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MORALITY BEFORE KNOWLEDGE

Composition of species, utilization, and conservation status of plant species in the sugar palm (*Arenga pinnata*) agroforestry system

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ABSTRACT

Background: The goal of agroforestry is to integrate perennial crops, seasonal crops, and livestock to increase income, protect the environment, and support sustainable resource management by maintaining soil fertility, biodiversity, and food security. The agroforestry system's principal components, such as trees, agricultural crops, and livestock, are interdependent to optimize and sustainably utilize resources. This study aims to determine the composition of plant species in sugar palm (*Arenga pinnata*) agroforestry, to identify plant utilization, and to assess the conservation status of plant species within the sugar palm agroforestry system. **Methods**: This study employed a quantitative approach, using survey methods and plant data collection by exploring the research site and observing all plant species present, accompanied by photography using a digital camera. **Findings:** The results indicate that the sugar palm (*Arenga pinnata*) agroforestry system has significant potential in supporting environmental sustainability and community welfare. A total of 31 plant species were identified, with 12 of them having recorded data in the IUCN with a Least Concern category. **Conclusion**: Based on data from the IUCN Red List, 10 identified species are distributed in Sulaw esi Island, including *Pangium edule* Reinw, *Arenga pinnata* (Wurmb) Merr., *Musa acuminata* Colla, *Hellenia speciosa* (J.Koenig) S.R.Dutta, *Macaranga tanarius* (L.) Müll.Arg., *Mimosa pudica* L., *Ficus septica* Burm.f., *Tacca leontopetaloides* (L.) Kuntze, C*eiba pentandra* (L.) Gaertn., and *Ficus minahassae* (de Vriese & Teijsm.) Miq. **Novelty/Originality of this article:** The novelty of this research lies in its comprehensive exploration of plant species composition, utilization, and conservation status within the sugar palm (*Arenga pinnata*) agroforestry system.

KEYWORDS: plant species composition, plant species conservation status, and agroforestry.

1. Introduction

Indonesia is located in a tropical climate, rich in biodiversity. Its balanced rainfall contributes to fertile soil, allowing various plants to grow well. The states that Indonesia is a country with exceptionally high biodiversity. The diversity of plant species with potential as food sources is abundant. These plant species need to be developed and managed properly to meet societal needs and achieve food self-sufficiency in Indonesia.

Indonesia's tropical forests also possess unique characteristics, with vegetation diversity tending to form strata, such as trees, shrubs, herbs, mosses, and others. This occurs due to competition among these plants for full sunlight, enabling their growth to proceed optimally (Hutasuhut, 2018). Forests are ecosystems comprising various plant and animal

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species. The plant communities within a forest ecosystem maintain close relationships with one another and their environment. Forests also serve as habitats and food sources for various fauna residing within them. The population of plants and animals in forests forms interdependent communities closely linked to their surroundings. Thus, forests are regarded as ecological systems or ecosystems highly beneficial to human life. Forests house diverse biodiversity, including both wildlife and plants. The biodiversity of forest resources is not limited to woody plant species but also includes diverse understory vegetation (ground cover/undergrowth), which exhibits high species diversity. These plants constitute the fundamental vegetation beneath the forest canopy, excluding tree saplings. Understory vegetation consists of grasses, herbs, shrubs, and ferns (Destaranti, 2017).

Global warming has emerged as a significant environmental issue in recent years. It occurs due to increasing levels of greenhouse gases (GHG) in the atmosphere, where energy received from sunlight is absorbed as shortwave radiation and reflected into the atmosphere as heat, raising air temperatures (Audi et al., 2020; Mander et al., 2016). This leads to global climate change, which contributes to rising sea levels and increasing surface temperatures (El Saman, 2022; Jia et al., 2022; Parimita & Ulfatun, 2023; Soza & Ayres, 2018). Climate change poses various challenges to the agricultural sector, including rising temperatures, altered rainfall patterns, and extreme events such as droughts and floods. Agroforestry enhances agricultural ecosystem resilience against climate change impacts (Gómez et al., 2022). Tree canopies protect the soil from erosion, reduce water evaporation, and moderate microclimates (Vasconcelos & Sacht, 2012). Additionally, deep-rooted trees improve water infiltration into the soil, mitigating flood risks. Agroforestry not only provides environmental benefits but also enhances farmers' income (Syofiandi et al., 2016). Diversifying agricultural products through the integration of trees and seasonal crops reduces financial risks caused by market price fluctuations. Moreover, agroforestry products such as fruits, timber, and medicinal plants hold high added value and cater to diverse consumer segments. Therefore, agroforestry is not merely an option but a necessity for establishing sustainable and resilient agriculture in the future.

Human activities have also contributed to rising atmospheric carbon dioxide (CO_2) levels through fossil fuel combustion, solid waste disposal, and other emissions (Pressburger et al., 2023; Skrable et al., 2022). The rate at which human activities release CO_2 into the atmosphere far exceeds nature's ability to absorb it. If this trend continues, atmospheric CO_2 levels will keep increasing, exacerbating the impacts of global warming. According to Astuti & Firdaus (2017), the rising concentration of atmospheric pollutants is influenced by increasing numbers of motor vehicles, population growth, and activities leading to forest ecosystem degradation.

One of the factors that can reduce CO_2 accumulation in the atmosphere is its absorption by vegetation. Atmospheric CO_2 is absorbed by trees through photosynthesis (Jauhari et al., 2021; Salamah & Cahyonugroho, 2023). The more CO_2 plants absorb and store as biomass carbon, the better greenhouse gas effects can be controlled (Adiaha et al., 2020). Photosynthesis occurs in chlorophyll-containing leaves, where CO_2 and water, with the aid of sunlight, undergo metabolic processes to form sugars, oxygen, and water. Other activities that help lower CO_2 emissions include forest conservation (Sasaki, 2021; Uttaruk et al., 2024). Forests play a crucial role in carbon sequestration and serve as the largest carbon sink (Wang et al., 2023; Zhu et al., 2023).

Recognizing the potential risks, the Indonesian government has shown serious concern regarding Forestry and Other Land Use (FOLU) carbon absorption. This commitment is demonstrated by Indonesia's written statement on achieving net carbon absorption through the FOLU Net Sink target by 2030. Indonesia's FOLU Net Sink 2030 target aims to achieve a balance between or exceed emissions from the forestry and land-use sectors. This goal underscores the critical role of forests, which contribute up to 60% of CO_2 reduction efforts to achieve net-zero emissions.

FOLU Net Sink 2030 represents a mitigation strategy aimed at reducing greenhouse gas emissions by ensuring that absorption levels surpass emissions by 2030. This policy reflects Indonesia's commitment to reducing greenhouse gas emissions and controlling climate change and its impacts. Carbon sequestration refers to the capacity of vegetation, soil, and other biomass to absorb atmospheric CO_2. The forestry and land-use sectors play a vital role as carbon sinks. Agroforestry systems, which integrate trees with agriculture, hold significant potential for increasing carbon sequestration while preserving biodiversity. The choice of agroforestry species influences the types of plants that can coexist with agricultural crops. Additionally, plant selection impacts the extent of carbon absorption by vegetation.

Agroforestry is a land-use system that integrates trees, crops, and livestock to enhance sustainability and resilience in agricultural practices. This approach not only promotes biodiversity and nutrient cycling but also delivers economic, ecological, and social benefits, making it a crucial strategy for climate adaptation and mitigation (Gassner & Dobie, 2022; Gómez et al., 2022; Raskin & Osborn, 2019). The primary goal of agroforestry is to integrate perennial plants, seasonal crops, and livestock to increase income, protect the environment, and support sustainable resource management by maintaining soil fertility, biodiversity, and food security. Agroforestry systems operate on the principle that tree components, agricultural crops, and livestock are interdependent and optimize resource use sustainably (Astuti et al., 2023; Fikry & Sarjan, 2024). Boalemo Regency is an area with diverse agroforestry types, including sugar palm (*Arenga pinnata*) agroforestry, which holds potential for mitigating global warming by assessing plant composition, utilization, and conservation status.

2. Methods

This study was conducted over approximately three months, from June to September 2024, in the agroforestry area of sugar palm (*Arenga pinnata*) in Boalemo Regency, Gorontalo Province. This research employs a quantitative approach, which involves a specific population or sample, data collection using research instruments, and data analysis of a quantitative or statistical nature to test the established hypotheses. The method used in this study is the survey method (Sugiyono, 2011). The population in this study consists of agroforestry areas within Boalemo Regency. The research sample represents plant species found in the sugar palm (*Arenga pinnata*) agroforestry area in Rumbia Village, Boalemo Regency, Gorontalo Province.

The tools used in this study include a measuring tape for determining transect lengths and plot delineation, flagging tape (colored ribbons/strings) to mark each observation plot, a Garmin e-map GPS receiver to record coordinate points for each transect sample, a magnifying glass (loupe) for identifying the characteristics of understory vegetation, a Canon EOS 550D camera for capturing images in the research location, writing instruments for recording field data, a soil tester for measuring soil pH, a lux meter for measuring light intensity, a hygrometer for measuring humidity and environmental temperature, a basket container for storing collected understory plant samples, plastic bags for storing plant samples to be further analyzed in the Botany Laboratory of Universitas Negeri Gorontalo, and label paper for numbering tree, pole, sapling, and understory plant samples. The materials used in this study include tally sheets for recording tree species, tree height, tree diameter, individual counts, and identification guidebooks.

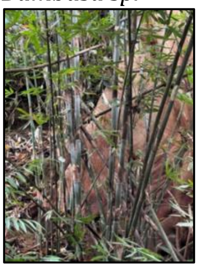
Then, plant data collection was conducted by exploring the study site and observing all plant species present while capturing images using a digital camera. Additional information, such as collector's name, collection number, collection date, location, and habitus, was recorded on prepared observation sheets, referring to the Fieldwork Royal Botanical Garden guidelines. Identification of tall plants was carried out using morphological observation procedures that included distinctive characteristics at the class, family, and genus levels up to the species level, and then compared with the *Flora of Sulawesi* by Pitopang et al. (2008), Harris & Harris (2001), as well as *Flora for Indonesia* (Steenis, 2008).

For fern species identification, morphological features were compared using *Additions to the Fern Flora of Sulawesi. Blumea: Biodiversity, Evolution and Biogeography of Plants* (Hovenkamp & Joncheere, 1988). Validation of accepted names, habitat distribution, and population status for each plant species was conducted using the *Plants of the World Online* database (2024) (https://powo.science.kew.org/). The identification results were then analyzed descriptively and qualitatively, while their conservation status was determined based on the *IUCN Red List* (http://www.iucnredlist.org) (IUCN, 2024). For unidentified plant species, herbarium specimens were prepared by collecting plant parts cleaned of soil, fungi, or any attached foreign materials.

3. Results and Discussion

Arenga pinnata Agroforestry is an agroforestry area dominated by the *Arenga pinnata* plant, which is locally known as aren or enau. The local community utilizes the sap from the fruit of the *Arenga pinnata* plant to produce palm sugar. Based on the exploration results in *Arenga pinnata* agroforestry, 31 plant species were identified, with 26 species, according to POWO Science, having a distribution across major Indonesian islands, including Sumatra, Java, Kalimantan, Sulawesi, and Papua.

Table 1. Description of plant species found in *Arenga pinnata* agroforestry

Plant name	Local name	Family	Morphology	Benefits
Palaquium sp. 	-	*Sapotaceae*	Cylindrical trunk, upright with rough brown surface. Oblong pinnate leaves arranged spirally, often clustered at the tip of branches, mostly bisexual flowers.	The latex is used in various industries, such as electronics, automotive, and medicine. Its wood is useful for construction and paper production.
Strobilanthes sp. 	-	*Acanthaceae*	Stems and branches are usually four-angled, often grooved, with woody and hollow base over time. Opposite, oblong pinnate leaves with a glossy green upper surface.	Used as an ornamental plant, medicinal plant, and animal feed.
Bambusa sp. 	-	*Poaceae*	Small, round, hollow stem with segments, covered with fine hair, green in color. Lanceolate, thin, pointed leaves growing densely on branches.	Small, round, hollow stem with segments, covered with fine hair, green in color. Lanceolate, thin, pointed leaves growing densely on branches.
Pangium edule Reinw. 	Pohon Kluwek	*Achariaceae*	Round trunk with a rough grayish-brown surface. Oval leaves with pointed tips and a smooth dark green surface. Large round fruit with a hard light brown shell.	Round trunk with a rough grayish-brown surface. Oval leaves with pointed tips and a smooth dark green surface. Large round fruit with a hard light brown shell.

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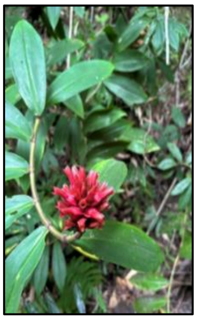
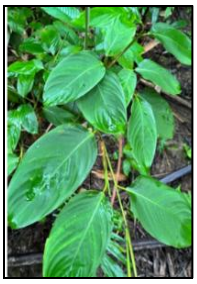
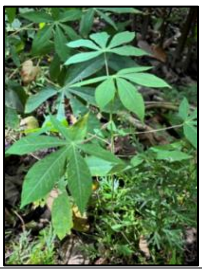
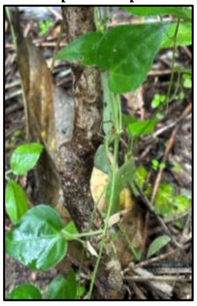
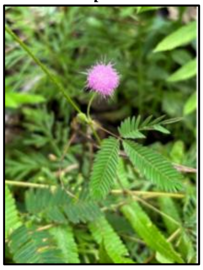
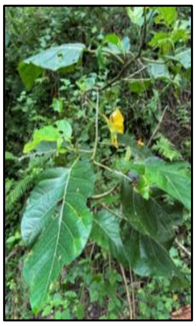
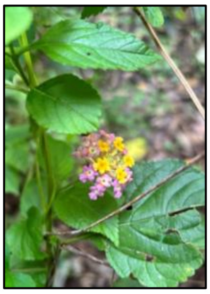
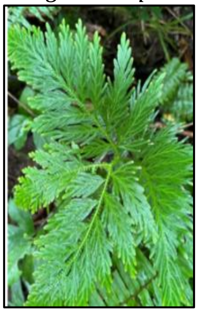
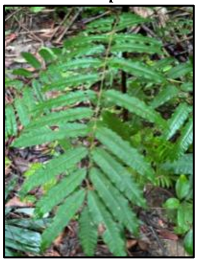
Arenga pinnata (Wurmb) Merr. 	Aren/ Enau	*Arecaceae*	Cylindrical and sturdy trunk, covered by leaf sheaths and black fibrous bases. Compound and long leaves, each leaflet resembling a ribbon with a hard texture. Flowers grow in dense clusters hanging downward.	Cylindrical and sturdy trunk, covered by leaf sheaths and black fibrous bases. Compound and long leaves, each leaflet resembling a ribbon with a hard texture. Flowers grow in dense clusters hanging downward.
Selaginella umbrosa Lem. ex Hieron. 	Cakar ayam	*Selaginellaceae*	Numerous small and soft green branches. Small, densely arranged leaves in a scale-like shape, bright green with pointed tips.	Numerous small and soft green branches. Small, densely arranged leaves in a scale-like shape, bright green with pointed tips.
Theobroma cacao L. 	Pohon cokelat	*Malvaceae*	Woody trunk with grayish-brown rough bark. Oblong leaves with pointed tips and a smooth dark green surface. Oval fruit with a thick, hard shell, green when young, turning yellow or red when ripe.	Woody trunk with grayish-brown rough bark. Oblong leaves with pointed tips and a smooth dark green surface. Oval fruit with a thick, hard shell, green when young, turning yellow or red when ripe.
Livistona chinensis (Jacq.) R.Br. ex Mart. 	Palem kipas	*Arecaceae*	The trunk has scars from old leaf stalks that form a pattern. The leaf sheaths are brown and spread out in a fan-like arrangement. The leaves are shaped like a fan with divided segments. Each leaf is long and has multiple segments fused at the base, forming a shield-like shape when young. The surface of the leaves is smooth and dark green.	Used as an ornamental plant and for ecological purposes. Additionally, its wood is used for construction or handicrafts.
Musa acuminata Colla 	Pisang merah	*Musaceae*	Slender pseudo stems with large patches at the leaf base. Large and broad single leaves with a waxy surface. Seeded fruit, flowers spreading to hanging position.	Slender pseudo stems with large patches at the leaf base. Large and broad single leaves with a waxy surface. Seeded fruit, flowers spreading to hanging position.

Aglaonema sp. 	Sri Rejeki	*Araceae*	Short, fleshy stem. Yellowish-brown leaf sheaths, oblong leaves, glossy green surface. Red, shiny, oval fruit.	Short, fleshy stem. Yellowish-brown leaf sheaths, oblong leaves, glossy green surface. Red, shiny, oval fruit.
Hellenia speciosa (J.Koenig) S.R.Dutta 	Pacing	*Costaceae*	Hard, cylindrical, segmented, light brown stem. Lanceolate leaves with pointed tips and a smooth surface, hairy petioles. Flowers grow in spiral clusters, red with white and yellow-striped centers.	Hard, cylindrical, segmented, light brown stem. Lanceolate leaves with pointed tips and a smooth surface, hairy petioles. Flowers grow in spiral clusters, red with white and yellow-striped centers.
Macaranga tanarius (L.) Müll.Arg. 	Pohon Mara	*Euphorbiaceae*	The trunk is cylindrical, brown at the bottom, and green at the top, with leaf scars on the stem. The leaves are round with pointed tips and prominent veins. The underside of the leaf is often paler than the upper surface.	The wood is used for construction, and some parts of the plant are used in traditional medicine to treat various ailments such as diarrhea, fever, and wounds. The leaves can be used as livestock feed, especially for ruminants.
Donax canniformis (G.Forst.) K.Schum. 	Bemban atau Bamban	*Marantaceae*	The stem is green, erect, segmented, and sympodially branched. It is hard and woody. The leaves are large, oblong, and broad, with a smooth surface.	The fibers from this plant are used as raw materials for weaving. Wood is used in construction, and the rhizome is used in traditional medicine.
Manihot esculenta Crantz 	Ketela pohon	*Euphorbiaceae*	The stem is woody with grayish-brown bark and a rough surface. The leaves are palmate with pointed tips, serrated edges, and a smooth or slightly hairy surface.	A primary source of carbohydrates and food. The leaves can be used as animal feed, especially for ruminants. The flour from its tubers is used as a raw material in various industries.

Tinospora sp. 	-	*Menispermaceae*	The stem has tendrils to help it climb other trees and is green in color. The leaves are stalked, heart-shaped, or shield-like, and dark green with a smooth surface.	It is commonly used as a medicinal plant.
Mimosa pudica L. 	Putri Malu	*Fabaceae*	The stem is creeping and has fine spines. The leaves are compounded, arranged in pairs, and fold quickly when touched or vibrated. The flowers are small, round, and purple or pink in color.	Various parts of the plant, such as leaves, stems, and roots, are used in traditional medicine to treat insomnia, fever, diarrhea, and wounds. The leaves can be used as ruminant feed. It is also used as a green manure and an ornamental plant.
Ficus septica Burm. f. 	Awar-awar	*Moraceae*	The stem is cylindrical, segmented, and has leaves growing at each node. The leaves are simple, ovate with pointed tips, smooth, and dark green.	The wood is used for construction, and the leaves are used as livestock feed. The roots, stems, leaves, and fruits have medicinal properties. The sap is used to treat wounds, ulcers, and snake bites. The leaves can treat skin diseases, appendicitis, and respiratory issues.
Lycopodium digitatum Dill. ex A.Braun 	Lumut Kipas	*Lycopodiaceae*	The stem is creeping and branches out like a pine or fan. The roots grow from the stem and spread across the ground. The leaves are small, scale-like, and green.	This plant plays an important role in ecological succession. Its spores were historically used as an ingredient for making highly flammable powder.
Centrosema pubescens Benth. 	Sentro	*Fabaceae*	The stem is round, slightly hairy, and has tendrils for climbing. The leaves are compound and ovate. The flowers are purple-white and shaped like a butterfly.	Commonly used as animal feed.

Piper sp. 	Sirih-sirihan	*Piperaceae*	The stem is a vine, green in color. The leaves are stalked, heart-shaped, or shield-like, and dark green.	Used as a spice in cooking. It is also used in traditional medicine to aid digestion, reduce inflammation, and relieve pain. It is commonly cultivated as an ornamental plant. Additionally, it can be used as a natural dye and raw material in the industry.
Diplopterygium glaucum (Thunb. ex Houtt.) NakaI 	-	*Gleicheniaceae*	The stem is creeping and covered with brown scales. The leaves are pinnate, alternate, and lanceolate.	Used as an ornamental plant and has potential medicinal properties.
Gmelina arborea Roxb. ex Sm. 	Jabon putih	*Lamiaceae*	The trunk is cylindrical and grows upright with scaly bark. The leaves are compound-pinnate, oval-shaped, dark green on the upper surface, and lighter on the underside.	The wood is used for construction, furniture, handicrafts, and reforestation. The bark, leaves, and roots are traditionally used to treat fever, diarrhea, and skin problems.
Lantana camara L. 	Tahi Ayam	*Verbenaceae*	The stem is woody and brown. The leaves are oval, rough, and finely hairy. The flowers are clustered and come in orange and pink.	Used as an ornamental plant and in traditional medicine. The leaves can also be used as animal feed.
Dioscorea sp. 	-	*Dioscoreaceae*	The stem is a vine with tendrils. The leaves are spear-shaped, with a base that splits into two lobes and a pointed tip.	A food source rich in fiber, vitamins, minerals, and carbohydrates.

Lygodium circinnatum (Burm.f.) Sw. 	Paku Hati	*Schizaeaceae*	The stem is slender and flexible, allowing it to climb other plants. The leaves are lanceolate. The rhizome grows underground.	Used in traditional medicine to treat wounds, inflammation, and skin conditions. Also used for weaving baskets or roofing materials and as an ornamental and ecological plant.
Selaginella sp. 	-	*Selaginellaceae*	The stem is erect and highly branched. The branches bear tiny, scale-like leaves that are densely arranged.	Used as an ornamental plant. Some species are used in traditional medicine to treat coughs, fever, and wounds. It is also used as pet food for small animals like birds.
Piper aduncum L. 	Kayu sirih	*Piperaceae*	The stem is cylindrical, with young stems covered in fine hair. The leaves are oblong with a smooth surface and fine hair on the underside.	It used to treat skin diseases like eczema and scabies. It has anti-inflammatory properties to reduce swelling. Some parts of the plant can be used as a natural dye and as an ornamental plant.
Pometia sp. 	Matoa	*Sapindaceae*	The trunk is woody, hard, and grayish brown with a rough surface. The leaves are compound, double-pinnate, and each leaflet is oblong with a pointed tip.	Used as a carbohydrate source. The extract from its fruit has potential as a treatment for diabetes and heart disease.
Ceiba pentandra (L.) Gaertn. 	Kapuk randu	*Malvaceae*	A large, upright trunk with sharp spines. The leaves are palmate-compound, with lance-shaped leaflets. The fruit is a large capsule containing cotton-like fibers.	The fiber is used as a filler for pillows, mattresses, and flotation devices. The wood is used for construction, household furniture, and paper pulp. The seeds contain oil used in the cosmetics and food industries. Additionally, kapok leaves can serve as supplementary animal feed.

Ficus minahassae (de Vriese & Teijsm.) Miq. 	Langusei	*Moraceae*	A large and sturdy trunk with grayish-brown bark. The leaves are oval or elongated with pointed tips. The surface is smooth and dark green. The fruit is round or slightly oval, green when young, turning yellow or red when ripe.	As an endemic species, Langusei plays an essential role in maintaining Sulawesi's biodiversity by providing habitat for various flora and fauna, contributing significantly to ecological balance.
Piper sp. 	Sirih-sirihan	*Piperaceae*	The stem is a vine, green in color. The leaves are stalked, heart-shaped, or shield-like, and dark green.	Used as a spice in cooking. It is also used in traditional medicine to aid digestion, reduce inflammation, and relieve pain. It is commonly cultivated as an ornamental plant. Additionally, it can be used as a natural dye and raw material in the industry.

Table 1 indicates that plant species from the genus *Piper* and the family *Piperaceae*, such as *Piper aduncum L.*, *Piper sp. 1*, and *Piper sp. 2*, were the most frequently found. The exploration evaluation revealed that the *Arenga pinnata* agroforestry area is predominantly composed of tree and shrub strata. However, species from sapling, herbaceous, climbing, and pioneer plants, such as mosses and ferns, were also discovered. Table 1 further shows that the *Arenga pinnata* agroforestry area contains numerous tree and sapling species from the families *Arecaceae*, *Dioscoreaceae*, *Euphorbiaceae*, *Fabaceae*, *Malvaceae*, and *Moraceae*, which contribute to CO_2 absorption within the agroforestry ecosystem.

Field data shows that out of the 31 plant species found, only 12 species have recorded data in the IUCN with the Least Concern category. Table 2 presents the plant species listed in the IUCN Red List, 10 of which are distributed in Sulawesi, including *Pangium edule* Reinw., *Arenga pinnata* (Wurmb) Merr., *Musa acuminata* Colla, *Hellenia speciosa* (J.Koenig) S.R.Dutta, *Macaranga tanarius* (L.) Müll.Arg., *Mimosa pudica* L., *Ficus septica* Burm.f., *Tacca leontopetaloides* (L.) Kuntze, *Ceiba pentandra* (L.) Gaertn., and *Ficus minahassae* (de Vriese & Teijsm.) Miq.

Table 2. Plant species in aren agroforestry listed in the IUCN red list

No.	Plant Name	Local Name	Genus	Family	IUCN Status
1	*Pangium edule* Reinw.	Pohon Kluwek	*Pangium*	Achariaceae	Least Concern
2	*Arenga pinnata* (Wurmb) Merr.	Aren/Enau	*Arenga*	Arecaceae	Least Concern
3	*Hellenia speciosa* (J.Koenig) S.R.Dutta	Pacing	*Hellenia*	Costaceae	Least Concern
4	*Tacca leontopetaloides* (L.) Kuntze	Jalawuri pantai	*Tacca*	Dioscoreaceae	Least Concern
5	*Macaranga tanarius* (L.) Müll.Arg.	Pohon Mara	*Macaranga*	Euphorbiaceae	Least Concern
6	*Mimosa pudica* L.	Putri Malu	*Mimosa*	Fabaceae	Least Concern
7	*Gmelina arborea* Roxb. ex Sm.	Jabon putih	*Gmelina*	Lamiaceae	Least Concern

8	*Ceiba pentandra* (L.) Gaertn.	Kapuk randu	*Ceiba*	Malvaceae	Least Concern
9	*Ficus minahassae* (de Vriese & Teijsm.) Miq.	Langusei	*Ficus*	Moraceae	Least Concern
10	*Ficus septica* Burm.f.	Awar-awar	*Ficus*	Moraceae	Least Concern
11	*Musa acuminata* Colla	Pisang merah	*Musa*	Musaceae	Least Concern
12	*Piper aduncum* L.	Kayu sirih	*Piper*	Piperaceae	Least Concern

Based on research findings, an interesting species was discovered, namely *Ficus minahassae*, which is an endemic plant from Sulawesi Island, found in the *Arenga* agroforestry area of Boalemo. *Ficus minahassae*, or *langusei*, is generally considered an endemic plant in Indonesia, specifically in North Sulawesi. This is supported by research conducted by Irawan et al. (2020), which states that *Ficus minahassae* is one of the endemic flora of Sulawesi that is distributed in northern Sulawesi, the Sangihe Islands, and Talaud. This plant can be found in primary forests, particularly along rivers, up to an elevation of 135 meters above sea level. The local community recognizes this species as the floral mascot of North Sulawesi Province. *Ficus minahassae* holds high cultural value for the Minahasa people, as it is often associated with various beliefs and traditional rituals and has many benefits for daily life. Besides its cultural value, *Ficus minahassae* also has environmental benefits such as helping to prevent erosion, providing habitat for various wildlife species, and absorbing carbon dioxide, which aligns with the primary goals of agroforestry.

The vegetation inhabiting the *Arenga pinnata* agroforestry area in Boalemo Regency, Gorontalo Province, is dominated by herbaceous and shrub strata. These two strata contribute to reducing atmospheric carbon dioxide (CO_2) levels, although the amount absorbed is less compared to trees. However, due to the high species diversity, total CO_2 absorption can occur significantly. Tree strata and their seedlings also occupy the third and fourth highest positions after herbs and shrubs. As explained by Hardiatmi (2008), trees with large biomass can store significant amounts of carbon. This directly contributes to climate change mitigation by reducing greenhouse gas concentrations in the atmosphere (Raskin & Osborn, 2019).

The diversity of species in the agroforestry area of Boalemo Regency has distinct characteristics. These differences are based on the commodities cultivated by the local community, leading to significant variations between different regions. The cultivated commodities influence the plants associated with the primary vegetation and impact the environmental characteristics of the area. For example, in the *Arenga pinnata* agroforestry area, the dominant plant is the *Arenga* palm itself. The *Arenga pinnata* found in the research location is intentionally cultivated to meet the local community's needs for palm sugar production. This condition results in low species diversity since the plants in the area are agricultural commodities deliberately planted by the community rather than naturally growing forest trees. This is reinforced by the statement of Indriyanto (2012), which explains that a community is considered to have high species diversity if it is composed of many species. Conversely, a community is considered to have low species diversity if it consists of only a few species and if only a few dominant species are present. Furthermore, Irwan (2010) stated that the higher the species diversity, the more stable the community and the greater its ability to withstand disturbances. High species diversity indicates that a community has high complexity due to the extensive species interactions within it.

The *Arenga pinnata* agroforestry system in Boalemo has a significant number of plant species with considerable diversity, as seen in its ability to absorb CO_2 and store high biomass carbon. The *Arenga pinnata* agroforestry system has a high carbon sequestration capacity because *Arenga* palm trees effectively absorb carbon through photosynthesis, store carbon in their biomass, and maintain carbon within the soil. The combination of trees and other plants in this system enhances carbon absorption and supports environmental sustainability (Irundu et al., 2023).

The *Arenga pinnata* agroforestry area holds great potential in supporting Indonesia's government program for carbon sequestration and achieving the FOLU Net Sink 2030 target. Agroforestry is a land management system that combines forestry plants with agricultural crops or livestock, providing both economic and environmental benefits. The implementing agroforestry can increase carbon storage by up to 30% compared to conventional agricultural systems. This makes it an effective strategy for climate change mitigation.

Carbon sequestration in agroforestry occurs through the photosynthesis process, where trees absorb CO_2 and convert it into biomass. It is shows that plant diversity within agroforestry can enhance carbon sequestration efficiency. By integrating trees, agricultural crops, and perennial plants, this system creates a microclimate that supports vegetation growth and increases carbon sequestration capacity. Furthermore, agroforestry also contributes to improving soil quality. The tree roots in agroforestry systems help improve soil structure, increase organic matter content, and enhance water retention. This condition is crucial in Indonesia, where agricultural land often suffers from degradation due to unsustainable farming practices. By improving soil conditions, agroforestry areas can serve a dual role as carbon sinks and agricultural production supporters.

In the context of government policy, Indonesia has targeted FOLU Net Sink 2030 as part of its national commitment to reducing greenhouse gas emissions. This strategy includes developing agroforestry as one of the key measures. According to the Ministry of Environment and Forestry (2021), developing agroforestry areas in various regions can support the achievement of net sink carbon targets. This includes establishing partnerships between farmers, communities, and the government to create sustainable agroforestry systems.

Challenges in developing agroforestry must also be addressed to maximize carbon sequestration potential while maintaining sustainable agricultural systems by considering environmental conditions. According to researchers, awareness and skills among communities, especially farmers, in implementing proper agroforestry techniques are key to success. Education and training provided to communities, particularly farmers, can enhance their understanding of the benefits of agroforestry and the appropriate techniques for its management. Therefore, support from all parties is essential for success and the realization of the FOLU Net Sink 2030 target.

The existence of agroforestry areas can also enhance biodiversity and provide socio-economic benefits for local communities. The agroforestry has been proven to improve livelihoods by diversifying income sources and increasing food security. This demonstrates that environmental sustainability can be achieved without compromising the economic needs of the community. The community plays a crucial role in maintaining and supporting plant species diversity within an area. Community activities can have both positive and negative impacts on the environment if people are not aware of how to manage an area sustainably. This is supported by Baderan et al. (2021), who stated in their research that the Geosite Benteng area is one of the historical tourist sites in Gorontalo Province frequently visited by people, leading to the increasing threat and degradation of rare plant species in the area. Therefore, in-situ conservation efforts need to be undertaken. The number of species and individuals within a community determines the biodiversity of that community (Sutrisna et al., 2018). If a community has many species without any dominant species, its species diversity will be high. The higher or lower biodiversity value of an area determines the stability of the community in that area (Indriyanto, 2012).

4. Conclusions

Research on species composition, utilization, and conservation status of plant species in the *Arenga pinnata* agroforestry area indicates that the agroforestry system has significant potential in supporting environmental sustainability and community well-being. A total of 31 plant species were identified, with 12 species recorded in the IUCN database under the *Least Concern* category. Additionally, 10 of these species are distributed across

Sulawesi, including *Pangium edule* Reinw., *Arenga pinnata* (Wurmb) Merr., *Musa acuminata* Colla, *Hellenia speciosa* (J.Koenig) S.R.Dutta, *Macaranga tanarius* (L.) Müll.Arg., *Mimosa pudica* L., *Ficus septica* Burm.f., *Tacca leontopetaloides* (L.) Kuntze, *Ceiba pentandra* (L.) Gaertn., and *Ficus minahassae* (de Vriese & Teijsm.) Miq.

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Author Contribution

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