgess et al. 2011). The inhabitants of these villages belong to the Ngindo, Matumbi, Mwera, and immigrants like Sukuma and Nyasa. Most villagers are farmers who own plots of land ranging from two to five acres. The size of their families varies, with an average of six to seven members per family or even more. They mainly grow subsistence crops such as maize, coconut, sorghum, pigeon peas, and beans (Perkin et al. 2008b).

Kilwa District has a coastal, hot, and humid climate with an average temperature between 22°C and 30°C. Humidity is high, nearly 98-100%, during long rains (Dickinson et al. 2010). The district receives a total rainfall of 800-1400 mm yr^{-1}, and its distribution varies by location. The period of precipitation coincides with the start of each monsoon, with the long rains starting from mid-February to April and the short rains from late October to December.

Data collection

Vegetation survey

The field study was conducted in November 2013. A systematic sample design was adopted as it increases the likelihood of including all vegetation types in the forest (Burgess and Muir 1994; Sutherland 2006). Five transects were established from the forest boundary, with the long axis running through the entire forest reserve, guided by a compass and a global positioning system (GPS). The start, endpoints, and textures were geotagged using GPS for mapping purposes.

With a sampling intensity of 0.15%, 40 rectangular test plots were set up along the transects. The distance between the plots in the same transept was 400 m and 1 km from one transept to another (Figure 1B). Rectangular plots were used because they are easy to identify, more accurate in area determination, and more than 10% of species can be recorded than square ones (Sutherland 2006; Jayakumar et al. 2011). This type of plot is also compared to previous studies in this forest. Therefore, three-level test plots (nested plots) adopted by Kibet (2011) and Howell et al. (2012) were used, including plots of 20 m x 40 m (0.08 ha) for woody plant species with a diameter of 10 cm, 10 m x 20 m (0.02 ha parcels) nested in 0.08 ha parcels for plants with a diameter of 10> DBH ≥ 5 cm and 1 m x 2 m (0.002 ha parcels) nested in parcels of 0.02 ha for regenerants and all trees/shrubs with 5> DBH ≥ 1 (Figure 2).

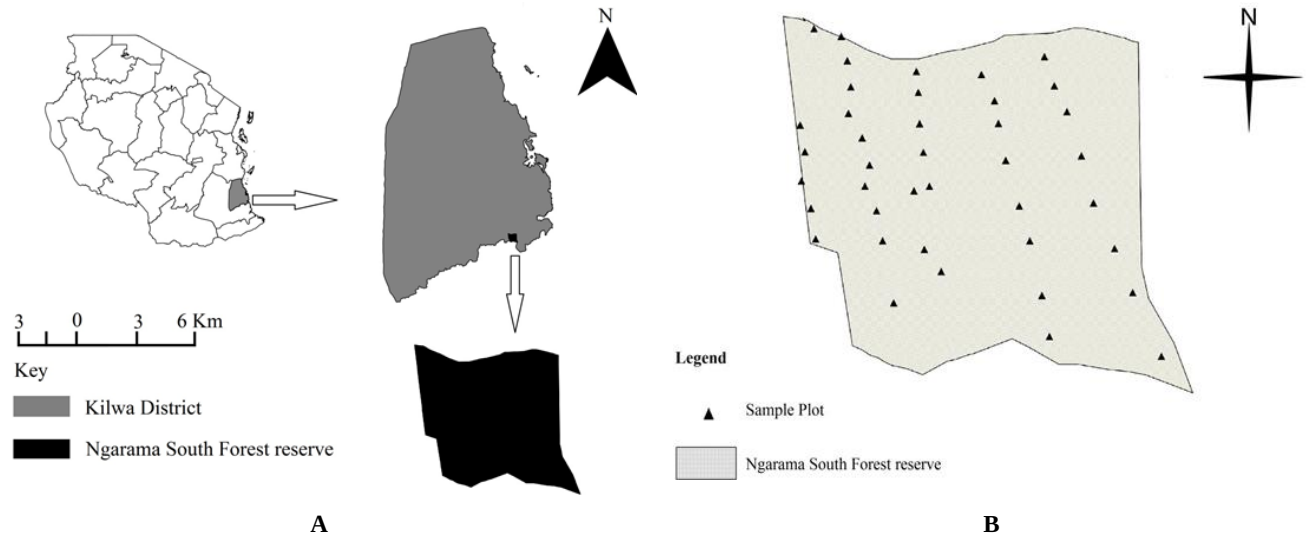

Figure 1. A. Map of Kilwa District showing the location of Ngarama Southern Forest Reserve (NSFR) in Tanzania. B. Sketch map of NSFR showing the distribution of the sample plots

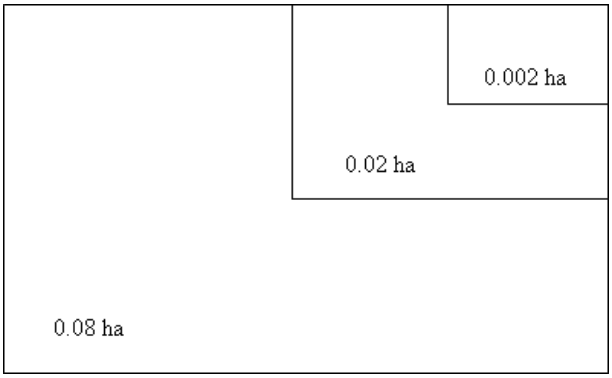

Figure 2. Three-level rectangular sample plots (nested plot) used in this study

The information recorded from each sample plot included: the name of all trees/shrubs measured (local and scientific names), diameter at breast height (DBH) for trees/shrubs 5 cm in diameter and above, and the height of selected sample trees (small, medium, large) and location of property based on GPS measurements. In addition, trees and shrubs were identified in the field to the species level. For those difficult to identify in the field, samples were collected and identified by a botanist from the Tanzania Forestry Research Institute (TAFORI) in Morogoro. The assistant researcher, who was local and knowledgeable in plant identification, provided local names.

Intensity and distribution of human disturbance

The intensity and distribution of human disturbance were recorded, according to Doggart (2006). The degree of disturbance was assessed based on the number of accidents within a test plot of 0.08 ha. In this study, felled trees and poles were described as "old felled" if there was any sign of blackening the stump and as "just felled" otherwise. All strains were measured by strain diameter and identified to the species level. Other indicators of human disturbance considered were areas highlighted by the presence of burned trees and ground vegetation. These areas were called "fire damage ."Another type of disturbance was areas cleared for pit sawing operations, with a pit sawing platform in the area or remnants of such parts. These areas were called "Pitsaw ."Sawn lumber, sawn planks, or poles that lay on the ground ready for transport have been described as "wood/planks/poles."Animal traps of any kind, whether adjustable or spring-loaded, were called "trapping ."Evidence of agriculture (past or present) has been referred to as "development," all paths used by humans as "trails" and, as a result of human intervention, well-established clearings in the forest (mostly short grasslands, possibly older stands) have been referred to as "cleansing". Once found in each plot, those types of ailments were recorded and counted.

Land cover changes in Ngarama Southern Forest Reserve

Mapping was done using forest cover images available on the Internet (Table 1). The objective was to obtain the current images taken during the dry season (June-October) and with minimal cloud cover. Therefore, three images from 1995, 2000, and 2011 were used to achieve the purpose of the study. Current images, i. H beyond 2011, however, was not available.

In addition, ground-truthing was performed to verify and modify land cover during preliminary imagery interpretation. GPS was used to locate samples of land cover observations, while digital cameras recorded photos of features such as water bodies, infrastructure, habitats, and forest use. All scanned GPS points were recorded as waypoints on reservation paper and numbered with a photo. Information is used to increase the accuracy of the satellite imagery interpretation and mapping process. Local people have also been involved with the team to provide information on boundaries, land cover history, and land use, particularly over the past 20 years. Drilling was performed during the dry season (November 2013) to access all areas that may be inaccessible during the rainy season.

Data analysis

Vegetation survey data

The following measurements were analyzed using the Microsoft Excel program and Biodiversity R software for statistical and quantitative analysis. First, species composition was expressed by species richness, diversity, and importance value index (IVI). Second, forest density was expressed by mean tree diameter, mean tree height, mean trunk density, and basal area for all trees with the following diameter classes (5 DBH <20 cm, 20 cm ≤ DBH <50 cm, and ≥ 50 cm). Third, IVI's were calculated as the mean of the relative basal area, density, and frequency (Malimbwi 2009; Tavankar and Bonyad 2015). Ecologically, the density and frequency of a species measure the distribution of a species within the population, while the basal area measures the area occupied by tree stems.

Table 1. Landsat images used in the analysis of land cover changes of NSFR

Image	Path/row	Acquisition date	Season	% Cloud
LANDSAT 5	165 / 067	02-June-1995	Dry	0
LANDSAT 7	165 / 067	22-June-2000	Dry	0
LANDSAT 5	165 / 067	17-Aug-2011	Dry	0

Species diversity was calculated using the Shannon-Wiener and Simpson diversity indices. The Shannon-Wiener diversity index was calculated as (H' = SPi*ln Pi), where H' is the diversity index and Pi is the importance value of a species relative to all species. Simpson's diversity index was calculated as C = SP2i, where C is the index number and Pi is defined above (Sutherland 2006; Rands et al. 2010). Knowledge of species diversity is useful in determining the influence of the biotic disturbance and the state of succession and stability in the environment. This biodiversity index increases with the number of species in the community (Armstrong et al. 2011). In addition, data on human disorders were organized using Microsoft Excel software using simple descriptive statistics, listed, tabulated, and ordered by their number of occurrences.

Land cover change in Ngarama Southern Forest Reserve

Methods for image analysis combined both visual and digital image processing (ILWIS 2001). Before image processing, image layers/bands were rectified, georeferenced, and enhanced using the GPS reading obtained from the field. Then the image layers/bands were stretched and filtered. All image processing and subsequent image analysis using Quantum GIS Desktop (1.8.0) and ILWIS Academic software Version 3.3. Often, image files contain areas much larger than a particular study area. Therefore, the image file was reduced to include only the area of interest (AOI). This eliminates the extraneous data in the file and speeds up processing due to the smaller amount of data to process (ILWIS 2001; Kashaigili et al. 2006).

The supervised classification process involved selecting training sites on the image, which represented specific land classes to be mapped. Training sites are sites of pixels that represent specific land classes to be mapped (Kashaigili and Majaliwa 2010). They are pixels representing what we're recognized as a potential land cover class during ground-truthing. The training sites were generated by on-screen digitizing selected areas for each land cover class identified on color composite. Training is an iterative process; basically, it is a visual tool that gives an overview of where the classes will be assigned in the image and whether additional classes are required (Kashaigili and Majaliwa 2010).

Training samples were refined until satisfactory results were obtained based on the inspection of results. The objective was to produce thematic classes that resemble or can be related to actual land cover types on the earth's surface. The advantage of digital image classification is that it can provide efficient, consistent, and repeatable routines for mapping large areas (Kashaigili and Majaliwa 2010). Classified images were recorded to respective classes (i.e., forest, woodland, and grassland). Following the recording, images were filtered using a 3 x 3 majority-neighborhood filter to eliminate patches smaller than a specified value and replace them with the most common value among the neighboring pixels. A mosaic operation was performed on multiple classified images to produce one map for the entire study area. Change detection is a very common and powerful application of satellite-based remote sensing. Change detection analysis entails findings on the type, amount, and location of land-use changes that are taking place (Kashaigili and Majaliwa 2010). This study used a post classification comparison method to assess land use and cover changes. The advantage of post-classification comparison is that it bypasses the difficulties associated with analyzing images acquired at different times of the year and by different sensors (Kashaigili et al. 2006). The method is the most suitable for detecting land cover changes as this enables estimation of the amount, location, and nature of change. The estimation for the rate of change for the different covers was computed based on the following formulae.

Percentage Cover change $= \frac{\text{Area}_{i\ \text{year}\ x} - \text{Area}_{i\ \text{year}\ x+1}}{\sum_{i=1}^{n} \text{Area}_{i\ \text{year}\ x}} \text{ x } 100\%.$

The annual rate of change $= \frac{\text{Area}_{i\ \text{year}\ x} - \text{Area}_{i\ \text{year}\ x+1}}{t_{\text{years}}}$

Percentage Annual rate of change $= \frac{\text{Area}_{i\ \text{year}\ x} - \text{Area}_{i\text{year}x+1}}{\text{Area}_{i\ \text{year}\ x} x t_{\text{years}}} \text{x} 100\%.$

Where;

Area $_{i\ year\ x}$ = area of cover i at the first date.

The area $_{i\ year\ x+1}$ = area of cover i at the second date.

$\sum_{i=1}^{n} \text{Area}_{i\ \text{year}\ x}$ = total cover area at the first date.

$t_{\ years}$ = years between the first and second scene acquisition dates.

RESULTS AND DISCUSSION

Species richness

This study identified 126 plant species with 79 tree species and 47 shrub species from 34 families in the NSFR (Tables 2, 3). Trees contributed 63% (28 families), and shrubs 37% (17 families). Plant species of the Fabaceae family contributed the most (26%) to the total number of species, followed by those of the Combretaceae (9%), Euphorbiaceae (8%), Rubiaceae (6%), and the Tiliaceae (5%) families. The families with the highest number of tree species in descending order were Fabaceae (27), followed by Euphorbiaceae (6), Combretaceae (6), and Malvaceae (4). Among shrub species, the most dominant families were Tiliaceae (6), Fabaceae (6), Rubiaceae (6), Combretaceae (5), and Euphorbiaceae (4) (data not shown).

The species accumulation curve (Figure 3) shows that the graph increases at a high rate, and as the number of plots increases, the increase becomes smaller and smaller. At 40 plots, the graph has not yet reached its asymptotic level but is beginning to converge, implying that any further increase in sample size should include other rare species.

Table 2. Average stem density (stem ha^{-1}) of tree and shrub species recorded in NSFR

Trees species	Density (Stem/ha)
Hymenocardia ulmoides Oliv	58
Spirostachys africana Sond	53
Markhamia lutea (Benth.) K. Schum	33
Isoberlinia globiflora (Benth.) Hutch. ex Greenway	32
Pseudolachnostylis maprouneifolia Pax	24
Combretum molle (Klotzsch) Engl. & Diels	24
Terminalia mollis M. A. Lawson	20
Crossopteryx febrifuga (Afzel. ex G. Don) Benth.	18
Diplorhynchus mossambicensis Benth. ex Oliv.	16
Pteleopsis myrtifolia (M. A. Lawson) Engl. & Diels	16
Combretum collinum Fresen	15
Brachystegia boehmii Taub	12
Dalbergia melanoxylon Guill. & Perr	10
Hymenocardia mollis Pax	10
Tamarindus indica L	9
Lannea stuhlmannii (Engl.) Engl	9
Acacia robusta Burch	8
Stereospermum kunthianum Cham	8
Terminalia sambesiaca Engl. & Diels	8
Combretum zeyheri Sond	8
Acacia nigrescens Oliv.	7
Carpodiptera africana Mast	7
Ochna holstii Engl	7
Bridelia cathartica Bertol	7
Xeroderris stuhlmannii (Taub.) Mendonça & E. C. Sousa	5
Lonchocarpus capassa Rolfe	5
Diospyros kirkii Hiern	4
Albizia harveyi E. Fourn.	4
Oxystigma msoo Harms	4
Diospyros mespiliformis Hochst. ex A. DC.	4
Commiphora eminii Engl.	4
Bombax rhodognaphalon K. Schum	4
Lonchocarpus eriocalyx Harms	3
Afzelia quanzensis Welw.	3
Dombeya acutangula Cav	3
Cylicomorpha parviflora Urb.	3
Erythroxylum emarginatum Thonn.	3
Lecaniodiscus fraxinifolius Baker	2
Dobera loranthifolia (Warb.) Harms	2
Lonchocarpus bussei Harms	2
Balanites aegyptiaca (L.) Delile	2
Diospyros abyssinica (Hiern) F. White	2
Terminalia sericea Burch. ex DC.	2
Julbernardia globiflora (Benth.) Troupin	2
Dalbergia nitidula Baker	2
Deinbollia borbonica f. glabrata Radlk.	2
Dombeya rotundifolia (Hochst.) Planch	2
Euphorbia candelabrum Trémaux ex Kotschy	1
Pterocarpus rotundifolius (Sond.) Druce	1
Dalbergia boehmii Taub	1
Boscia salicifolia Oliv	1
Ehretia silvatica Gürke	1
Sclerocarya birrea (A. Rich.) Hochst.	1
Pterocarpus chrysothrix Taub	1
Haplocoelum inoploeum Radlk	1
Albizia lebbeck (L.) Benth	1
Acacia goetzei Harms	1
Sterculia quinqueloba (Garcke) K. Schum	1
Ricinodendron gracilius Mildbr	1
Schrebera alata (Hochst.) Welw	1
Adansonia digitata L	1
Pterocarpus angolensis DC.	1
Cassine aethiopica Thunb	1
Markhamia obtusifolia (Baker) Sprague	1
Lannea fulva (Engl.) Engl.	1
Piliostigma thonningii (Schumach.) Milne-Redh	1
Milicia excelsa (Welw.) C.C. Berg	1
Shrubs species	
Strychnos spinosa Lam.	22
Diospyros kabuyeana F. White	13
Grewia bicolor Juss	11
*Commiphora africana (*A. Rich.) Engl	11
Combretum adenogonium Steud. ex A. Rich	9
Bauhinia petersiana Bolle	7
Dichrostachys cinerea (L.) Wight & Arn	7
Catunaregam spinosa (Thunb.) Tirveng	6
Millettia dura Dunn	5
Allophylus rubifolius (Hochst. ex A. Rich.) Engl	5
Uvaria welwitschii (Hiern) Engl. & Diels	5
Ehretia stuhlmannii Gürke	5
Canthium oligocarpum Hiern	4
Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don	3
Ehretia amoena Klotzsch	3
Grewia platyclada K. Schum	3
Spermacoce assurgens Ruiz & Pav.	3
Acacia hockii De Wild	3
Grewia similis K. Schum	2
Ptaeroxylon obliquum (Thunb.) Radlk	2
Manilkara mochisia (Baker) Dubard	2
Maytenus lancifolia (Thonn.) Loes.	2
Lannea humilis (Oliv.) Engl.	2
Strychnos innocua Delile	2
Margaritaria discoidea (Baill.) G.L. Webster	2
Diospyros fischeri Gürke	1
Ziziphus mucronata Willd.	1
Rytigynia uhligii (K. Schum. & K. Krause) Verdc	1
Antidesma venosum E. Mey. ex Tul.	1
Combretum schumannii Engl	1
Grewia holstii Burret	1
Suregada zanzibariensis Baill	1
Combretum padoides Engl. & Diels	1
Grewia trichocarpa Hochst. ex A. Rich	1
Zanthoxylum chalybeum Engl	1
Sericanthe odoratissima (K. Schum.) Robbr	1
Erythrococca kirkii (Müll. Arg.) Prain	1
Grewia monticola Sond	1
Rotheca myricoides (Hochst.) Steane & Mabb	1

Table 3. Richness, diversity, and stem density of woody plant species in NSFR

Parameter	Values
Sample size (n)	40
Richness (total number of species)	126
Mean tree height (m)	8.7
Mean tree diameter (cm)	13.1
Mean stem density (stems ha^{-1})	667±19
Basal area (m^2 ha^{-1})	12.78±0.34
Shannon's index	3.95
Simpson's index	0.03

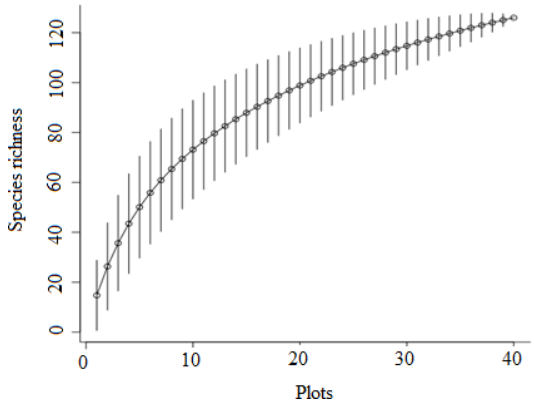

Figure 3. Species accumulation curve of trees/shrubs sampled in NSFR

Species diversity

Species diversity according to the Shannon-Wiener and Simpson indices in the NSFR is shown in Table 3 and Figure 4. Species that contributed to the high species diversity according to the Shannon-Wiener index included *Spirostachys africana* (0.185), *Pseudolachnostylis maprouneifolia* (0.163), *Isoberlinia globiflora* (0.162), *Crossopteryx febrifuga* (0.151) and *Terminalia mollis* (0.150). In terms of frequency of occurrence of individual trees and shrubs, *Hymenocardia ulmoides* was the most common species, with 9% of the 126 species, followed by *S. africana* (8%), *Markhamia lutea* (5%), and *I. globiflora* (5%).). According to the IVI, *S. africana* (2.78) was the most dominant species, followed by *P. maprouneifolia* (2.28), *I. globiflora* (2.25), *C. febrifuga* (2.02), *T. mollis* (2) and *Combretum molle* (1.47). *Brachystegia spiciformis* and *Diospyros squarrosa* were the least important species because they had a small IVI (Figure 4).

Vegetation structure

The average stem density in the NSFR was 667 ± 19 stems ha^{-1}, with the stem density for shrubs being 165 ± 8 stems ha^{-1} and the stem density for trees being 503 ± 11 stems ha^{-1} (Tables 2 and 3). Among trees, the most common tree species was *H. ulmoides* (11% of 503 stems ha^{-1}), followed by *S. africana* (11%), *Pteleopsis myrtifolia* (10%), *M. lutea* (7%), *I. globiflora* (6%) and *P. maprouneifolia* (5%). Among shrubs, the most abundant shrub species were *Strychnos spinosa* (13% of 165 stems ha^{-1}), followed by *Diospyros kabuyeana* (8%), *Grewia bicolor* (7%), and *Commiphora africana* (6%). The stem density of trees/shrubs with a diameter of 5-20 cm was 565 ± 18 stems ha^{-1}, while those with a diameter of 20-50 cm were 99 ± 3 stems-ha^{-1}, and those with a diameter > 50 cm 3 ± 0 were strain ha^{-1} (Figure 5).

The total basal area of the NSFR was 12.78 ± 0.34 m² ha^{-1}, the basal area of shrubs was 2.7 ± 0.21 m² ha^{-1}, and that of trees was 10.4 ± 0.18 m² ha^{-1} (Table 3, Figure 6). *S. spinosa* (26%), followed by *C. africana* (11%), *G. bicolor* (5%), and *Spermacoce assurgens* (4%) were the shrub species that contributed the most to the footprint. The species that contributed most to the basal area for tree species were *S. africana* (8%), *I. globiflora* (6%), *Dalbergia melanoxylon* (6%), *P. maprouneifolia* (5%) and *H. ulmoides* (4%). The base area of trees/shrubs with a diameter of 5-20 cm was 5.3 ± 0.15 m² ha^{-1}, while those with a diameter of 20-50 cm were 6.1 ± 0.17 m² ha^{-1} and those with a diameter> 50 cm 1.7 ± 0.23 m² ha^{-1} (Figure 6).

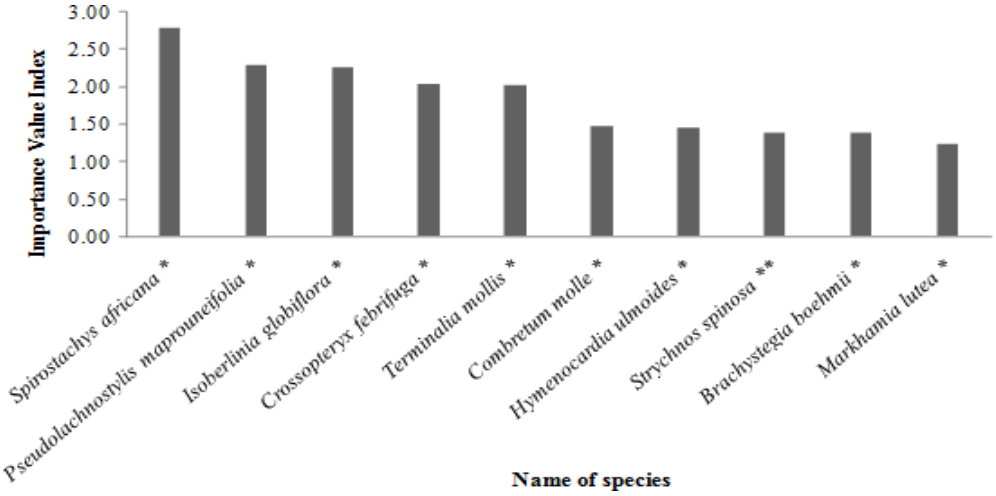

Figure 4. Species diversity according to Importance Value Index (IVI) in NSFR. ** = shrubs and * = trees)

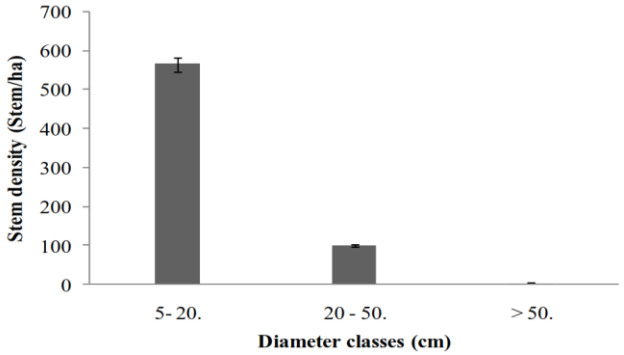

Figure 5. Stem density of woody plant species in NSFR, Tanzania

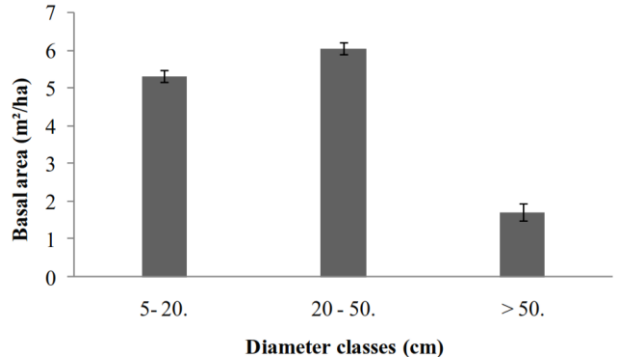

Figure 6. Basal area of woody plant species in NSFR, Tanzania

Intensity and distribution of human disturbance

The number of strains recorded in the NSFR was 23, corresponding to 7 ± 3 strains ha^{-1}, with an average footprint of 0.24 ± 0.09 m^2 ha^{-1} (Figure 7). New sections were 78%, and 22% were old sections. In terms of frequency, *S. africana* seems to be harvested most frequently, accounting for 56% of all strains, followed by *Allophylus rubifolius* (17%), *Grewia platyclada* (09%), *D. melanoxylon* (09%) and the rest (09%). *Terminalia sambesiaca* and *Carpodiptera africana*. All other forms of anthropogenic disturbance in the sample plots were observed in this study, with 51% being fire damage, 13% being paths or roads, 8% being hole saws, 8% being wood/planks/piles, and 5% being trapping sites, 5% was cultivation and 8% deforestation (Figure 8).

Land cover change in Ngarama Southern Forest Reserve

Land cover maps for 1995, 2000, and 2011 are shown in Figure 9. The figure shows the variation in forest cover between the three periods considered. The coverage of each land cover/use class in 1995, 2000, and 2011, including area and percent change in the area between the three periods for the NSFR, is shown in Tables 4 and 5. 1995 to 2000, forest and forest cover classes increased by +15.9 ha yr^{-1} (+1% yr^{-1}) and +12.6 ha yr^{-1} (+3% yr^{-1}), respectively, while grass cover decreased at a rate of -28.5 ha yr^{-1} (-7% yr^{-1}). From 2000 to 2011, the area of grassland and forest increased at a rate of +32.1 ha yr^{-1} (+13% yr^{-1}) and +43.2 ha yr^{-1} (+8% yr^{-1}), respectively, while forest area increased and decreased at a rate of -75.4 ha yr^{-1} (-4% yr^{-1}). In general, the NSFR experienced notable changes in land cover during the years 1995-2000 and 2000-2011, during which forest cover areas were severely degraded from 68% (1995) to 39% (2011), and forest and grass cover was noted. continuously increased from 15% or 17% (1995) to 23% or 38% (2011).

Discussion

Floristic composition

Defining an optimal sample size is based on the idea that the larger the sample size, the larger the number of species in the sample, but the rate of increase becomes smaller and smaller, so the curve tends to be a flat line (Rands et al. 2010). The point at which the curve becomes horizontal is the minimum area representing the plant community (Sutherland 2006). This concept assumes that the plant community is a spatially discrete entity with a fixed species composition. It is particularly difficult to identify community boundaries in tropical forests, and due to their high species richness, species accumulation curves do not flatten even with large samples (Sutherland 2006; Rands et al. 2010). Thus, the species accumulation curve shows that at 40 plots, the graph has not yet reached its asymptotic level, but it is beginning to converge. This implies that 40 sites/plots used in this study were sufficient to cover much of the variation and species diversity of the study area. Any further increase in sample size would likely result in the inclusion of additional rare species.

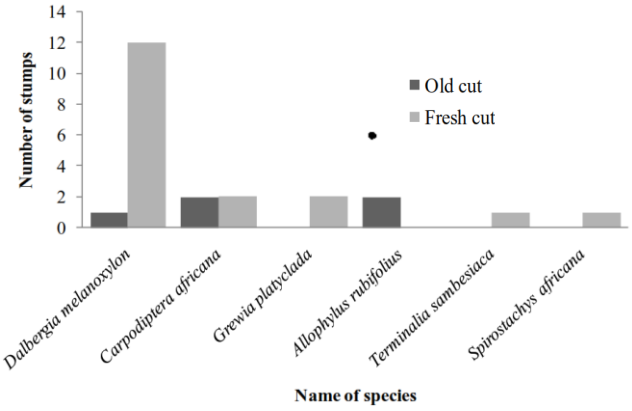

Figure 7. Quantity of old cut and fresh-cut stumps recorded in NSFR

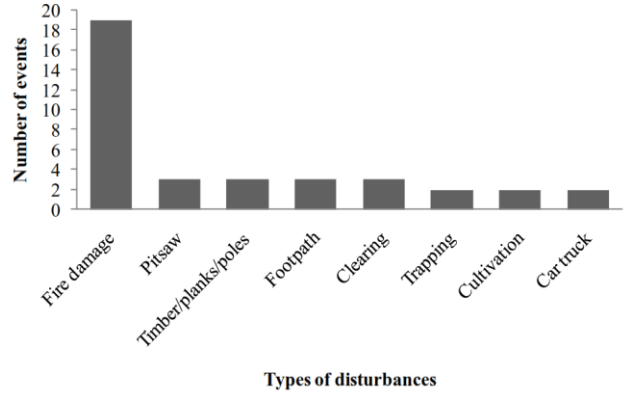

Figure 8. Types of disturbance observed in NSFR

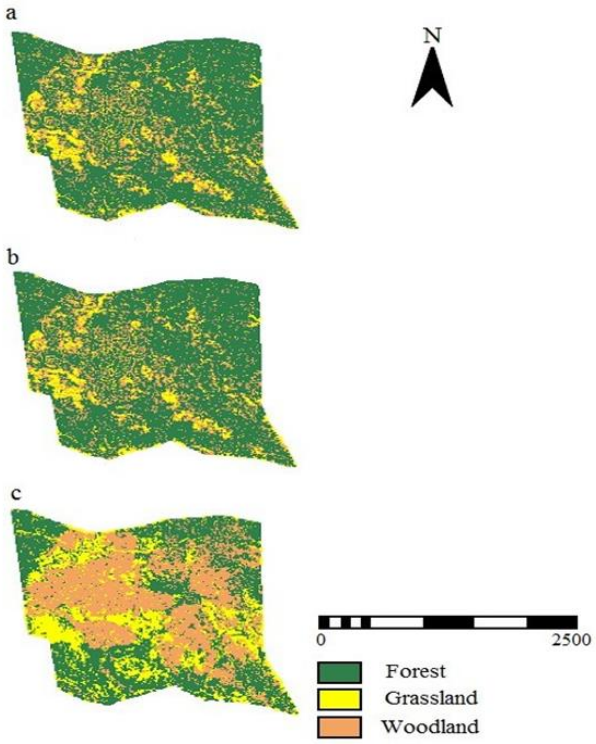

Figure 9. Classified land cover map of (a) 1995, (b) 2000, and (c) 2011 of NSFR

The species composition found in the NSFR, based on the predominance of species of the Euphorbiaceae and Fabaceae families, agrees well with previous descriptions of coastal forests belonging to the mixed scrub type of the coastal forest community. Characterized by the rare dominance of a species and with the most common species such as *H. ulmoides*, *P. myrtifolia*, *Bombax rhodognaphalon*, *Afzelia quanzensis*, and genera such as *Albizia*, *Combretum*, *Diospyros*, *Grewia*, and *Strychnos* found well in the forest composition of NSFR and Clarke Burgess (Burgess et al. 2003, 2011; Godoy et al. 2011). The high species richness in the study area is probably attributed to the presence of riparian forests along the Mbwemkulu River, which contributes to the growth of many species (Burgess et al. 2003). The Shannon-Wiener (H') diversity index indicates species richness and evenness, where the higher the H' value, the greater the species diversity and vice versa (Rands et al. 2010). An ecosystem with an H' value greater than 2 is considered species-rich (Rands et al. 2010). Thus, with a Shannon-Wiener diversity index (H') of 3.95, NSFR exhibits high species diversity. Munishi et al. (2011) reported that the higher the Simpson's Index value, the lower the species diversity and vice versa, from 0 to 1. The Simpson's Index value of 0.03 (Table 3) in the NSFR implies that the probability of selecting two individuals belonging to the same species is very low or the probability that a species encountered by chance is a different species (Prins and Clarke 2006; Dickinson et al. 2010). So having that index shows that the plant species found in NSFR are more equally diverse.

Forest structure

Forest structure usually refers to tree characteristics distributed within a forest ecosystem (Sutherland 2006; Rands et al. 2010). The forest structure results from natural processes, such as growth, mortality, recruitment of plant species, and natural disturbances, such as damage from fire, wind, or snow (Godoy et al. 2011). However, the state of most coastal forest ecosystems today is the result of human interventions such as clearcutting, deforestation, and fire damage, which often results in altered ecosystems with novel species compositions and structures (Burgess et al. 2011; Godoy et al. 2011). Characterized by various structural characteristics such as low trunk density, small basal area, low average shaft height, and small average shaft diameter. To explain this, Burgess and Clarke (2000) described some forests affected by a range of human ailments, the most common of which in terms of the affected area were fire damage, pile-up, logging, and burning of the coal (Table 6).

Table 4. Cover area, changing area, and the rate of change between 1995 and 2000

Cover class	1995		2000		Change area (ha)	% Change	Annual rate of change (ha yr^{-1})	% Annual rate of change (% yr^{-1})
	Cover area (ha)	% Cover coverage	Cover area (ha)	% Cover coverage				
Forest	1,770.84	68%	1,850.31	71%	79.47	3%	15.894	1%
Grassland	380.61	15%	238.32	9%	-142.29	-5%	-28.458	-7%
Woodland	453.96	17%	516.78	20%	62.82	2%	12.564	3%
	2,605.41	100%	2,605.41	100%				

Table 5. Cover area, changing area, and the rate of change between 2000 and 2011

Cover class	2000		2011		Change area (ha)	% Change	Annual rate of change (ha yr^{-1})	% Annual rate of change (% yr^{-1})
	Cover area (ha)	% Cover coverage	Cover area (ha)	% Cover coverage				
Forest	1,850.31	71%	1,021.41	39%	-828.9	-32%	-75.35	-4%
Grassland	238.32	9%	591.66	23%	353.34	14%	32.12	13%
Woodland	516.78	20%	992.34	38%	475.56	18%	43.23	8%
	2,605.41	100%	2,605.41	100%				

Table 6. Structural parameters of the forest sites with a known history of disturbance

Site	Plot area (ha)	Sample size (n)	Mean tree height (m)	Mean tree DBH (m)	Mean stem density (trees/ha)	Stem density/ha by DBH class		Basal area (m^2/ha)	
						10 - 20 (cm)	20 - 50 (cm)	> 50 (cm)	
Gendagenda B*	0.03	15	14	0.277	500	267	200	33	30.1
Namakutwa 1*	0.16	88	15.2	0.226	550	331	181	38	22
Kazimzumbwi 4*	0.025	11	13.5	0.248	440	280	80	80	21.3
Kazimzumbwi 2*	0.075	40	9.9	0.204	533	373	133	27	16.4
Kazimzumbwi 3*	0.25	148	11.4	0.169	592	444	144	4	13.3
Namakutwa 2*	0.16	95	12.7	0.162	594	456	138	0	12.2
Ruvu North*	0.16	47	14.1	0.222	294	70	212	12	11.4
Litipo 1*	0.16	49	14.6	0.21	306	156	125	25	10.7
Kilulu C*	0.03	13	10.1	0.173	433	300	133	0	10.2
Litipo 2*	0.16	62	12.1	0.178	387	244	143	0	9.7
Rondo Plantation*	0.16	48	13.4	0.189	300	238	50	12	8.4
Kazimzumbwi 1*	0.25	93	9.9	0.167	372	300	24	48	8.2
Namburika Hill*	0.16	22	12.3	0.259	138	68	56	12	7.3
Gendagenda C*	0.03	10	10.3	0.16	333	267	67	0	6.6
NSFR**	0.08	40	8.7	0.131	667	565	99	3	13.1

Note: * Adopted from Burgess and Clarke (2000); **This study, 2013

To varying degrees, all forests affected by anthropogenic disturbance appeared to have a consistently significant impact on the forest structure of many coastal forest areas, such as relatively low trunk density and low average tree height and diameter. It is clear that anthropogenic disturbance causes a disturbance to the forest structure and changes the community composition of the forest (Godoy et al. 2011; Kibet 2011; Munishi et al. 2011). Based on the forest structure, the results in NSFR (Table 6 and Figure 6) with a significant number of strains and number of events from other forms of anthropogenic disturbance (Figures 7 and 8). This indicates that the large human disturbance is likely to affect the vegetation structure of NSFR and these disturbances remain detectable in the resulting forest physiognomy of NSFR.

Besides the relatively low trunk density, basal area, and few large-diameter trees, likely due to human encroachment, the trunk density distribution still reflects an inverted J shape common to natural forests with regeneration and active recruitment (Munishi et al. 2011). Accordingly, active regeneration and recruitment in the NSFR coastal forest, as presented in this study, bodes well for the sustainability of the forest stand, which is only likely to provide a sustainable supply of products and services if not subject to greater anthropogenic disturbance (Ahrends 2005; Dickinson et al. 2010; Giliba et al. 2011).

Forest condition

The results for the cover classes over an average period of 5 years (i.e., 1995 and 2000) (Tables 4, 5) show that two classes of forest and wooded cover at a rate of +15.9 ha yr^{-1} (+1% yr^{-1}) and +12.6 ha yr^{-1} (+3% yr^{-1}), with grass cover decreasing at the rate of -28.5 ha yr^{-1} (-7% yr^{-1}). It is possible that the increase in forest cover is due to a reduction in forest disturbance due to poor infrastructure before the opening of the Mkapa Bridge over the Rufiji River in 2003 (Burgess and Clarke 2000). Furthermore, the limited technical capacity and a small population in the villages surrounding the study area had little impact on the forest and, therefore, a much lower impact on the condition of the forest reserve compared to other factors such as elephant damage and climate change impacts (Howell and Msuya 2002; Perkin et al. 2008b). The effects were also noted by Howell et al. (2012) described in their study when they found that the increase in forest cover was due to earlier exploration of gypsum mining activities in Makangaga village. Where mining machinery in the area destroyed vegetation by removing underground rock deposits in the southern part of the NSFR and nearby areas (Howell and Msuya, 2002). Fire is a major threat to coastal forests, including NSFR, as shown in Figure 8. Although forests are generally tolerant to low-temperature fires, most forest species are sensitive to and easily destroyed by fire (Maliondo et al. 2000; Howell et al. 2012). The fire intrusion opens the forest to widespread forest species, reducing habitats and their biodiversity values, both in terms of species diversity and strongly impacting species with restricted distribution patterns (Edwin 2004; Munishi et al. 2011). This may be the reason for the increase in forest cover, as shown in Table 4.

From 2000 to 2011 (Table 4), grassland and forest areas increased respectively by +32.1 ha yr^{-1} (+13% yr^{-1}) and +43.2 ha yr^{-1} (+8% $year^{-1}$), at Forest cover decreased at a rate of -75.4 ha yr^{-1} (-4% yr^{-1}). This decline in forest cover is attributed to increased forest disturbance after the opening of the Mkapa Bridge and improved infrastructure, which has increased the pressure and risk of forest destruction and overexploitation in southern coastal areas of Tanzania (Ahrends 2005). Howell et al. (2012) and Mhache (2014) also pointed out that rapid population growth has led to strong demand for timber and non-timber products in Dar es Salaam, Zanzibar, Tanga, and the areas around NSFR. This results in a loss of forests due to the direct effects of human activities such as habitat destruction (deforestation), land-use change, invasive species, overexploitation, and indirect effects of human activities such as climate change (Howell et al. 2012). This observation is consistent with the findings of this NSFR

study that fires, sawing, logging, and logging (Figure 8) were activities that likely led to a decrease in forest cover and an increase in forest and meadow cover over the past 20 years in this forest.

Conclusion

The main objectives of this study were to assess the floristic composition, stand, and the impact of anthropogenic activities on the forest condition of the NSFR and to provide data that constitute a basis for the definition of appropriate protection strategies and monitoring in the forest. The NSFR coastal forest was found to have reasonably good tree/shrub composition and species richness. Additionally, the tree/shrub species identified as dominant and high-diversity fit quite well into the general definition of coastal forests, which belong to the mixed scrub forest community. On the other hand, the vegetation structure of NSFR is characterized by relatively low trunk density, low average tree height, low average tree diameter, small basal area, and a lack of large-diameter trees, suggesting that the forest is subject to anthropogenic disturbance and reckless use of the forest as a resource.

Moreover, the anthropogenic disturbance indicators observed in the forest suggest that human disturbances were the main factors affecting the vegetation structure of the forest. The study also showed that the NSFR had experienced notable changes in land cover over the past 20 years (1995-2011). If we compare the two periods (1995-2000 and 2000-2011), in the period 2000-2011, there have been greater variations in the coverage areas. Forest cover is severely affected; in particular, forest and grassland areas have been shown to continuously increase, indicating poor forest performance and the need to improve overall forest resources by controlling human disturbances and avoiding reckless use of forest resource boundaries to protect the integrity of the forest.

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