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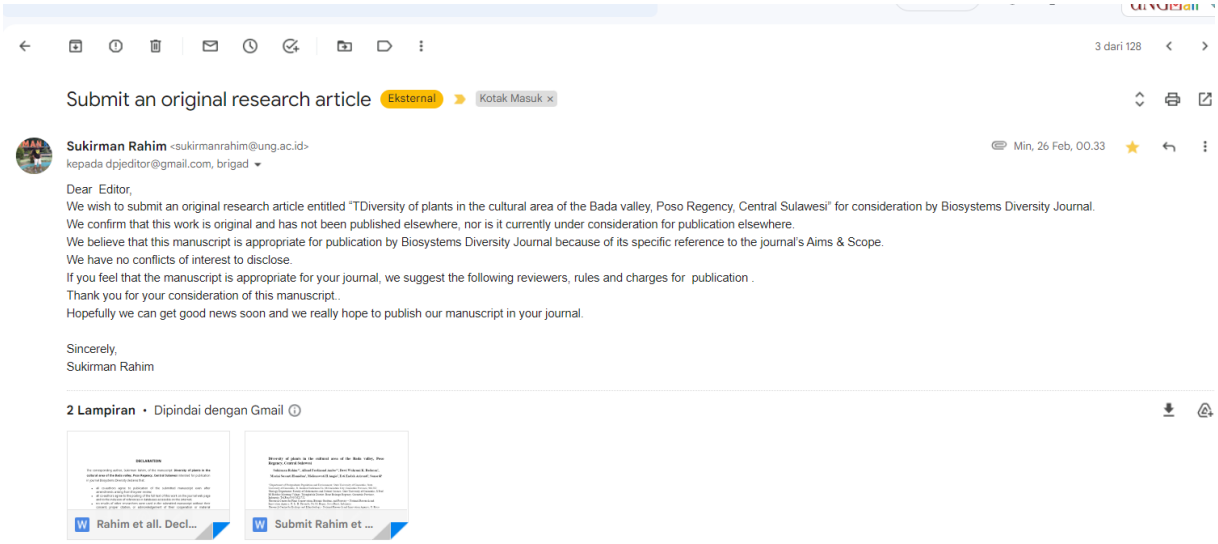

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Date: 24 February 2023

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Diversity of plants in the cultural area of the Bada valley, Poso Regency, Central Sulawesi

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ABSTRACT

The Bada Valley is one of the Lore Lindu Megalithic cultural heritage areas which has high scientific, historical, cultural and biodiversity values. The aim of the study was to determine the diversity index, evenness index and plant species richness index in the Bada Valley cultural area, Poso Regency, Central Sulawesi. This study used an exploring technique with purposive sampling. The results of the study found vegetation composition for herbaceous strata (555 individuals), trees (91 individuals), shrubs (64 individuals) and vines (57 individuals). The diversity index value of each stratum is different for trees (H'=1.2); herbs (H'=1.91), shrubs (H'=1.32), and vines (H'=0.62). The diversity of plants in the Bada valley in the tree, herb, and shrub strata was moderate ($1.0 \leq H' \leq 3.0$), and the encroaching plant stratum had low diversity ($H' < 1.0$). The evenness index at the level of shrubs, vines, herbs and trees has a value of 0.95; 0.9; 0.83; 0.61 respectively. The species richness index of plants in the Bada valley is in the low category ($R < 3.5$) with R values for herbaceous plants (1.42), trees (1.33), shrubs (0.72), and vines (0.24). Information on plant biodiversity is used as a data base for ecotourism development in the Bada Valley cultural reserve area.

Keywords: biodiversity, plant species, Bada Valley

Introduction

Indonesia is a country that is very rich in biodiversity and has won an essential position on the world biodiversity map. Indonesia, together with Brazil and Zaire, is in the top three countries in the world that have the highest biodiversity (megadiversity countries), covering 17% of the total bird species in the world found in Indonesia (1,531 species), of which 381 species are endemic (Boedhirtano, 2017; Scales & Marsden, 2008; Murray et al., 2015;), has around 30,000 species of plants and has been used as a source of medicinal raw materials (Budiarti et al., 2017; Kasmawati et al., 2019; Silalahi et al., 2015). Diversity is the variation and also the variability of life on earth (Hooper el al, 2005), diversity is a characteristic difference between communities (Harrison et al., 2020; Lausch et al., 2016).

One area in Indonesia that has high biodiversity is Sulawesi; one of provinces is Central Sulawesi. This province is located in the Wallacea region, a biogeographical area between the Sunda Shelf and the Sahul Shelf which has high diversity of endemic floras and faunas. However, the plant abundance of this region is insufficiently explored (Pitopang et al, 2019). The Bada Valley is one of the cultural heritage areas in Central Sulawesi, which together with the Behoa Valley and the Napu Valley, as well as the Palu Valley and Lake Lindu are a Lore Lindu Megalithic Area (KMLL) which has important scientific, historical and cultural values. This area has the oldest cultural chronology in Indonesia, and is currently in submission to the United Nations Educational, Scientific and Cultural Organization (UNESCO) for designation as a world cultural heritage (World Heritage).

The report from the Gorontalo Cultural Heritage Preservation Center (2018) mentions potential threats to archaeological remains in the Bada Valley. Threats caused by natural factors include: weathering caused by interactions between archaeological remains and their environment; environmental factors such as climate, temperature, humidity, sunshine; organisms such as insects, fungi, lichens, and bacteria. Other natural factors are erosion, landslides and floods, and the activities of large animals that have the potential to damage these objects. In addition to natural factors, human activities also have the potential to threaten the existence of these archaeological remains. Destruction and theft, vandalism, mining activities, land clearing for agriculture, plantations and development (Satrija et al., 2015).

Mining activities in the Bada Valley Cultural Heritage area are spread over four villages, namely: Bulili Village, Badangkaia Village, Bewa Village and Gintu Village which were discovered since 2017. The perpetrators of this illegal mining are not only the local people of the Bada valley but many also come from outside the Bada Valley and even from outside Poso Regency. The use of tromol, mercury and other materials in the mining process will certainly be very damaging to the environment. The impact of this activity is frequent flooding, landslides, destruction of the habitat of various species of animals, including endemic birds such as the maleo bird, babirusa, anoa, alo bird and hundreds of other species of animals that have been living and breeding in the forest in the Lore Lindu National Park area.

In addition to human activities, one of the causes of the decline in biodiversity is the invasion of foreign species. Invasive foreign species including species of flora, fauna, microorganisms and pathogens originating from outside their original habitat that enter new areas and can cause harm to ecosystems or the environment, the economy and public health (CBD, 2000). There are approximately 300 species of weeds that have been found in Indonesia (Setyawati et al. 2015; Widjaja et al. 2014).

The percentage of successful weed species becoming dominant and causing negative impacts on new habitats is 10% (Sitepu, 2020).

The lack of attention to plant biodiversity has become the reason for conducting research on the biodiversity index of the Bada valley cultural reserve area. Data on plant diversity is complementary to realizing the development of ecotourism in Central Sulawesi Province.

Methods

This research was conducted in the Bada Valley cultural heritage area, Poso Regency, Central Sulawesi Province. Bada Valley is located in South Lore and West Lore Districts, Poso Regency. South Lore District with the capital city of Gintu and West Lore District with the capital city of Langkeka. Administratively, the Bada Valley is bordered to the north by Lore Tengah District, Poso Regency, to the east by Pamona Puselemba and West Pamona Districts, Poso Regency, to the south by Rampi Seko District, North Luwu Regency, South Sulawesi, and to the west by the District Kulawi, Poso Regency. The total area of the Bada valley is 997.7 km2 (Central Bureau of Statistics, 2022). The map of the Bada Valley Cultural Heritage Area is presented in Figure 1.

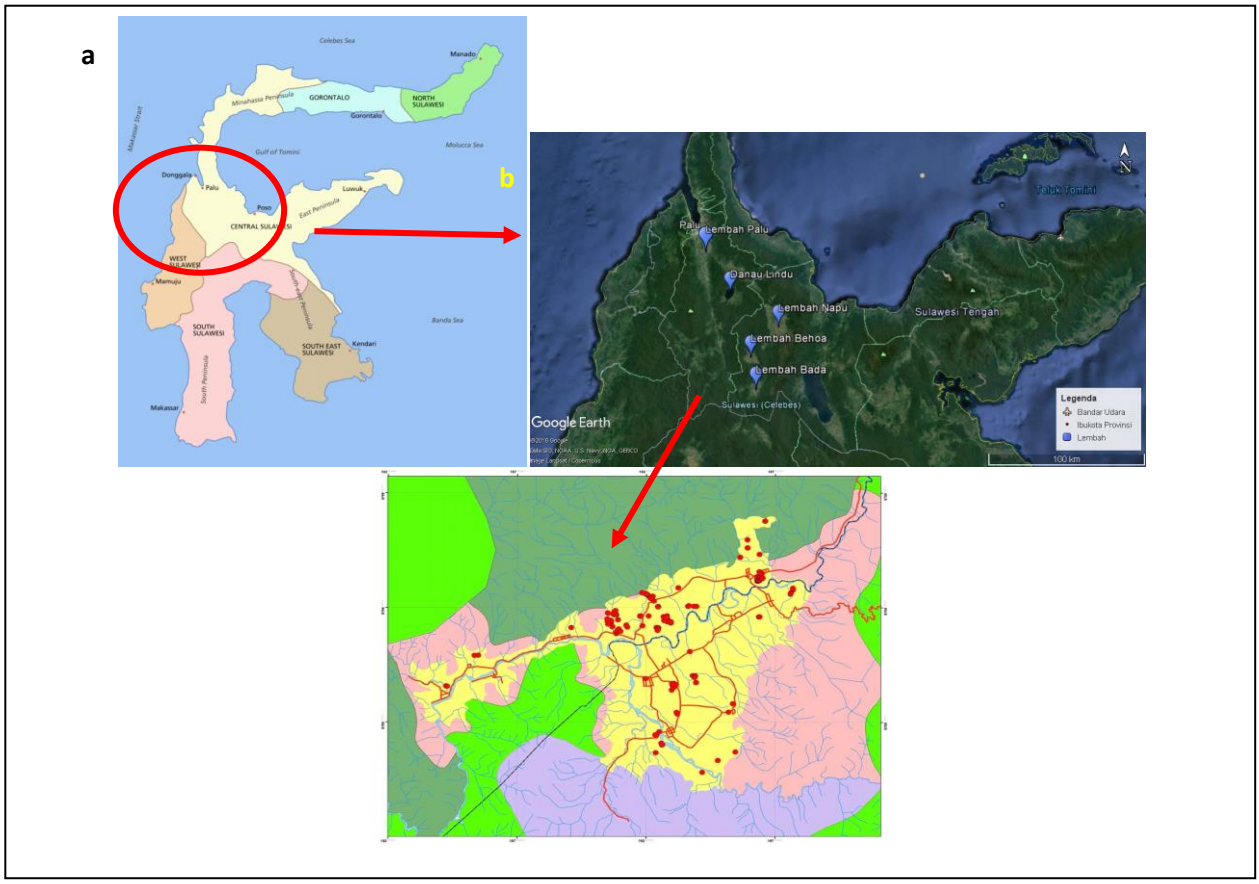


Fig. 1. Map of the Bada Valley Cultural Heritage Area

(Source: Ramadhan, 2023 (a); Faiz, 2017 (b))

The research method uses exploring methods for exploration of plant species. Collection of plant data by exploring the location of the Bada Valley cultural heritage area and observing all the existing plant species accompanied by taking pictures using a digital camera. Additional information was recorded in the form of collector's name, collection number, collection date, location, and habitus which were recorded in the observation sheet that had been prepared. Identification of plants was carried out using the procedure for observing plant morphological characters which included special features in each class and family or genus down to the species level and then compared with the book Pitopang et al., (2008,) Tjitrosoepomo, (1985), Harris & Harris, 2001 and Flora for Indonesia (Steenis, 2008). Accepted name validation for each plant species is carried out using The Plant List website, 2022 (http://www.theplantlist.org/). Identification results were then analyzed by descriptive qualitative. For plant species that have not been identified, herbarium specimens were made by taking plant parts that have been cleaned of soil, fungus or foreign material adhering to them. Identification of invasive plant species was carried out based on the Guide to The Naturalized and Invasive Plants of Southeast Asia (Witt, 2017) and the CABI Compendium Invasive Species (https://www.cabidigitallibrary.org/product/qi).

Data analysis

Species Diversity Index

Data on the diversity of plant species is identified through the Diversity Index (H') (Shannon & Wiener, 1963; Fachrul, 2012).

$$\mathrm{H}' = -\sum_{i=1}^{S} \mathrm{pi}\, ln\, \mathrm{pi} \quad \text{where: } \mathrm{pi} = \frac{\mathrm{ni}}{\mathrm{N}}$$

Description: H'(Shannon-Wienner diversity index), *S* (Number of species), ni (Number of individuals in one species), *ln* (Natural logarithm), N (Total number of individual species found). The value of H' determines the level of species diversity in an area, where the definition of the value of species diversity according to Shannon-Wienner is: H'> 3 : high species diversity, 1 ≤ H' ≤ 3 : medium species diversity, H' < 1 : Low species diversity.

Species Evenness Index

The evenness index of species refers to the *Pielow evenness indices* formula (Ludwig & Reynolds 1988), namely: E = H'/ln S, where E (Evenness Index), and H' (Shannon-Wienner diversity index)

Species Richness Index (R1)

The species richness index uses the Margalef formula (Magurran, 1988), namely $\mathrm{R}_1 = \frac{(\mathrm{S}-1)}{(\ln(\mathrm{N}))}$, where R1 (Wealth Index), S (Number of species found), and N (total number of individuals)

Results

Vegetation Composition

The composition of the vegetation in the Bada valley area is dominated by plants with herbaceous strata with a total of 555 individuals, then tree strata of 91 individuals, shrubs 64 individuals and vines 57 individuals. The composition of plants in the Bada valley is presented in Table 1.

Table 1
Composition of Plants in the Bada Valley Area

Stratum	Species	Local name	Individual number	Uses
Tree	*Antidesma ghaesembilla* Gaertn.	Tumbuhan Buni.	62	Buni plants are widely used as traditional medicine to treat high blood pressure, palpitations, anemia, syphilis
	Cryptocarya sp.	Kayu masohi	6	This plant is used to treat fever, stomach cramps and relieve joint pain.
	Bischofia javanica Blume	Bintungan	3	The bark of the plant is used to lower blood cholesterol levels and treat diarrhea
	Premna serratifolia L.	Bebuas	4	Water decoction of the leaves of this plant is used to treat fever
	Casearia sp.	Hulu tulang	3	The benefits of this plant are used as natural dyes and also used as ornamental plants
	Melia azedarach L.	Renceh	8	Medication to lower high blood pressure
	Psidium guajava L.	Jambu biji	6	Diarrhea and cough medicine
	Total		**91**	
Herbs	*Euphorbia hirta* L.	Tanaman asma	34	The benefits of this plant can overcome asthma, malaria drugs and wound healing drugs.
	Ageratum conyzoides (L.) L.	Babandotan	183	The benefits of this plant can be used as a wound healer, leprosy and ulcers
	Chromolaena odorata (L.) R.M.King & H.Rob.	Krinyuh	88	The benefits of this plant can be used as a wound healing

				drug and can stop bleeding quickly
	Stachytarpheta cayennensis (Rich.) Vahl	Pecut kuda	56	Used as a medicine for malaria, fever and diabetes
	Crotalaria trichotoma Bojer	Orok-orok	16	Utilized as animal feed and potentially as green manure.
	Erigeron sp.	Jabung	13	can treat pain due to rheumatism, has a sedative effect, and heals wounds, so now it is widely used in cosmetic products
	Melastoma malabathricum L.	Senduduk	9	Can be used to treat burns
	Tridax procumbens L.	Songgolangit	104	Can be used to treat gout, aching rheumatic pain and gout
	Euphorbia heterophylla L.	Daun katemas	24	Used to treat asthma, constipation and bronchitis
	Crassocephalum crepidioides (Benth.) S.Moore	Daun sintrong	28	Can increase immunity
	Total		**555**	
Shrub	*Syzygium paniculatum* Gaertn.	Pucuk merah	20	The benefits of this plant can improve immune function and can lower blood sugar levels
	Ixora coccinea L.	Asoka	10	Used for wound healing
	Ricinus communis L.	Daun jarak	11	Can be used to launch defecation
	Broussonetia papyrifera (L.) L'Hér. ex Vent.	Pohon saeh	23	The benefits of the bark of this plant are used as a basic ingredient in making traditional clothes for the people of the Bada Valley.
	Total		**64**	
Vines	*Calopogonium mucunoides* Desv.	Kalopo	39	It can be used as green manure and as a land cover plant
	Scurrula parasitica L.	Benalu	18	The benefits of this plant have the potential as anticancer,

			anti-malarial and as a medicine for hemorrhoids and diarrhea
	Total	**57**	

Source: Data Primer, 2022

Based on the results of the identification of plant species composition, several species were identified as invasive species. Some of these species are foreign species whose natural habitat is outside the Southeast Asian region.

Table 2
Identified Invasive Species in the Bada Valley Region

No	Species	Invasiveness	Information
1	*Melia azedarach* L.	Invasive	This species is native or originate from the Southeast Asia region but has the potential as an invasive alien species in several areas outside its natural habitat. *M. azedarach* is fast growing and has few natural enemies. This species is spread by seeds by birds and other animals. It has been reported as an invasive species in a number of locations in the Americas, Pacific and Africa, South Africa and Hawaii, USA. This species is difficult to control because of its ability to grow again vegetatively
2	*Euphorbia hirta* L.	Invasive	It is a weed or invasive species on agricultural land and is a host for several types of pests and diseases in plants.
3	*Ageratum conyzoides* (L.) L.	Invasive	*A. conyzoides* is reported as an invasive and harmful weed in agricultural fields. This species tends to invade open or degraded land. This species causes a decrease in crop yields and affects biodiversity (Kohli et al., 2006; GISD, 2016; PIER, 2016), and is a host of pathogens and nematodes that affect several types of agricultural crops (BioNET-EAFRINET, 2016).
4	*Chromolaena odorata* (L.) R.M. King & H. Rob.	Invasive	*C. odorata* is a species of herb or shrub that has a very wide distribution. This species is included as one of the 100 dangerous invasive species in the world. This species will be very easy to spread and invade new areas that are degraded through seeds that are easily carried by the wind.
5	*Stachytarpheta cayennensis* (Rich.) Vahl	Invasive	*S. cayenneensis* is a species originating from South and Central America and the Caribbean. This species is widely introduced to various regions because it has attractive flowers. *S. cayenneensis* has a wide environmental tolerance and often invades disturbed areas thereby overpowering native flora. This species is considered a noxious weed in the Northern Territory, Australia and is increasingly abundant in Florida, USA. According to the risk assessment, this species is considered highly invasive (score 20 = high risk) (PIER, 2015).

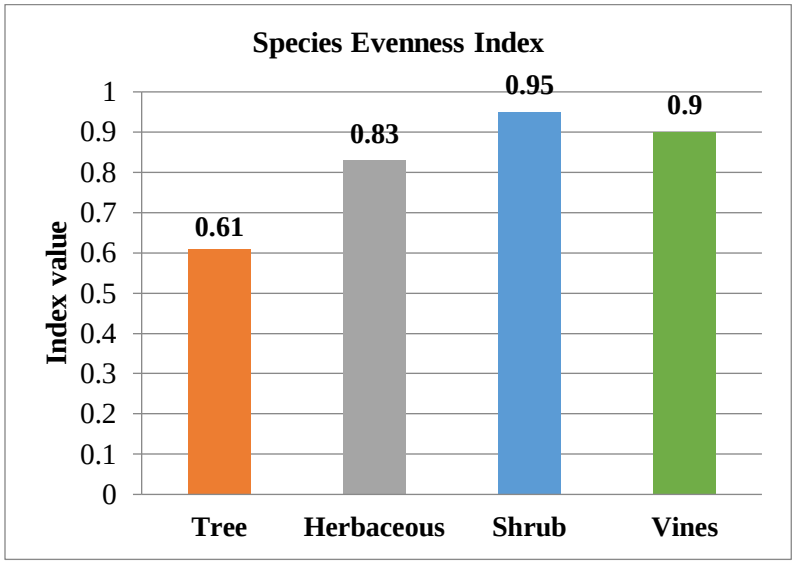
6	*Melastoma malabathricum* L.	Invasive	*M. malabathricum* is known as a weed on mahogany (*Swietenia macrophylla*) in Sumatra, Indonesia (Nazif and Pratiwi, 1989). It is a primary weed commonly found growing in industrial plantation forests. *M. malabathricum* is registered as a Federal Noxious Weed in the US.
7	*Euphorbia heterophylla* L.	Invasive	According to Holm et al. (1979), *E. heterophylla* is a major weed in Fiji, Ghana, Mexico, Philippines, Indonesia and Thailand, Brazil, India, Italy, Papua New Guinea, Cuba, Honduras, Peru, Uganda and the United States. This species has a negative impact on several agricultural crops including cocoa, coffee, cotton, cowpea, corn, papaya, peanuts, sorghum, soybeans, sugarcane, tea, and upland rice (Parsons and Cuthbertson, 1982). It has fast growth so it is easy to compete in getting light, water and nutrients.
8	*Crassocephalum crepidioides* (Benth.) S.Moore	Invasive	*C. crepidiodes* is an invasive species which is included in the Global Compendium of Weeds as one of the most aggressive weeds that occurs in tropical and subtropical regions (Randall, 2012). It is a pioneer species with the ability to produce large numbers of downy seeds which are dispersed by the wind.
9	*Syzygium paniculatum* Gaertn.	Alien Invasive	It is an invasive foreign species. The original habitat of this species is the territory of Australia.
10	*Calopogonium mucunoides* Desv.	Invasive	*C. mucunoides* is a woody plant listed in the Global Compendium of Weeds that has an impact on agricultural and semi-natural ecosystems (Randall, 2012). *C. mucunoides* has been widely introduced as a forage legume and nitrogen fixing plant in tropical and subtropical regions (Cook et al., 2005). *C. mucunoides* has the potential to kill native vegetation and food crops in agricultural areas. Currently, *C. mucunoides* is classified as a noxious weed in Australia (Queensland Department of Primary Industries and Fisheries, 2011), and as an invasive species in Malaysia, the Philippines, Puerto Rico, and several islands in the Pacific Ocean such as French Polynesia, Cook Islands, Samoa, Palau, and the Solomon Islands (Acevedo-Rodríguez and Strong, 2012; PIER, 2013).

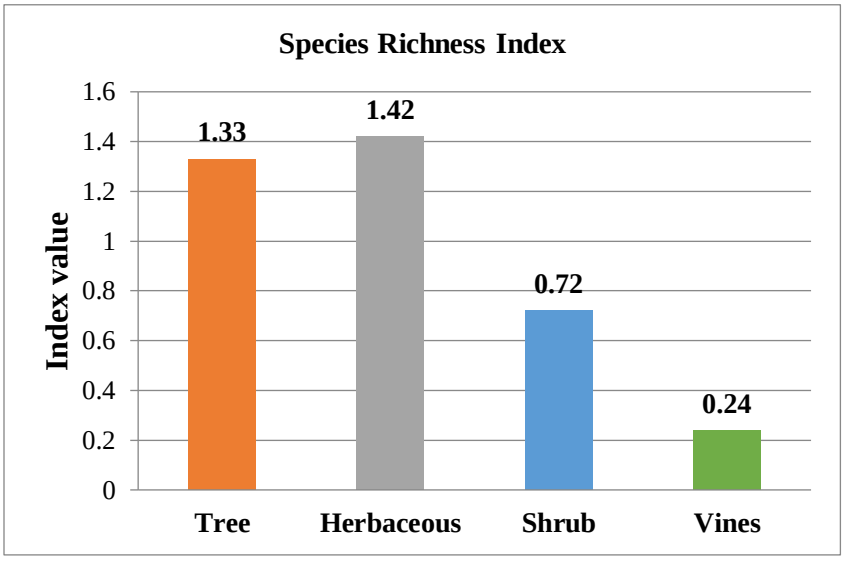
Diversity, Evenness, Species Richness

The value of the diversity index in the Bada Valley Cultural Conservation Area has differences in diversity in each stratum. The tree strata had a diversity index of 1.2, the herbaceous strata 1.91, the shrub strata 1.32 and the vines strata 0.62 (Figure 2). Based on the criteria for the value of species diversity according to Shannon-Wienner the diversity of plants in the Bada valley in the strata of trees, herbs and shrubs is included in the criteria of moderate diversity because the value is $1.0 \leq H' \leq 3.0$, and the strata of vines has low diversity criteria because $H' < 1.0$.

The evenness index for the shrub stratum had the highest value, namely 0.95, followed by vines at 0.9, herbaceous plants at 0.83 and trees at 0.61 (Figure 2). The highest species richness index was owned by herbaceous plants with a value of 1.42, tree strata 1.33, shrub strata 0.72 and vines strata 0.24. Based

on the species richness index criteria, plants in the Bada valley area have low species richness criteria because the R value <3.5.





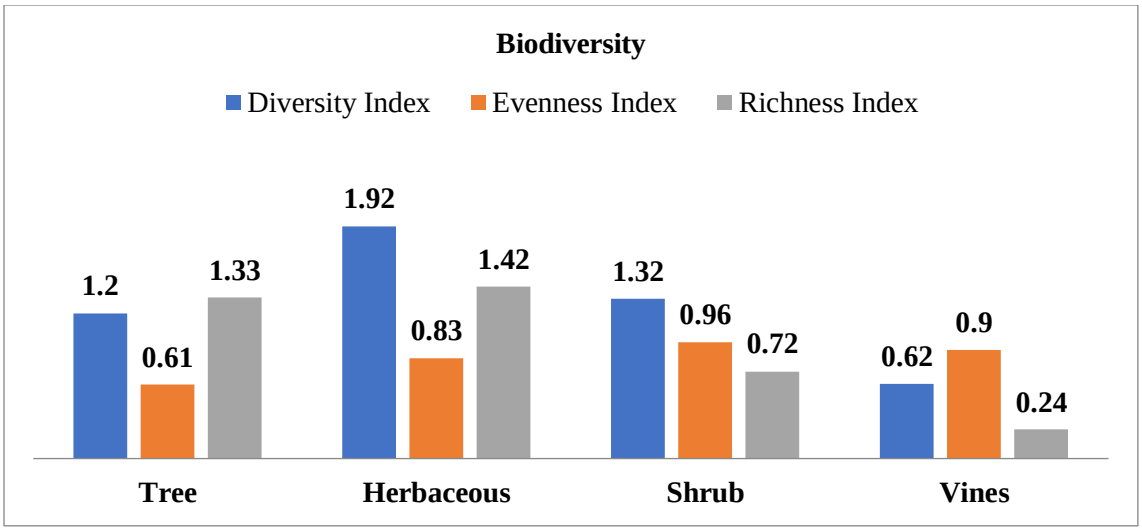


Fig. 2. The value of Diversity index, Evenness index and Species Richness index

Discussion

The plants that have the highest diversity index value in the Bada valley are the herbaceous strata. Herbaceous strata dominate the area with a total of 555 individuals. Herbaceous plants are plants that have a height or stem length of 0.3 – 2 meters and have wet or soft trunks because they have a lot of water content. The high composition of herbaceous plants is closely related to the good adaptability of these plants in both tropical and subtropical environmental conditions. Herbaceous plants can be dispersed easily in groups with the same individual or solitary in a variety of different habitat conditions such as moist or watery soil dry, rocks and habitats with less dense or open shade (Aguilar et al., 2019; Lelli et al., 2019; Zelnik, 2012).

Herbaceous plants have strong competitiveness and high adaptation to the surrounding plants (such as bushes, shrubs, and even trees) so they can grow in empty places. Herbaceous plants in different habitats are very different in the amount that can be produced by an area that has different habitats such as habitats with high humidity to dry areas (Litza & Diekmann, 2019; Spicer et al., 2022; Träger et al., 2019).

The dominating plant is the *Ageratum conyzoides* (L.) L. This plant can spread quickly both from the wind and by insects and humans who are active in that location, this plant also has very fast growth and has a relatively small size compared to other herbaceous plants. According to (Shen et al., 2019;) herbaceous plants whose body size is relatively small have the opportunity to get a wider living space, thus enabling the life of more individuals (wealth) and more species (diversity).

The role of herbaceous plants in the region has a very important role, among others, when experiencing succession which is marked by many pioneer plants and small plants such as herbaceous plants. Herbs play an important role in the annual nutrient cycle, namely the herb litter that is returned to the soil contains high levels of nutrients. In addition, herbs are also used as a source of animal feed, medicine and a source of wealth in germplasm, for example,

the preservation of wild animals as a component of an ecosystem is influenced by the presence and diversity of undergrowth as a place to live and a high source of food and many other functions (Álvarez et al., 2022; Schmidt et al., 2019).

The diversity of plants in the Bada valley area is included in the medium and low diversity index criteria. This is caused by several factors including the control of the area in the cultural heritage area, soil type, climate, biotic influences (living things) and so on. This is supported by the statement of Compant et al. (2019) which states that plant diversity is influenced by several factors, including climate, soil type, altitude and biotic influences (living things). Furthermore, Dar & Reshi (2020) states that diversity is synonymous with the stability of an ecosystem, that is, if the diversity of an ecosystem is relatively high, the condition of the ecosystem tends to be stable. Ecosystem environments that have diversity disturbances tend to be moderate, in the case of ecosystem environments that are polluted, species diversity tends to be low.

Geng et al. (2019) states that the higher the species diversity, the more stable the community will be and have a higher ability to deal with disturbances. Furthermore, van der Plas (2019) argued that high species diversity indicates that a community has high complexity because the species interactions that occur in that community are very high. A community is said to have high species diversity if the community is composed of many species. Conversely, a community is said to have low species diversity if the community is composed of a few species and if there are only a few dominant species. In line with the statement of Pitopang & Ihsan (2014), which explains that the higher the value of the diversity index, the better the ecosystem in the region.

Based on the results of the analysis of the evenness index of species, the Bada valley area has plants that are included in the criteria for high species distribution. Evenness index values or Evenness (E) range from 0 to 1 (Magurrann, 1988), meaning that the plants in the area can grow and spread throughout the observation sites. The even distribution of plants in this location cannot be separated from the influence of environmental factors. The high level of biodiversity is because Indonesia is a tropical country with high levels of rainfall, temperature and humidity. According to Pramudya (2020), Indonesia has a diversity of flora and fauna due to its geographical location around the equator and between the continents of Asia and the continents of Australia, giving rise to the emergence of certain characteristics and characteristics in resources in the form of tropical forest ecosystems. Furthermore, according to Kitayama et al. (2021), tropical forests are located along the equator, that is, in areas with high radiation intensity, with small daily and annual amplitudes.

The value of the Diversity index relates to the value of species richness, but is also influenced by the distribution of species abundance. Midolo et al. (2019) states species richness is the number of species in a community. The greater the number of species found, the greater the wealth index.

The richness of plant species in the Bada valley area is classified as low. It has been explained above that the number of species will affect species richness. It is also known that the number of plant species for each stratum in the Bada valley area is still relatively small, thus affecting species richness. This is in accordance with the opinion of Roswell et al. (2021) that a community has high species diversity if the community is composed of many species, conversely if the community is composed of very few species and only a few dominant species, then the species diversity is low.

Species richness shows all the variations found in living things between species. Differences between species of organisms in one or more families will be visible, making it easier to observe than differences between individuals in one species. Richness at the species level occurs because of the variety of these species. The species richness index is the simplest measure because it only takes into account differences in the number of species in a certain area. Species richness serves to determine the amount of species richness in each community found. This was confirmed by Mahaut et al (2020) who stated that species richness refers to the quantity of species in a community. The quantity of species in the field determines the size of the richness index. In the context of cultural heritage sites or areas the presence of certain plant species at the site or area strongly supports the concept of preservation in accordance with local values and traditions. Sites identified as places of worship, such as the Sepe Site in Kolori Village and the Suso Site in Lengkeka Village, Lore Barat District, are of course closely related to the use of certain plant species in carrying out worship ceremonies or rituals in accordance with the beliefs that developed at that time. In addition, there is a tradition that continues today, namely the use of the bark of the *Broussonetia papyrifera* (L.) L'Hér. Ex Vent., or better known as the Saeh tree, to be used as traditional clothing for the people of the Bada valley.

The development of the Cultural Conservation site or area also requires environmental management by applying the principle of authenticity so that in selecting plant species, efforts are made to use and cultivate endemic or existing plant species found around the Cultural Conservation site or area. Thus the development of the intended Cultural Conservation area can be carried out in accordance with the principles of Cultural Conservation and environmental preservation.

Conclusion

The value of the diversity index in the Bada Valley Cultural Conservation Area has differences in diversity in each stratum. Tree strata had a diversity index of 1.2, herbaceous strata 1.91, shrub strata 1.32 and vines strata 0.62. The tree, herb and shrub strata are included in the medium diversity criteria because the value is $1.0 \leq H' \leq 3.0$, and the vines stratum has the low diversity criteria because the H' value <1.0. The evenness index for the shrub strata had the highest value, namely 0.95, followed by vines 0.9, herbaceous plants 0.83 and trees 0.61. The highest species richness index was owned by herbaceous plants with a value of 1.42, tree strata 1.33, shrub strata 0.72 and vines strata 0.24. Based on the species richness index criteria, plants in the Bada valley area have low species richness criteria because the R value <3.5. Further research is needed to determine the biodiversity of flora and fauna from cultural areas in Central Sulawesi Province.

Acknowledgments

The authors would like to thank the Regional Government, namely the Head of the Gorontalo Cultural Heritage Preservation Center Drs. Mohammad Natsir, M.Pd, as research grantor and research permit; Regional Government (PEMDA) from the village level, District in Lembah Bada, Poso Regency, Central Sulawesi Province, which has given permission to carry out this research; colleagues and local communities who have assisted in the data collection process in the field, and colleagues at the Gorontalo Cultural Heritage Preservation Center as researchers' discussion partners during the research.

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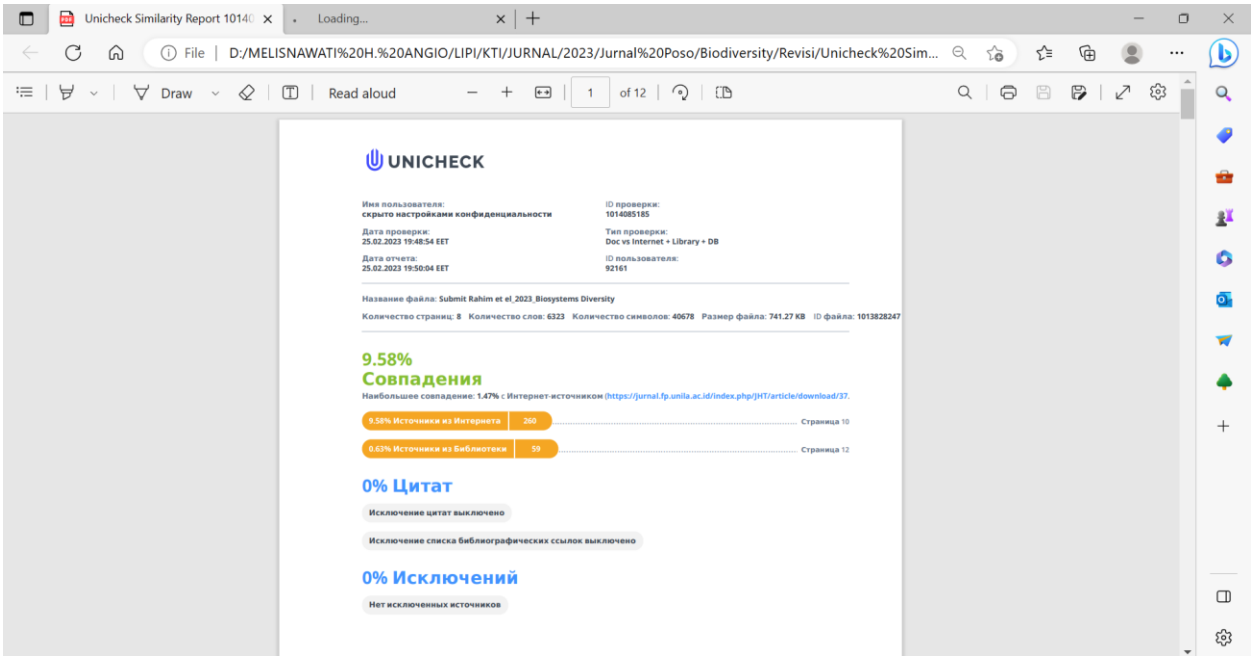

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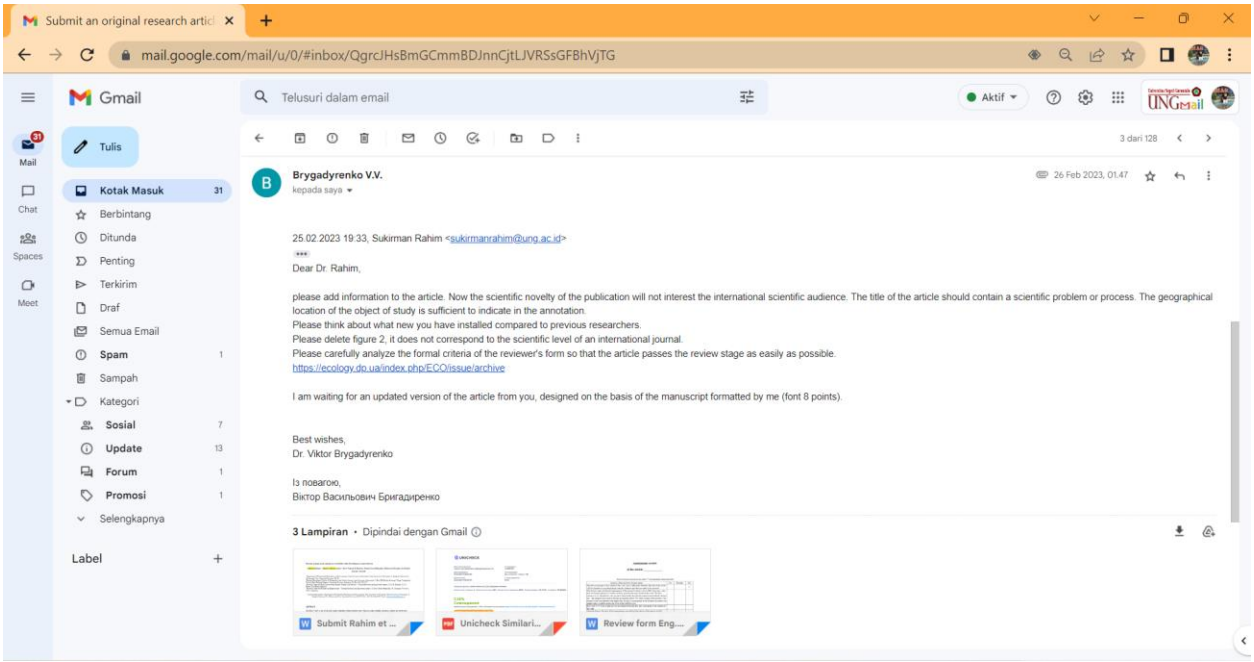

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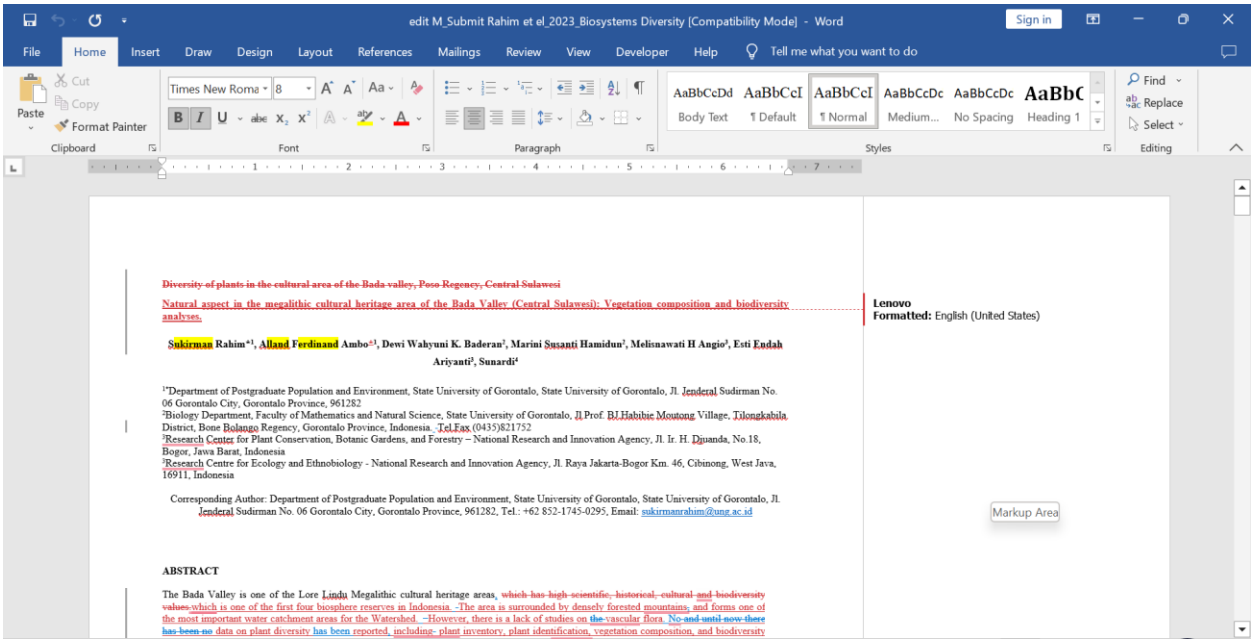

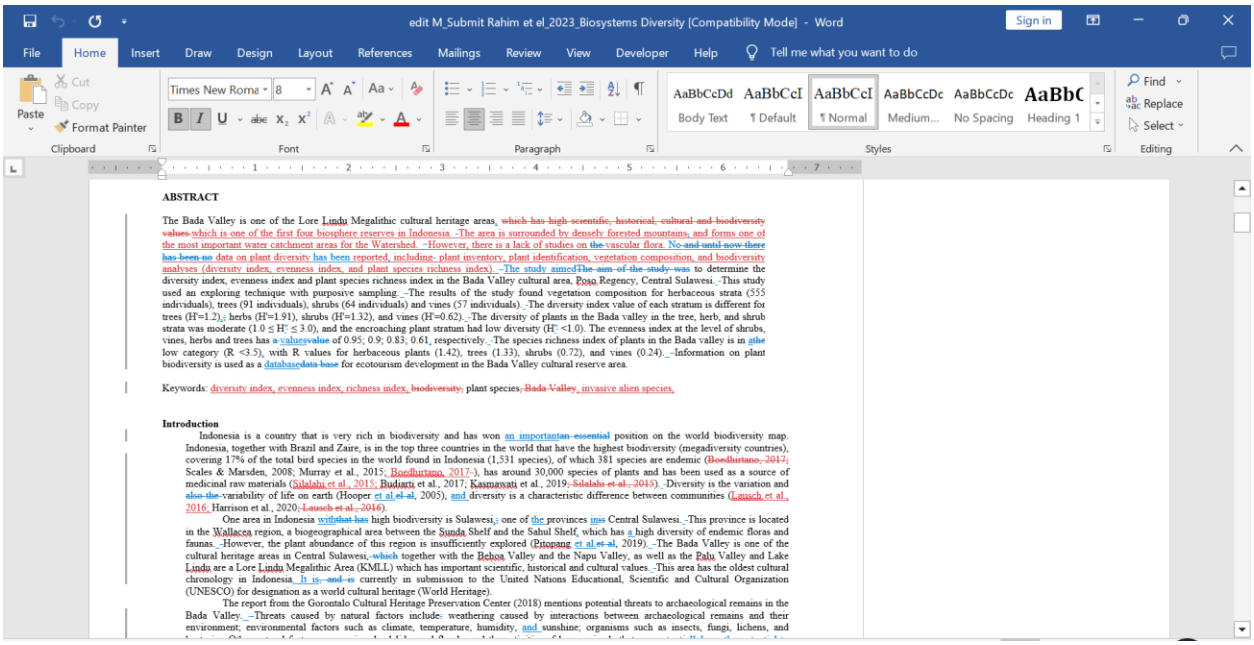

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ABSTRACT

The Bada Valley is one of the Lore Lindu Megalithic cultural heritage areas, ~~which has high scientific, historical, cultural and biodiversity values~~ which is one of the first four biosphere reserves in Indonesia. The area is surrounded by densely forested mountains, and forms one of the most important water catchment areas for the Watershed. However, there is a lack of studies on ~~the~~ vascular flora. ~~No and until now there has been no~~ data on plant diversity has been reported, including plant inventory, plant identification, vegetation composition, and biodiversity analyses (diversity index, evenness index, and plant species richness index). ~~The study aimed~~ ~~The aim of the study was~~ to determine the diversity index, evenness index and plant species richness index in the Bada Valley cultural area, Poso Regency, Central Sulawesi. This study used an exploring technique with purposive sampling. The results of the study found vegetation composition for herbaceous strata (555 individuals), trees (91 individuals), shrubs (64 individuals) and vines (57 individuals). The diversity index value of each stratum is different for trees (H=1.2), herbs (H=1.91), shrubs (H=1.32), and vines (H=0.62). The diversity of plants in the Bada valley in the tree, herb, and shrub strata was moderate ($1.0 \leq H' \leq 3.0$), and the encroaching plant stratum had low diversity ($H' < 1.0$). The evenness index at the level of shrubs, vines, herbs and trees has a ~~values~~ ~~value~~ of 0.95; 0.9; 0.83; 0.61, respectively. The species richness index of plants in the Bada valley is in ~~the~~ low category ($R < 3.5$), with R values for herbaceous plants (1.42), trees (1.33), shrubs (0.72), and vines (0.24). Information on plant biodiversity is used as a ~~database~~ ~~data base~~ for ecotourism development in the Bada Valley cultural reserve area.

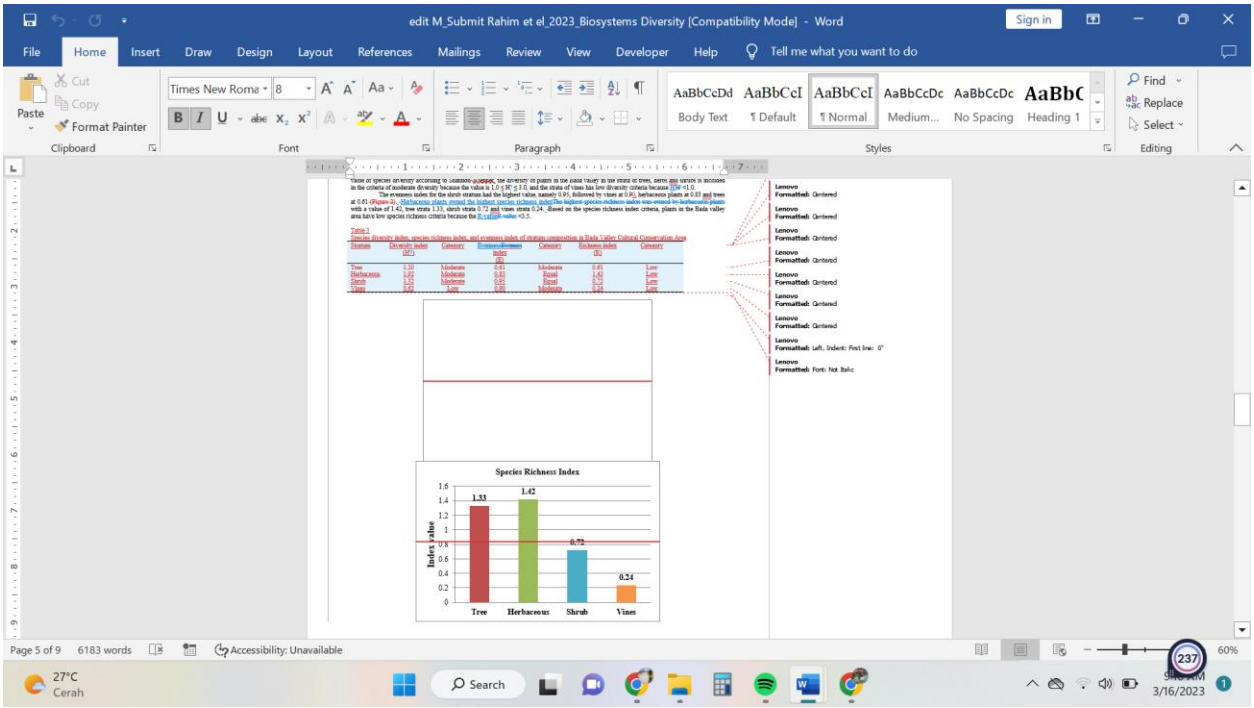
Keywords: ~~diversity index, evenness index, richness index, biodiversity,~~ plant species, ~~Bada Valley, invasive alien species,~~

Introduction

Indonesia is a country that is very rich in biodiversity and has won an ~~important~~ ~~an essential~~ position on the world biodiversity map. Indonesia, together with Brazil and Zaire, is in the top three countries in the world that have the highest biodiversity (megadiversity countries), covering 17% of the total bird species in the world found in Indonesia (1,531 species), of which 381 species are endemic (~~Boedhiarsano, 2017;~~ Scales & Marsden, 2008; Murray et al., 2015; Boedhiarsano, 2017-), has around 30,000 species of plants and has been used as a source of medicinal raw materials (Silalahi et al., 2015; Budiarti et al., 2017; Kasmawati et al., 2019; ~~Silalahi et al., 2015~~). Diversity is the variation and ~~also the~~ variability of life on earth (Hooper et al ~~et al~~ al, 2005), and diversity is a characteristic difference between communities (Lausch et al., 2016; Harrison et al., 2020; ~~Lausch et al., 2016~~).

One area in Indonesia ~~with~~ ~~that has~~ high biodiversity is Sulawesi, one of the provinces ~~inis~~ Central Sulawesi. This province is located in the Wallacea region, a biogeographical area between the Sunda Shelf and the Sahul Shelf, which has a high diversity of endemic floras and faunas. However, the plant abundance of this region is insufficiently explored (Pitopang et al ~~et al~~, 2019). The Bada Valley is one of the cultural heritage areas in Central Sulawesi, ~~which~~ together with the Behoa Valley and the Napu Valley, as well as the Palu Valley and Lake Lindu are a Lore Lindu Megalithic Area (KMLL) which has important scientific, historical and cultural values. This area has the oldest cultural chronology in Indonesia. It is ~~, and is~~ currently in submission to the United Nations Educational, Scientific and Cultural Organization (UNESCO) for designation as a world cultural heritage (World Heritage).

The report from the Gorontalo Cultural Heritage Preservation Center (2018) mentions potential threats to archaeological remains in the Bada Valley. Threats caused by natural factors include: weathering caused by interactions between archaeological remains and their environment; environmental factors such as climate, temperature, humidity, and sunshine; organisms such as insects, fungi, lichens, and



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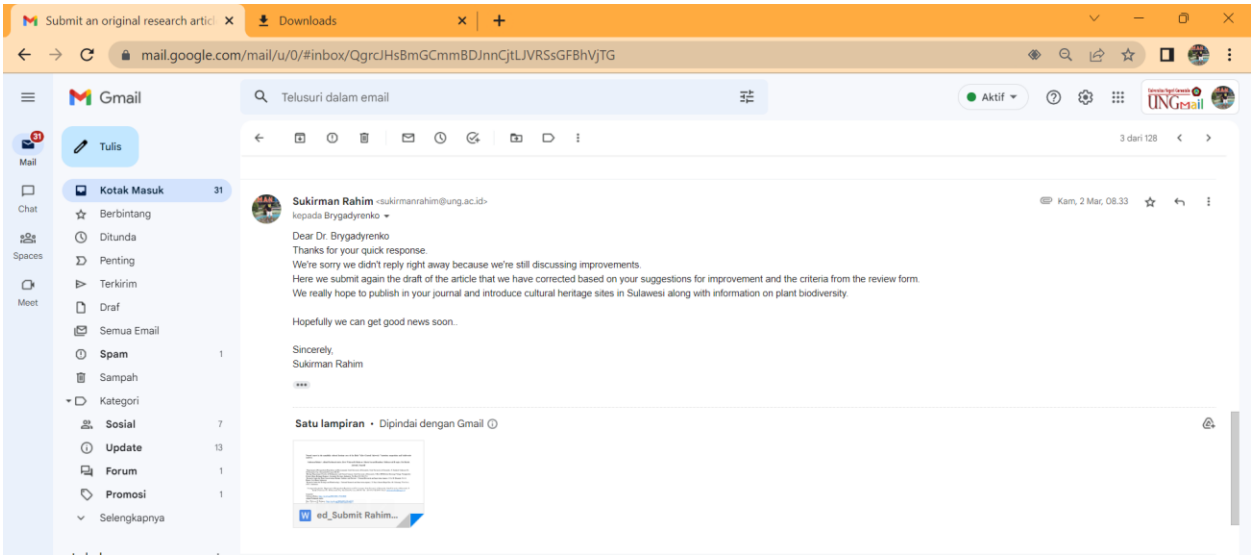

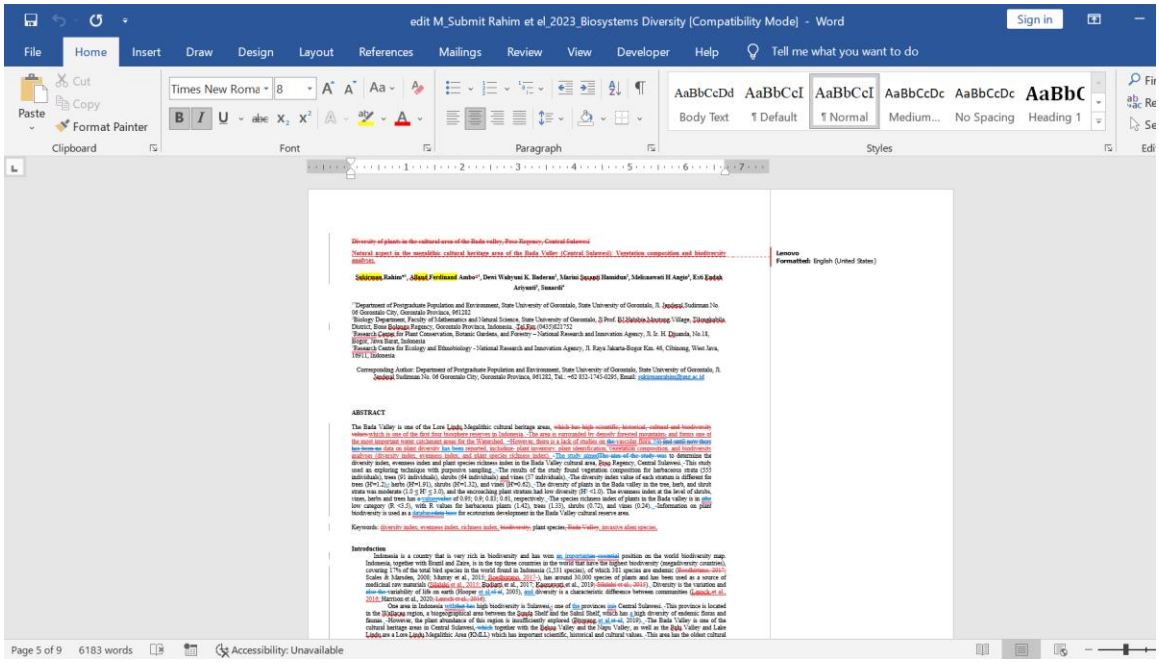

Material and methods

Study area. This research was conducted in the Bada Valley cultural heritage area, Poso Regency, Central Sulawesi Province. Bada Valley is located in South Lore and West Lore Districts, Poso Regency. South Lore District is the capital city of Gintu, and West Lore District with the capital city of Langkeka. Administratively, the Bada Valley is bordered to the north by Lore Tengah District, Poso Regency; to the east by Pamona Puselemba and West Pamona Districts, Poso Regency; to the south by Rampi Seko District, North Luwu Regency, South Sulawesi, and to the west by the District Kulawi, Poso Regency. The total area of the Bada valley is 997.7 km2 (Central Bureau of Statistics, 2022). The map of the Bada Valley Cultural Heritage Area is presented in Figure 1.

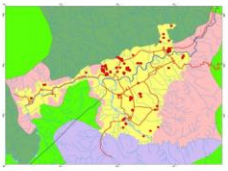

Fig. 1. Research observation point of the Bada Valley Cultural Heritage Area

Bada Valley is a valley surrounded by mountains with an altitude between 750 meters above sea level-1250 meters above sea level with a tropical climate with an average temperature of 22oC-31oC with average air humidity reaching 90%, with an average rainfall of 2000 mm to 4000 mm per year. The geological condition of Poso district, especially in the Bada valley area, consists of rocks of the Tinemba Volcano Formation in the form of Andesite and Andesite Basalt lava rocks resulting from the eruption of submarine volcanoes in the Pliocene to Pleistocene period aged 15 to 2 million years ago. The existence of volcanic activity in the Bada valley area can still be found in the presence of hot springs in Kagerao Village and Langkeka Village, West Lore District.

The research method uses exploring methods for the exploration of plant species. Exploration of the Bada Valley cultural heritage area and observation of all existing plant species, accompanied by digital photographs with a digital camera, was used to collect plant data. Additional information was recorded in the form of the collector's name, collection number, collection date, location, and habitus, which were recorded in the observation sheet that had been prepared. Identification of plants was carried out using the procedure for observing plant morphological characters, which included special features in each class and family or genus down to the species level and then compared with the book Tjitrosoepomo (1985), Harris & Harris (2001), Pitopang et al., (2008) and Steenis (2008). Accepted name validation for each plant species is done using The Plant List website, 2022 (http://www.theplantlist.org/). Identification results were then analyzed by descriptive qualitative. For plant species that have not been identified,

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The role of herbaceous plants in the region has a significant role, among others, when experiencing succession, marked by many pioneer plants and small plants such as herbaceous plants. Herbs play an essential role in the annual nutrient cycle; the herb litter that is returned to the soil contains high levels of nutrients. In addition, herbs are also used as a source of animal feed, medicine and wealth in germplasm. For example, preserving wild animals as a component of an ecosystem is influenced by the presence and diversity of undergrowth as a place to live and a high source of food and many other functions (Schmidt et al., 2019; Alvarez et al., 2022).

The diversity of plants in the Bada valley area is included in the medium and low diversity index criteria. The low diversity is caused by several factors, including the control of the area in the cultural heritage area, soil type, climate, and biotic influences (living things). This actual condition is supported by Compant et al. (2019) statement, which states that plant diversity is influenced by several factors, including climate, soil type, altitude and biotic influences (living things). Furthermore, Dar & Reshi (2020) states that diversity is synonymous with the stability of an ecosystem; that is, if the diversity of an ecosystem is relatively high, the condition of the ecosystem tends to be stable. Ecosystem environments that have diversity disturbances tend to be moderate. In the case of polluted ecosystem environments, species diversity tends to be low.

Geng et al. (2019) state that the higher the species diversity, the more stable the community will be and have a higher ability to deal with disturbances. Furthermore, van der Plas (2019) argued that high species diversity indicates a community has high complexity because the species interactions in that community are very high. A community is said to have high species diversity if the community is composed of many species. Conversely, a community is said to have low species diversity if the community is composed of a few species and only a few dominant species, in line with the statement of Pitopang & Ihsan (2014), which explains that the higher the value of the diversity index, the better the ecosystem in the region.

Based on the analysis of the evenness index of species, the Bada valley area has plants included in the criteria for high species distribution. Evenness index values or Evenness (E) range from 0 to 1 (Magurran, 1988), meaning that the plants in the area can grow and spread throughout the observation sites. The even distribution of plants in this location cannot be separated from the influence of environmental factors. The high level of biodiversity is because Indonesia is a tropical country with high levels of rainfall, temperature and humidity. According to Pramudya (2020), Indonesia has a diversity of flora and fauna due to its geographical location around the equator and between the continents of Asia and Australia, giving rise to the emergence of particular characteristics and characteristics in resources in the form of tropical forest ecosystems. Furthermore, according to Kitayama et al. (2021), tropical forests are located along the equator, that is, in areas with high radiation intensity, with small daily and annual amplitudes.

The value of the Diversity index relates to the value of species richness but is also influenced by the distribution of species abundance. Madole et al. (2019) state that species richness is the number of species in a community. The greater the number of species found, the greater the wealth index.

The richness of plant species in the Bada valley area is classified as low. It has been explained above that the number of species will affect species richness. The number of plant species for each stratum in the Bada valley area is still relatively small, thus affecting species richness. This follows the opinion of Roswell et al. (2021) that a community has high species diversity if the community is composed of many species. Conversely, if the community comprises very few species and only a few dominant species, then the species diversity is low.

Species richness shows all the variations found in living things between species. Differences between species of organisms in one or more families will be visible, making it easier to observe than differences between individuals in one species. Richness at the species level occurs because of the variety of these species. The species richness index is the most straightforward measure because it only considers differences in the number of species in a particular area. Species richness determines the amount of species richness in each community. This was confirmed by Mahaut et al. (2020), who stated that species richness refers to the number of species in a community. The quantity of species in the field determines the size of the richness index. In the context of cultural heritage sites or areas, the presence of certain plant species at the site or area strongly supports the concept of preservation by local values and traditions. Sites identified as places of worship, such as the Sepe Site in Kolori Village and the Suso Site in Lengkeka Village, Lore Barat District, are, of course, closely related to the use of certain plant species in carrying out worship ceremonies or rituals following the beliefs that developed at that time. In addition, a tradition continues today, namely the use of the bark of the *Broussonetia papyrifera* (L.) L'Her. Ex Vent., better known as the Saeh tree, to be used as traditional clothing for the people of the Bada valley.

Developing the Cultural Conservation site or area also requires environmental management by applying the principle of authenticity. In

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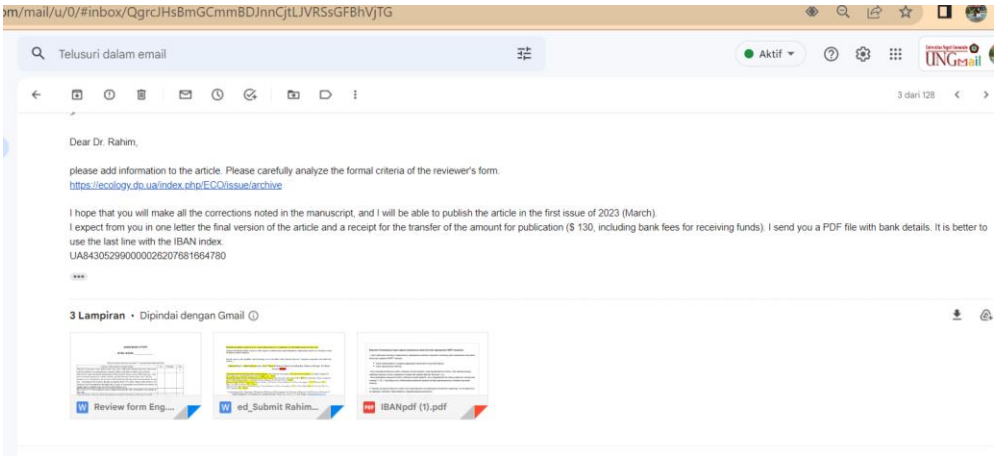

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Natural aspect in the megalithic cultural heritage area of the Bada Valley (Central Sulawesi): Vegetation composition and biodiversity analyses.

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ABSTRACT

Структура аннотации не соответствует требованиям бланка рецензента

The Bada Valley is one of the Lore Lindu Megalithic cultural heritage areas, which is one of the first four biosphere reserves in Indonesia. The area is surrounded by densely forested mountains and forms one of the most important water catchment areas for the Watershed. However, there is a lack of studies on vascular flora. No data on plant diversity has been reported, including plant inventory, plant identification, vegetation composition, and biodiversity analyses (diversity index, evenness index, and plant species richness index). The study aimed to determine the diversity index, evenness index and plant species richness index in the Bada Valley cultural area, Poso Regency, Central Sulawesi. This study used an exploring technique with purposive sampling. The results of the study found vegetation composition for herbaceous strata (555 individuals), trees (91 individuals), shrubs (64 individuals) and vines (57 individuals). The diversity index value of each stratum is different for trees (H'=1.20), herbs (H'=1.92), shrubs (H'=1.32), and vines (H'=0.62). The diversity of plants in the Bada valley in the tree, herb, and shrub strata was moderate ($1.0 \leq H' \leq 3.0$), and the encroaching plant stratum had low diversity ($H' < 1.0$). The evenness index at the level of shrubs, vines, herbs and trees has values of 0.95; 0.90; 0.83; 0.61, respectively. The species richness index of plants in the Bada valley is in a low category ($R < 3.5$), with R values for herbaceous plants (1.42), trees (1.33), shrubs (0.72), and vines (0.24). Information on plant biodiversity is used as a database for ecotourism development in the Bada Valley cultural reserve area.

Keywords: diversity index, evenness index, richness index, plant species, invasive alien species добавьте еще 5-6 слов

Introduction

Indonesia is a country that is very rich in biodiversity and has won an important position on the world biodiversity map. Indonesia, together with Brazil and Zaire, is in the top three countries in the world that have the highest biodiversity (megadiversity countries), covering 17% of the total bird species in the world found in Indonesia (1,531 species), of which 381 species are endemic (Scales & Marsden, 2008; Murray et al., 2015; Boedhirtano, 2017), has around 30,000 species of plants and has been used as a source of medicinal raw materials (Silalahi et al., 2015; Budiarti et al., 2017; Kasmawati et al., 2019). Diversity is the variation and variability of life on earth (Hooper et al., 2005), and diversity is a characteristic difference between communities (Lausch et al., 2016; Harrison et al., 2020).

One area in Indonesia with high biodiversity is Sulawesi, one of the provinces in Central Sulawesi. This province is located in the Wallacea region, a biogeographical area between the Sunda Shelf and the Sahul Shelf, which has a high diversity of endemic floras and faunas. However, the plant abundance of this region is insufficiently explored (Baderan et al., 2021; Pitopang et al., 2019). The Bada Valley is one of the cultural heritage areas in Central Sulawesi, together with the Behoa Valley and the Napu Valley, as well as the Palu Valley and Lake Lindu are a Lore Lindu Megalithic Area (KMLL) which has important scientific, historical and cultural values. This area has the oldest cultural chronology in Indonesia. It is currently in submission to the United Nations Educational, Scientific and Cultural Organization (UNESCO) for designation as a world cultural heritage (World Heritage).

The report from the Gorontalo Cultural Heritage Preservation Center (2018) mentions potential threats to archaeological remains in the Bada Valley. Threats caused by natural factors include weathering caused by interactions between archaeological remains and their environment; environmental factors such as climate, temperature, humidity, and sunshine; organisms such as insects, fungi, lichens, and bacteria. Other natural factors are erosion, landslides and floods, and the activities of large animals that can potentially damage these objects. In addition to natural factors, human activities also have the potential to threaten the existence of these archaeological remains. Destruction and theft, vandalism, mining activities, agricultural land clearing, plantations and development (Satrija et al., 2015).

Mining activities in the Bada Valley Cultural Heritage area are spread over four villages: Bulili Village, Badangkaia Village, Bewa Village and Gintu Village, which were discovered in 2017. The perpetrators of this illegal mining are not only the local people of the Bada valley but also come from outside the Bada Valley or the Poso Regency. Using trommel, mercury, and other materials in mining will damage the environment. The impact of this activity is frequent flooding, landslides, and destruction of the habitat of various species of animals, including endemic birds such as the Maleo bird, Babirusa, and Anoa, also hundreds of other species of animals that have been living and breeding in the forest in the Lore Lindu National Park area.

In addition to human activities, one of the causes of the decline in biodiversity is the invasion of alien species. Invasive alien species are species of flora, fauna, microorganisms and pathogens originating from outside their original habitat that enters new areas and can cause harm to ecosystems or the environment, the economy and public health (CBD, 2000). Approximately 300 species of weeds have become invasive and have been found in Indonesia (Widjaja et al. 2014; Setyawati et al. 2015;). The percentage of successful weed species becoming dominant and causing negative impacts on new habitats is 10% (Sitepu, 2020).

The lack of attention to plant biodiversity has become the reason for researching the biodiversity index of the Bada valley cultural reserve area. Data on plant diversity is complementary to realizing the development of ecotourism in Central Sulawesi Province.

Material and methods

Study area. This research was conducted in the Bada Valley cultural heritage area, Poso Regency, Central Sulawesi Province. Bada Valley is located in South Lore and West Lore Districts, Poso Regency. South Lore District is the capital city of Gintu, and West Lore District with the capital city of Langkeka. Administratively, the Bada Valley is bordered to the north by Lore Tengah District, Poso Regency; to the east by Pamona Puselemba and West Pamona Districts, Poso Regency; to the south by Rampi Seko District, North Luwu Regency, South Sulawesi, and to the west by the District Kulawi, Poso Regency. The total area of the Bada valley is 997.7 km2 (Central Bureau of Statistics, 2022). The map of the Bada Valley Cultural Heritage Area is presented in Figure 1. Не рекомендуется оформлять ссылку на рисунок или таблицу в виде отдельного предложения, не содержащего никакой другой информации.

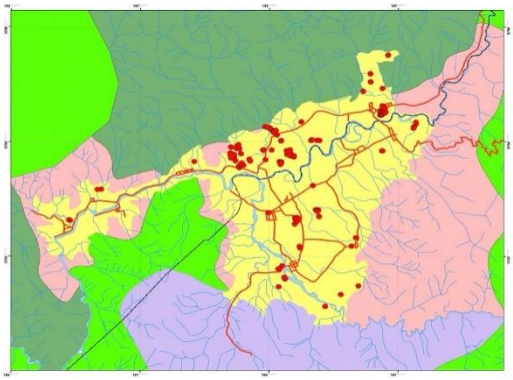

Fig. 1. Research observation point of the Bada Valley Cultural Heritage Area

Bada Valley is a valley surrounded by mountains with an altitude between 750 meters above sea level-1250 meters above sea level with a tropical climate with an average temperature of 22oC-31oC with average air humidity reaching 90%, with an average rainfall of 2000 mm to 4000 mm per year. The geological condition of Poso district, especially in the Bada valley area, consists of rocks of the Tinemba Volcano Formation in the form of Andesite and Andesite Basalt lava rocks resulting from the eruption of submarine volcanoes in the Pliocene to Pleistocene period aged 15 to 2 million years ago. The existence of volcanic activity in the Bada valley area can still be found in the presence of hot springs in Kagerao Village and Langkeka Village, West Lore District.

The research method uses exploring methods for the exploration of plant species. Exploration of the Bada Valley cultural heritage area and observation of all existing plant species, accompanied by digital photographs with a digital camera, was used to collect plant data. Additional information was recorded in the form of the collector's name, collection number, collection date, location, and habitus, which were recorded in

the observation sheet that had been prepared. Identification of plants was carried out using the procedure for observing plant morphological characters, which included special features in each class and family or genus down to the species level and then compared with the book Tjitrosoepomo (1985), Harris & Harris (2001), Pitopang et al., (2008) and Steenis (2008). Accepted name validation for each plant species is done using The Plant List website, 2022 (http://www.theplantlist.org/). Identification results were then analyzed by descriptive qualitative. For plant species that have not been identified, herbarium specimens were made by taking plant parts cleaned of soil, fungus or foreign material adhering to them. Identification of invasive plant species was carried out based on the Guide to The Naturalized and Invasive Plants of Southeast Asia (Witt, 2017) and the CABI Compendium Invasive Species (https://www.cabidigitallibrary.org/product/qi).

Data analysis

Species Diversity Index

Data on the diversity of plant species is identified through the Diversity Index (H') (Shannon & Wiener, 1963; Fachrul, 2012).

$$H' = -\sum_{i=1}^{S} \text{pi}\, ln\, \text{pi} \quad \text{where: pi} = \frac{ni}{N}$$

Description: H' (Shannon-Wienner diversity index), *S* (Number of species), ni (Number of individuals in one species), *ln* (Natural logarithm), N (Total number of individual species found). The value of H' determines the level of species diversity in an area, where the definition of the value of species diversity according to Shannon-Wienner is: H'> 3: high species diversity, 1 ≤ H' ≤ 3: medium species diversity, H' < 1: Low species diversity.

Species Evenness Index

The evenness index of species refers to the *Pielow evenness indices* formula (Ludwig & Reynolds 1988), namely: E = H'/ln S, where E (Evenness Index), and H' (Shannon-Wienner diversity index)

Species Richness Index (R1)

The species richness index uses the Margalef formula (Magurran, 1988), namely, $R_1 = \frac{(S-1)}{(\ln(N))}$, where R1 (Wealth Index), S (Number of species found), and N (total number of individuals)

Results

Vegetation Composition

Plants dominate the vegetation composition in the Bada valley area with herbaceous strata with a total of 555 individuals, then tree strata of 91 individuals, shrubs of 64 individuals and vines of 57 individuals. The composition of plants in the Bada valley is presented in Table 1.

Table 1
Composition of Plants in the Bada Valley Area

Stratum	Species	Local name	Individual number	Uses
Tree	*Antidesma ghaesembilla* Gaertn.	Tumbuhan Buni.	62	Buni plants are widely used as a traditional medicine to treat high blood pressure, palpitations, anaemia, syphilis
	Cryptocarya sp.	Kayu masohi	6	This plant treats fever and stomach cramps and relieves joint pain.
	Bischofia javanica Blume	Bintungan	3	The bark of the plant is used to lower blood cholesterol levels and treat diarrhoea
	Premna serratifolia L.	Bebuas	4	Water decoction of the leaves of this plant is used to treat fever

	Casearia sp.	Hulu tulang	3	The benefits of this plant are used as natural dyes and also used as ornamental plants
	Melia azedarach L.	Renceh	8	Medication to lower high blood pressure
	Psidium guajava L.	Jambu biji	6	Diarrhoea and cough medicine
	Total	???	**91**	????
Herbs	*Euphorbia hirta* L.	Tanaman asma	34	Benefits of this plant can overcome asthma, malaria drugs and wound-healing drugs.
	Ageratum conyzoides (L.) L.	Babandotan	183	The benefits of this plant can be used as a wound healer, leprosy and ulcers
	Chromolaena odorata (L.) R.M.King & H.Rob.	Krinyuh	88	The benefits of this plant can be used as a wound healing drug and can stop bleeding quickly
	Stachytarpheta cayennensis (Rich.) Vahl	Pecut kuda	56	Used as a medicine for malaria, fever and diabetes
	Crotalaria trichotoma Bojer	Orok-orok	16	Utilized as animal feed and potentially as green manure.
	Erigeron sp.	Jabung	13	can treat pain due to rheumatism, has a soothing effect, and heals wounds, so now it is widely used in cosmetic products
	Melastoma malabathricum L.	Senduduk	9	It can be used to treat burns
	Tridax procumbens L.	Songgolangit	104	It can be used to treat gout, aching rheumatic pain and gout
	Euphorbia heterophylla L.	Daun katemas	24	Used to treat asthma, constipation and bronchitis
	Crassocephalum crepidioides (Benth.) S.Moore	Daun sintrong	28	Can increase immunity
	Total	???	**555**	???
Shrub	*Syzygium paniculatum* Gaertn.	Pucuk merah	20	The benefits of this plant can improve immune function and can lower blood sugar levels
	Ixora coccinea L.	Asoka	10	Used for wound healing
	Ricinus communis L.	Daun jarak	11	It can be used to launch defecation
	Broussonetia papyrifera (L.) L'Hér. ex Vent.	Pohon saeh	23	The bark of this plant is used as a primary ingredient in making traditional clothes for the people of the Bada Valley.
	Total		**64**	

	Calopogonium mucunoides Desv.	Kalopo	39	It can be used as green manure and as a land cover plant
Vines	*Scurrula parasitica* L.	Benalu	18	The benefits of this plant have the potential as anticancer, antimalarial and medicine for haemorrhoids and diarrhoea
	Total		**57**	

Source: Data Primer, 2022

Based on the results of the identification of plant species composition, several species were identified as invasive species. Some of these species are foreign species whose natural habitat is outside the Southeast Asian region.

Table 2
Identified Invasive Species in the Bada Valley Region
Эта таблица содержит ссылки на литературу. В разделе Результаты ссылки на литературу содержаться не могут. Рекомнедую переместить таблицу в раздел Обсуждение.

No	Species	Invasiveness	Information
1	*Melia azedarach* L.	Invasive	This species is native or originates from the Southeast Asia region but has the potential as an invasive alien species in several areas outside its natural habitat. *M. azedarach* is fast-growing and has few natural enemies. Seeds spread this species by birds and other animals. It has been reported as an invasive species in several locations in the Americas, Pacific and Africa, South Africa and Hawaii, USA. This species is difficult to control because of its ability to grow again vegetatively (Bhat et al., 2021).
2	*Euphorbia hirta* L.	Invasive	It is a weed or invasive species on agricultural land and hosts several pests and plant diseases (Tripathi et al., 2021).
3	*Ageratum conyzoides* (L.) L.	Invasive	*A. conyzoides* is reported as an invasive and harmful weed in agricultural fields. This species tends to invade open or degraded land. This species causes a decrease in crop yields and affects biodiversity, and is a host of pathogens and nematodes that affect several types of crops (Kohli et al., 2006).
4	*Chromolaena odorata* (L.) R.M. King & H. Rob.	Invasive	*C. odorata* is a species of herb or shrub with a wide distribution. This species is included as one of the 100 dangerous invasive species in the world. This species will quickly spread and invade new areas that are degraded through seeds easily carried by the wind (Yu et al., 2016).
5	*Stachytarpheta cayennensis* (Rich.) Vahl	Invasive	*S. cayenneensis* originates from South and Central America and the Caribbean. This species is widely introduced to various regions because it has attractive flowers. *S. cayenneensis* has a broad environmental tolerance and often invades disturbed areas, thereby overpowering native flora. This species is considered a noxious weed in the Northern Territory, Australia and is increasingly abundant in Florida, USA. According to the risk assessment, this species is considered highly invasive (score 20 = high risk) (Chandler et al., 2014).
6	*Melastoma malabathricum* L.	Invasive	*M. malabathricum* is known as a weed on mahogany (*Swietenia macrophylla*) in Sumatra, Indonesia (Master et al., 2020). It is a primary weed commonly found growing in industrial plantation forests. *M. malabathricum* is registered as a Federal Noxious Weed in the US.
7	*Euphorbia heterophylla* L.	Invasive	According to Utami et al. (2017), *E. heterophylla* is a major weed in Fiji, Ghana, Mexico, Philippines, Indonesia and Thailand, Brazil, India, Italy, Papua New Guinea, Cuba, Honduras, Peru, Uganda and the United States. This species harms several crops, including cocoa, coffee, cotton, cowpea, corn, papaya, peanuts, sorghum, soybeans, sugarcane, tea, and upland rice. It has fast growth, and it is easy to compete in getting light, water and nutrients.

8	*Crassocephalum crepidioides* (Benth.) S.Moore	Invasive	*C. crepidiodes* is an invasive species included in the Global Compendium of Weeds as one of the most aggressive weeds in tropical and subtropical regions (Dong et al., 2010). It is a pioneer species that can produce large numbers of downy seeds dispersed by the wind.
9	*Syzygium paniculatum* Gaertn.	Alien Invasive	It is an invasive foreign species. This species' original habitat is Australia's territory (Ramirez & Kallarackal, 2019).
10	*Calopogonium mucunoides* Desv.	Invasive	*C. mucunoides* is a woody plant listed in the Global Compendium of Weeds that impacts agricultural and semi-natural ecosystems. *C. mucunoides* has been widely introduced as a forage legume and nitrogen-fixing plant in tropical and subtropical regions (Feitoza et al., 2018). *C. mucunoides* can potentially kill native vegetation and food crops in agricultural areas. Currently, *C. mucunoides* is classified as a noxious weed in Australia and an invasive species in Malaysia, the Philippines, Puerto Rico, and several islands in the Pacific Ocean, such as French Polynesia, Cook Islands, Samoa, Palau, and the Solomon Islands.

Diversity, Evenness, Species Richness

The value of the diversity index in the Bada Valley Cultural Conservation Area has differences in diversity in each stratum. The tree strata had a diversity index of 1.20, the herbaceous strata 1.92, the shrub strata 1.32 and the vines strata 0.62 (Table 2). Based on the criteria for the value of species diversity according to Shannon-Wienner, the diversity of plants in the Bada valley in the strata of trees, herbs and shrubs is included in the criteria of moderate diversity because the value is $1.0 \leq H' \leq 3.0$, and the strata of vines has low diversity criteria because $H' < 1.0$.

The evenness index for the shrub stratum had the highest value, namely 0.95, followed by vines at 0.90, herbaceous plants at 0.83 and trees at 0.61. Herbaceous plants owned the highest species richness index with a value of 1.42, tree strata 1.33, shrub strata 0.72 and vines strata 0.24. Based on the species richness index criteria, plants in the Bada valley area have low species richness criteria because the R-value <3.5.

Table 3

Species diversity index, species richness index, and evenness index of stratum composition in Bada Valley Cultural Conservation Area

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Stratum	Diversity index (H')	Category	Evenness index (E)	Category	Richness index (R)	Category
Tree	1.20	Moderate	0.61	Moderate	1.33	Low
Herbaceous	1.92	Moderate	0.83	Equal	1.42	Low
Shrub	1.32	Moderate	0.95	Equal	0.72	Low
Vines	0.62	Low	0.90	Moderate	0.24	Low

Discussion

The herbaceous strata are the plants with the highest diversity index value in the Bada valley. Herbaceous strata dominate the area with a total of 555 individuals. Herbaceous plants have a height or stem length of 0.3 – 2 meters and have wet or soft trunks because they have a lot of water content. The high composition of herbaceous plants is closely related to the excellent adaptability of these plants in both tropical and subtropical environmental conditions. Herbaceous plants can be dispersed easily in groups with the same individual or solitary in a variety of different habitat conditions, such as moist or watery soil dry, rocks and habitats with less dense or open shade (Zelnik, 2012; Aguilar et al., 2019; Lelli et al., 2019).

Herbaceous plants have strong competitiveness and high adaptation to the surrounding plants (such as bushes, shrubs, and even trees), so they can grow in empty places. Herbaceous plants in different habitats are very different in the amount that an area can produce with different habitats, such as habitats with high humidity to dry areas (Litza & Diekmann, 2019; Träger et al., 2019; Spicer et al., 2022).

The dominating plant is the *Ageratum conyzoides* (L.) L. This plant can spread quickly from the wind and by insects and active humans in that location. This plant also has speedy growth and is relatively small compared to other herbaceous plants. According to (Shen et al., 2019), herbaceous plants whose body size is relatively tiny could get a more expansive living space, thus enabling the life of more individuals (wealth) and more species (diversity).

The role of herbaceous plants in the region has a significant role, among others, when experiencing succession, marked by many pioneer plants and small plants such as herbaceous plants. Herbs play an essential role in the annual nutrient cycle; the herb litter that is returned to the soil contains high levels of nutrients. In addition, herbs are also used as a source of animal feed, medicine and wealth in germplasm. For

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The diversity of plants in the Bada valley area is included in the medium and low diversity index criteria. The low diversity is caused by several factors, including the control of the area in the cultural heritage area, soil type, climate, and biotic influences (living things). This actual condition is supported by Compant et al. (2019) statement, which states that plant diversity is influenced by several factors, including climate, soil type, altitude and biotic influences (living things). Furthermore, Dar & Reshi (2020) states that diversity is synonymous with the stability of an ecosystem; that is, if the diversity of an ecosystem is relatively high, the condition of the ecosystem tends to be stable. Ecosystem environments that have diversity disturbances tend to be moderate. In the case of polluted ecosystem environments, species diversity tends to be low.

Geng et al. (2019) state that the higher the species diversity, the more stable the community will be and have a higher ability to deal with disturbances. Furthermore, van der Plas (2019) argued that high species diversity indicates a community has high complexity because the species interactions in that community are very high. A community is said to have high species diversity if the community is composed of many species. Conversely, a community is said to have low species diversity if the community is composed of a few species and only a few dominant species, in line with the statement of Pitopang & Ihsan (2014), which explains that the higher the value of the diversity index, the better the ecosystem in the region.

Based on the analysis of the evenness index of species, the Bada valley area has plants included in the criteria for high species distribution. Evenness index values or Evenness (E) range from 0 to 1 (Magurrann, 1988), meaning that the plants in the area can grow and spread throughout the observation sites. The even distribution of plants in this location cannot be separated from the influence of environmental factors. The high level of biodiversity is because Indonesia is a tropical country with high levels of rainfall, temperature and humidity. According to Pramudya (2020), Indonesia has a diversity of flora and fauna due to its geographical location around the equator and between the continents of Asia and Australia, giving rise to the emergence of particular characteristics and characteristics in resources in the form of tropical forest ecosystems. Furthermore, according to Kitayama et al. (2021), tropical forests are located along the equator, that is, in areas with high radiation intensity, with small daily and annual amplitudes.

The value of the Diversity index relates to the value of species richness but is also influenced by the distribution of species abundance. Midolo et al. (2019) state that species richness is the number of species in a community. The greater the number of species found, the greater the wealth index.

The richness of plant species in the Bada valley area is classified as low. It has been explained above that the number of species will affect species richness. The number of plant species for each stratum in the Bada valley area is still relatively small, thus affecting species richness. This follows the opinion of Roswell et al. (2021) that a community has high species diversity if the community is composed of many species. Conversely, if the community comprises very few species and only a few dominant species, then the species diversity is low.

Species richness shows all the variations found in living things between species. Differences between species of organisms in one or more families will be visible, making it easier to observe than differences between individuals in one species. Richness at the species level occurs because of the variety of these species. The species richness index is the most straightforward measure because it only considers differences in the number of species in a particular area. Species richness determines the amount of species richness in each community. This was confirmed by Mahaut et al. (2020), who stated that species richness refers to the number of species in a community. The quantity of species in the field determines the size of the richness index. In the context of cultural heritage sites or areas, the presence of certain plant species at the site or area strongly supports the concept of preservation by local values and traditions. Sites identified as places of worship, such as the Sepe Site in Kolori Village and the Suso Site in Lengkeka Village, Lore Barat District, are, of course, closely related to the use of certain plant species in carrying out worship ceremonies or rituals following the beliefs that developed at that time. In addition, a tradition continues today, namely the use of the bark of the *Broussonetia papyrifera* (L.) L'Hér. Ex Vent., better known as the Saeh tree, to be used as traditional clothing for the people of the Bada valley.

Developing the Cultural Conservation site or area also requires environmental management by applying the principle of authenticity. In selecting plant species, efforts are made to use and cultivate endemic or existing plant species around the Cultural Conservation site or area. Thus, the intended Cultural Conservation area can be developed under the principles of Cultural Conservation and environmental preservation.

Conclusion

The value of the diversity index in the Bada Valley Cultural Conservation Area has differences in diversity in each stratum. Tree strata had a diversity index of 1.2, herbaceous strata 1.91, shrub strata 1.32 and vines strata 0.62. The tree, herb and shrub strata are included in the medium diversity criteria because the value is $1.0 \leq H' \leq 3.0$, and the vines stratum has the low diversity criteria because the H' value <1.0. The evenness index for the shrub strata had the highest value, namely 0.95, followed by vines at 0.9, herbaceous plants at 0.83 and treat es at 0.61. Herbaceous plants owned the highest species richness index with a value of 1.42, tree strata 1.33, shrub strata 0.72 and vines strata 0.24. Based on the species richness index criteria, plants in the Bada valley area have low species richness criteria because the R-value <3.5. Further research is needed to determine the biodiversity of flora and fauna from cultural areas in Central Sulawesi Province.

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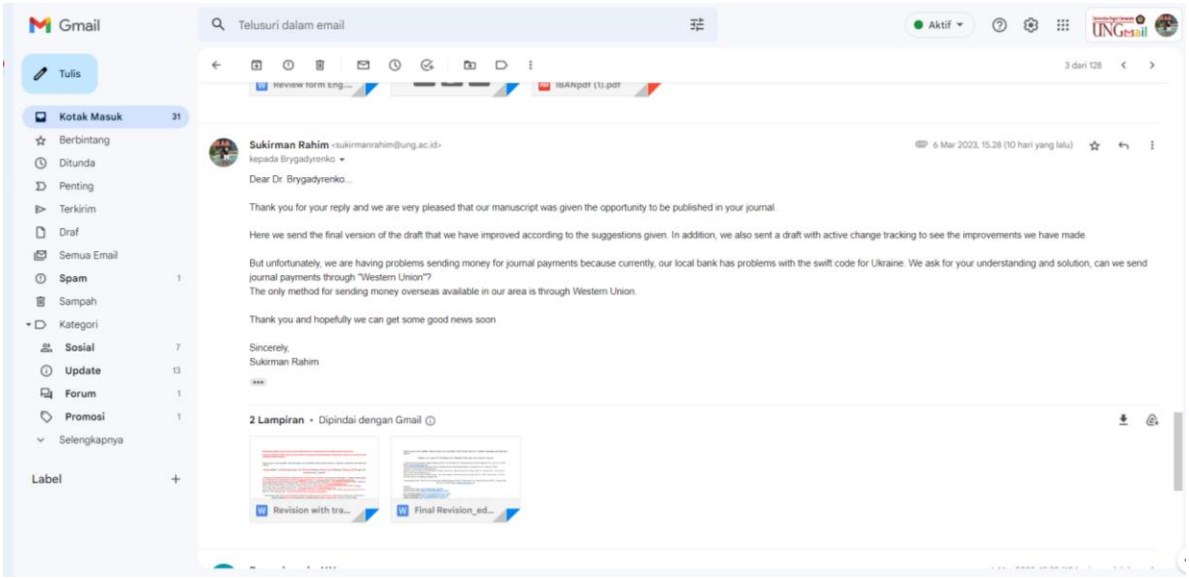

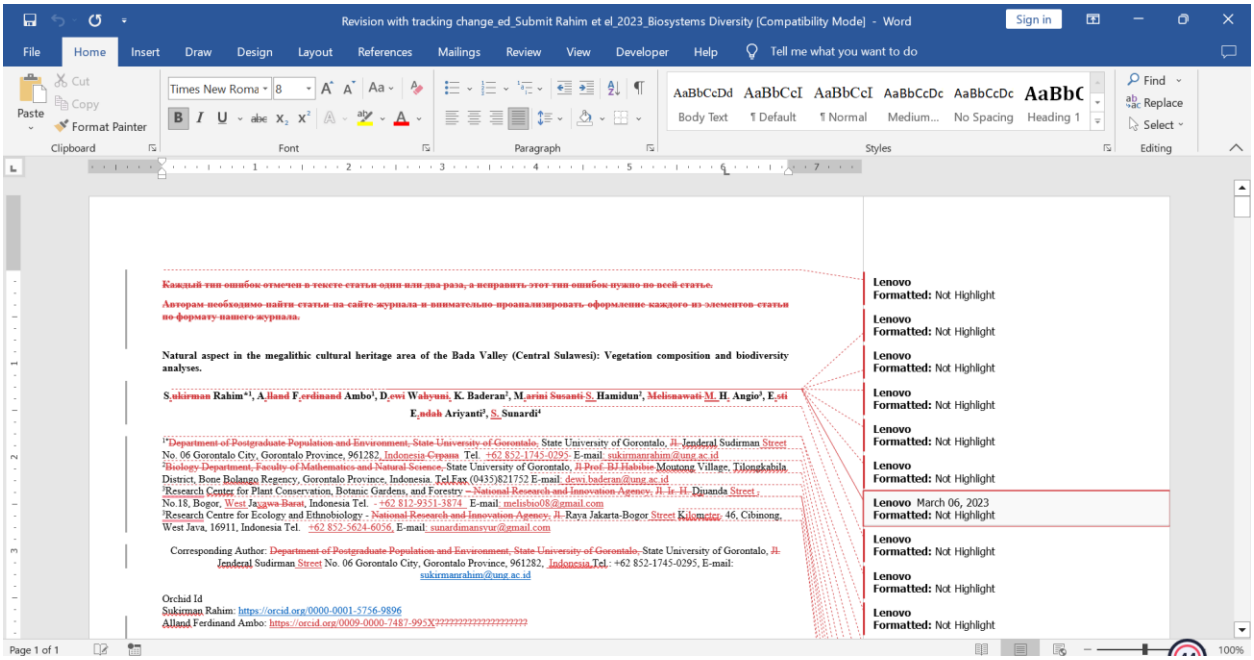

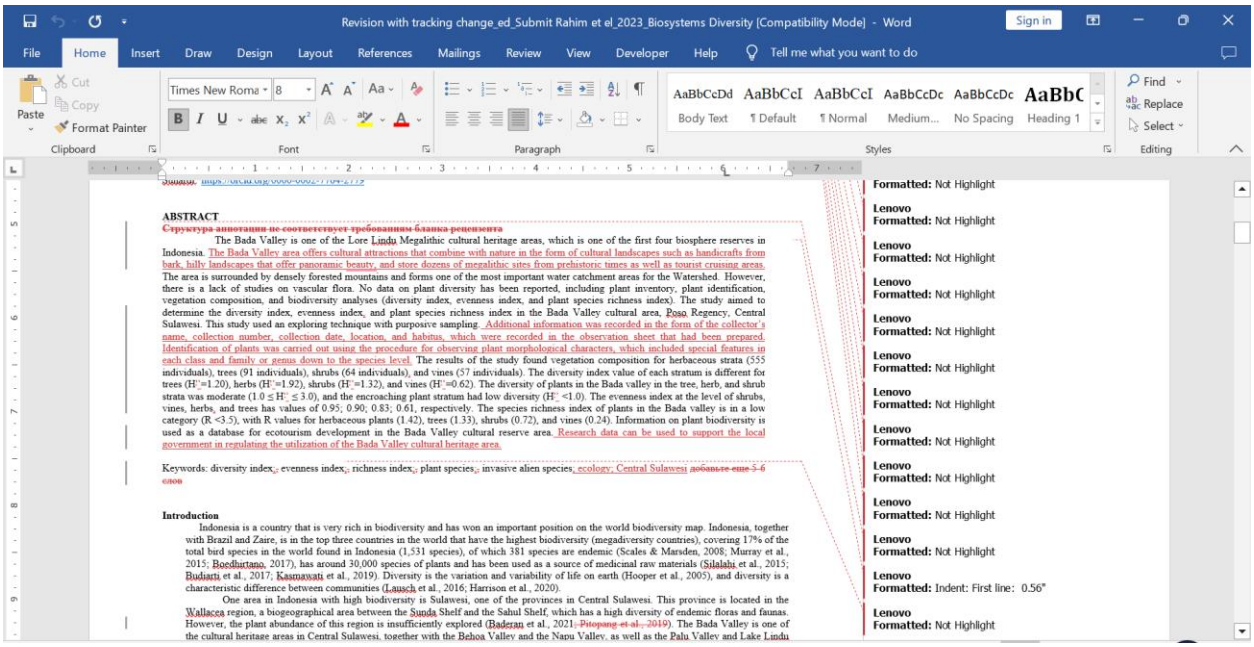
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ABSTRACT
Структура аннотации не соответствует требованиям бланка рецензента
The Bada Valley is one of the Lore Lindu Megalithic cultural heritage areas, which is one of the first four biosphere reserves in Indonesia. The Bada Valley area offers cultural attractions that combine with nature in the form of cultural landscapes such as handicrafts from bark, hilly landscapes that offer panoramic beauty, and store dozens of megalithic sites from prehistoric times as well as tourist crussing areas. The area is surrounded by densely forested mountains and forms one of the most important water catchment areas for the Watershed. However, there is a lack of studies on vascular flora. No data on plant diversity has been reported, including plant inventory, plant identification, vegetation composition, and biodiversity analyses (diversity index, evenness index, and plant species richness index). The study aimed to determine the diversity index, evenness index, and plant species richness index in the Bada Valley cultural area, Poso Regency, Central Sulawesi. This study used an exploring technique with purposive sampling. Additional information was recorded in the form of the collector's name, collection number, collection date, location, and habitus, which were recorded in the observation sheet that had been prepared. Identification of plants was carried out using the procedure for observing plant morphological characters, which included special features in each class and family or genus down to the species level. The results of the study found vegetation composition for herbaceous strata (555 individuals), trees (91 individuals), shrubs (64 individuals), and vines (57 individuals). The diversity index value of each stratum is different for trees (H'=1.20), herbs (H'=1.92), shrubs (H'=1.32), and vines (H'=0.62). The diversity of plants in the Bada valley in the tree, herb, and shrub strata was moderate (1.0 ≤ H' ≤ 3.0), and the encroaching plant stratum had low diversity (H' <1.0). The evenness index at the level of shrubs, vines, herbs, and trees has values of 0.95; 0.90; 0.83; 0.61, respectively. The species richness index of plants in the Bada valley is in a low category (R <3.5), with R values for herbaceous plants (1.42), trees (1.33), shrubs (0.72), and vines (0.24). Information on plant biodiversity is used as a database for ecotourism development in the Bada Valley cultural reserve area. Research data can be used to support the local government in regulating the utilization of the Bada Valley cultural heritage area.
Keywords: diversity index, evenness index, richness index, plant species, invasive alien species, ecology; Central Sulawesi дополнительно 5-6 слов
Introduction
Indonesia is a country that is very rich in biodiversity and has won an important position on the world biodiversity map. Indonesia, together with Brazil and Zaire, is in the top three countries in the world that have the highest biodiversity (megadiversity countries), covering 17% of the total bird species in the world found in Indonesia (1,531 species), of which 381 species are endemic (Scales & Marsden, 2008; Murray et al., 2015; Boedhiartono, 2017), has around 30,000 species of plants and has been used as a source of medicinal raw materials (Silalahi et al., 2015; Budiarti et al., 2017; Kasmawati et al., 2019). Diversity is the variation and variability of life on earth (Hooper et al., 2005), and diversity is a characteristic difference between communities (Lausch et al., 2016; Harrison et al., 2020).
One area in Indonesia with high biodiversity is Sulawesi, one of the provinces in Central Sulawesi. This province is located in the Wallacea region, a biogeographical area between the Sunda Shelf and the Sahul Shelf, which has a high diversity of endemic floras and faunas. However, the plant abundance of this region is insufficiently explored (Baderan et al., 2021; Pitopang et al., 2019). The Bada Valley is one of the cultural heritage areas in Central Sulawesi, together with the Behoa Valley and the Napu Valley, as well as the Palu Valley and Lake Lindu
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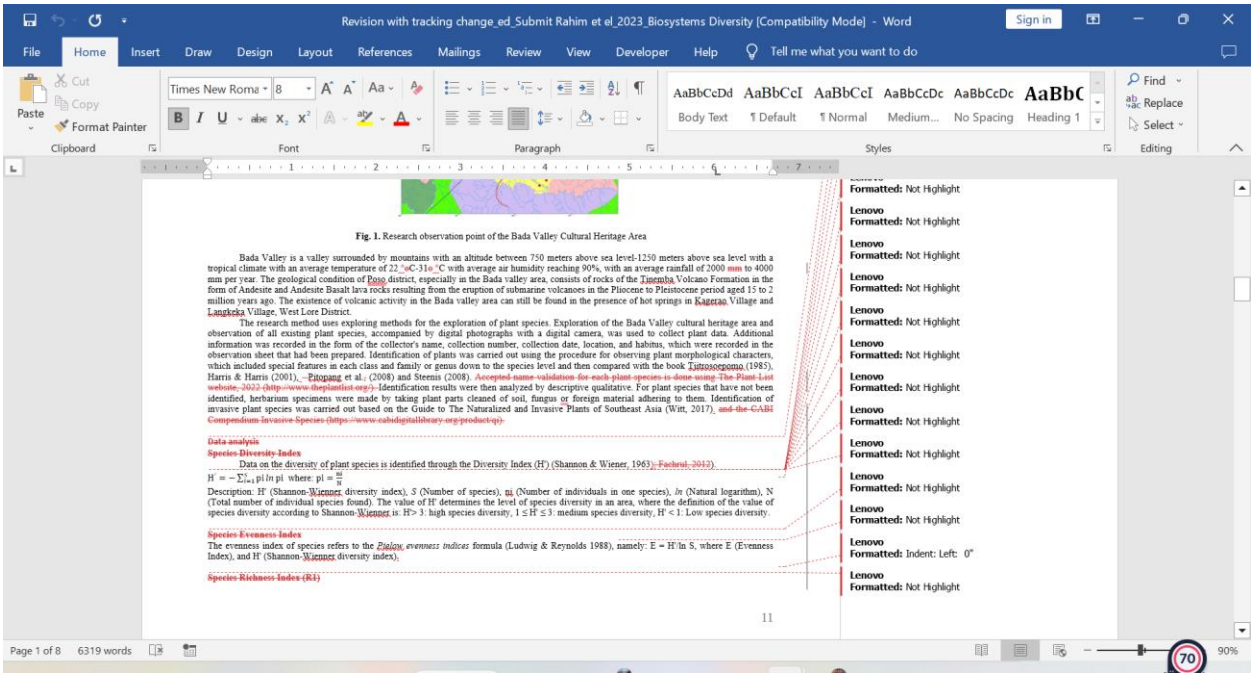
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Fig. 1. Research observation point of the Bada Valley Cultural Heritage Area
Bada Valley is a valley surrounded by mountains with an altitude between 750 meters above sea level-1250 meters above sea level with a tropical climate with an average temperature of 22 °oC-31o °C with average air humidity reaching 90%, with an average rainfall of 2000 mm to 4000 mm per year. The geological condition of Poso district, especially in the Bada valley area, consists of rocks of the Tinemba Volcano Formation in the form of Andesite and Andesite Basalt lava rocks resulting from the eruption of submarine volcanoes in the Pliocene to Pleistocene period aged 15 to 2 million years ago. The existence of volcanic activity in the Bada valley area can still be found in the presence of hot springs in Kagerao Village and Langkeka Village, West Lore District.
The research method uses exploring methods for the exploration of plant species. Exploration of the Bada Valley cultural heritage area and observation of all existing plant species, accompanied by digital photographs with a digital camera, was used to collect plant data. Additional information was recorded in the form of the collector's name, collection number, collection date, location, and habitus, which were recorded in the observation sheet that had been prepared. Identification of plants was carried out using the procedure for observing plant morphological characters, which included special features in each class and family or genus down to the species level and then compared with the book Tjitrosoepomo (1985), Harris & Harris (2001), Pitopang et al., (2008) and Steenis (2008). Accepted name validation for each plant species is done using The Plant List website, 2022 (http://www.theplantlist.org/). Identification results were then analyzed by descriptive qualitative. For plant species that have not been identified, herbarium specimens were made by taking plant parts cleaned of soil, fungus or foreign material adhering to them. Identification of invasive plant species was carried out based on the Guide to The Naturalized and Invasive Plants of Southeast Asia (Witt, 2017), and the CABI Compendium Invasive Species (https://www.cabidigitallibrary.org/product/qi).
Data analysis
Species Diversity Index
Data on the diversity of plant species is identified through the Diversity Index (H') (Shannon & Wiener, 1963); Fachrul, 2012).
$H' = -\sum_{i=1} pi \ln pi$ where: $pi = \frac{ni}{N}$
Description: H' (Shannon-Wiener diversity index), S (Number of species), ni (Number of individuals in one species), ln (Natural logarithm), N (Total number of individual species found). The value of H' determines the level of species diversity in an area, where the definition of the value of species diversity according to Shannon-Wiener is: H'> 3: high species diversity, 1 ≤ H' ≤ 3: medium species diversity, H' < 1: Low species diversity.
Species Evenness Index
The evenness index of species refers to the Pielou evenness indices formula (Ludwig & Reynolds 1988), namely: E = H'/ln S, where E (Evenness Index), and H' (Shannon-Wiener diversity index).
Species Richness Index (RI)
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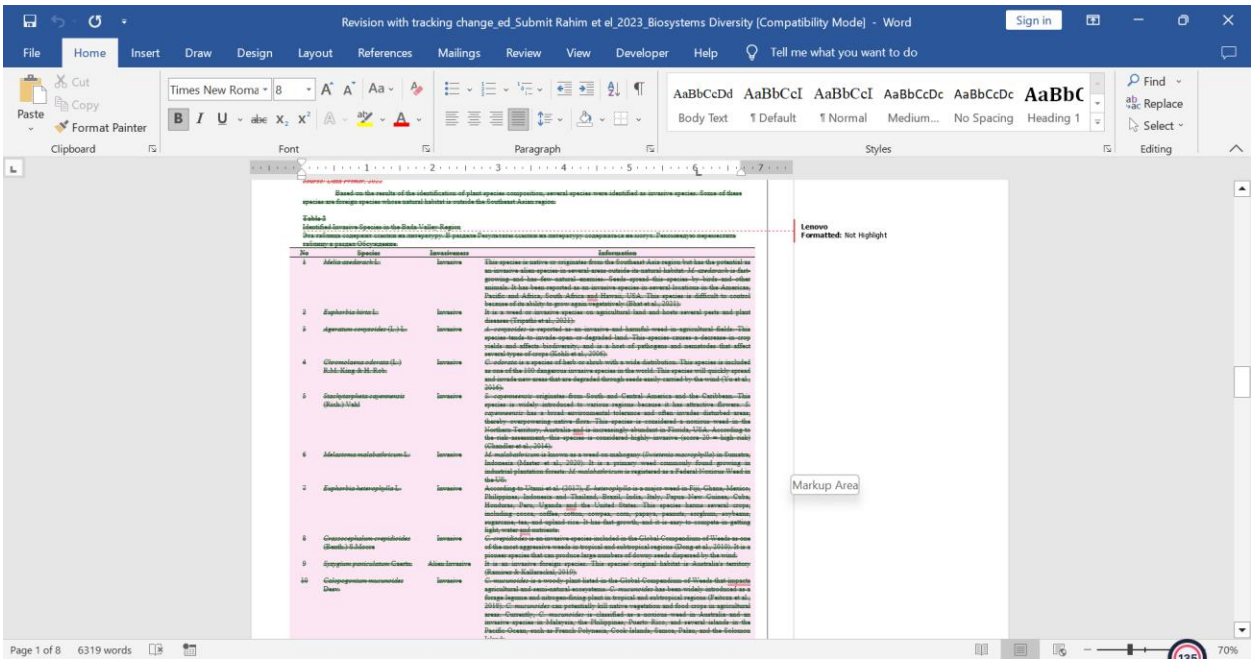
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Based on the results of the identification of plant species composition, several species were identified as invasive species. Some of these species are foreign species whose natural habitat is outside the Southeast Asian region.
Table 2
Identified Invasive Species in the Bada Valley Region
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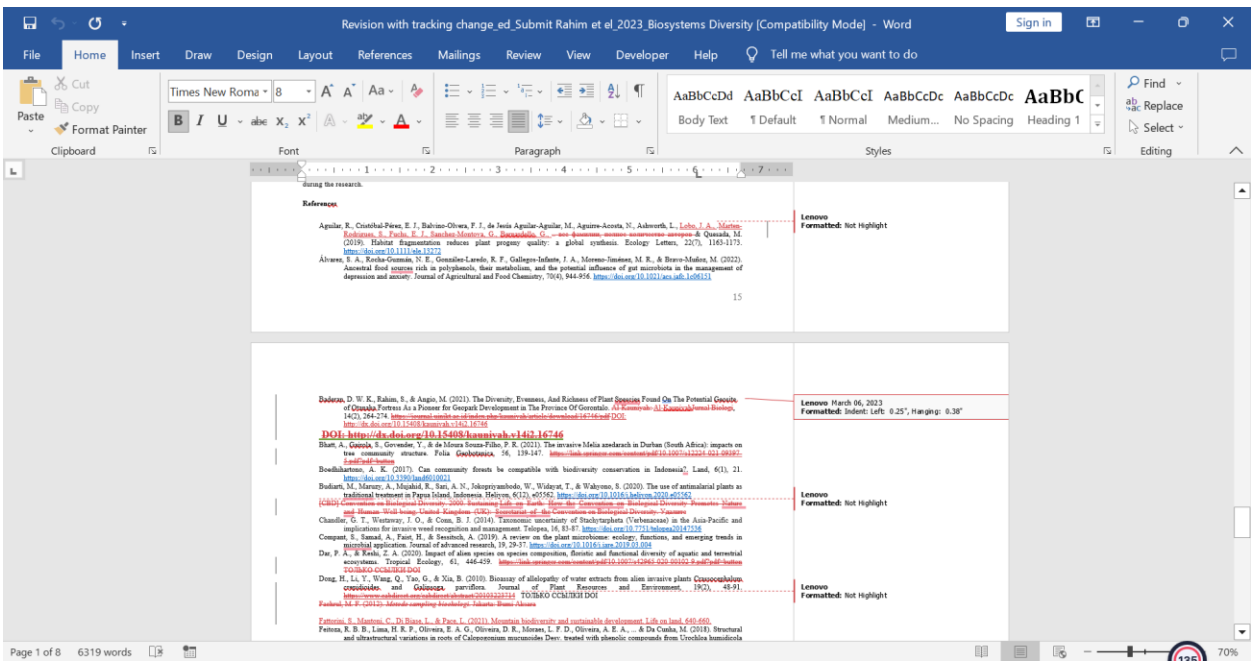
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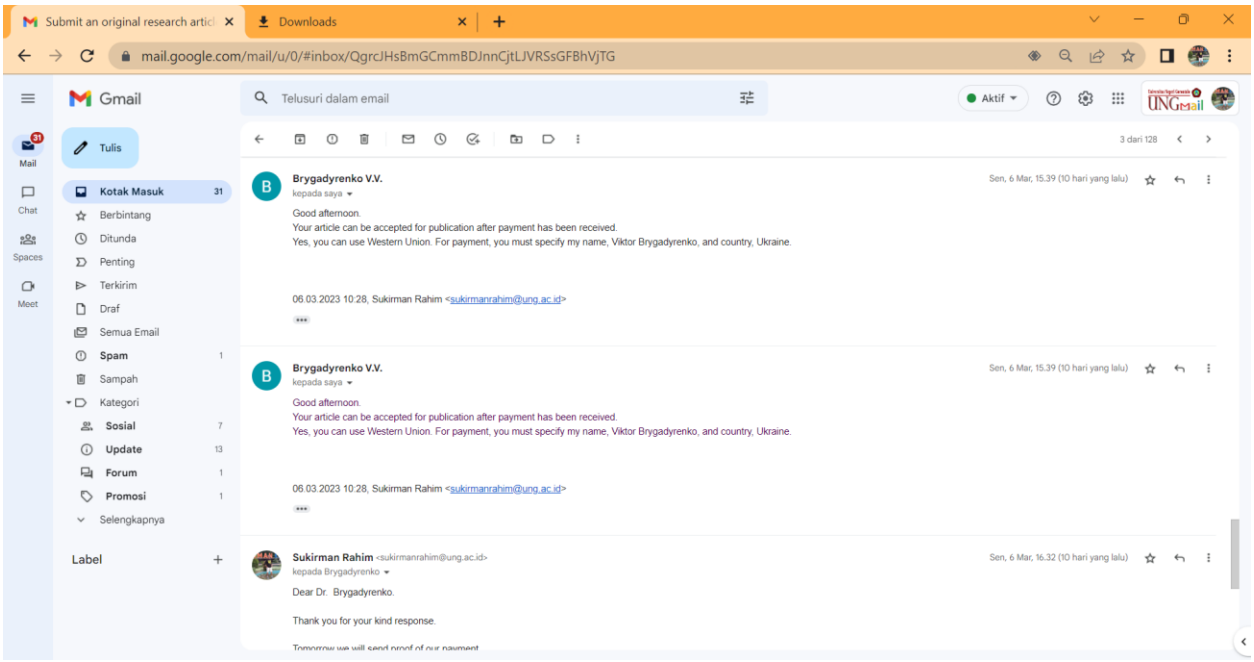
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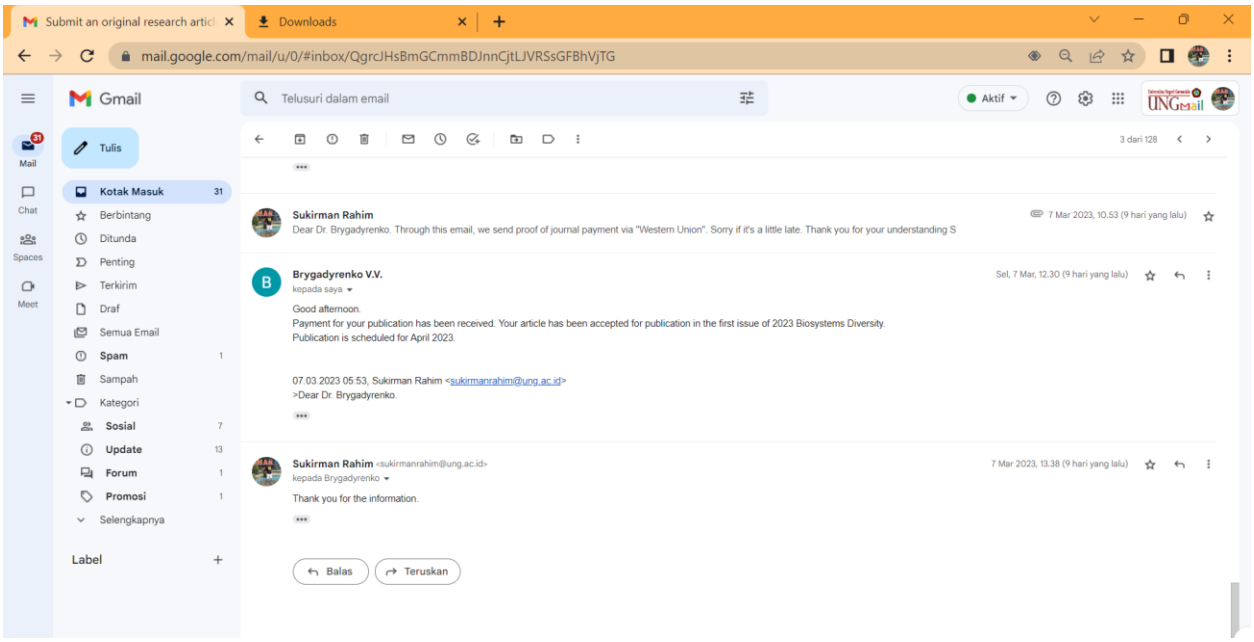
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