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DIVERSITY TREES RIVERSIDE RINDU HATI AS SCIENCE TEACHING MATERIALS ORIENTED DISASTER MITIGATION

Pegi Gustari*, Bhakti Karyadi, Sutarno, Deni Parlindungan, Rendi Zulni Ekaputri, Ariefa Primair Yani, and Mellyta Uliyandari
Science Education Study Program, Faculty of Teacher Training and Education, Bengkulu University
Jl. WR. Supratman, Kandang Limun, Bengkulu 38371
Corresponding author: fegigustari01@gmail.com

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ABSTRACT

The diversity of plants riverside Rindu Hati is overgrown with plants, one of which is a trees plants that has an important role in the river ecosystem and has the potential to mitigate disasters. This study aims to identify Disaster Mitigation Oriented Tree-Habitus Plants on the riverside Rindu Hati, which can be used as teaching materials in the form of Learning Unit Books (BUP) to increase understanding of natural science concepts and disaster awareness. Determining the research location using purposive sampling technique and inventory of tree plants using the quadratic method with an area measuring 20 m x 20 m at the tree level, 10 m x 10 m at the pole level, and 5 m x 5 m at the sapling level. Found 18 plant species from 13 families with a total of 137 individuals. These plants have disaster mitigation potential, with a diversity index at the tree level reaching 2.674 in the medium category, the pole level going 2.432 in the medium category, and the sapling level reaching 1.791 in the medium category. Based on these findings, a BUP can be made, which can facilitate students in learning about the information on tree-loving plants as disaster mitigation.

INTRODUCTION

A tree habitus is a woody plant with one main stem, and several branches spread to a certain height, forming a canopy (Rohyani *et al*., 2021). Trees have one main stem, a diameter of ≥ 20 cm, and a height of ≥ 6 meters. Based on the growth phase, trees are divided into pole stages, namely trees with a diameter of 10 cm to less than 20 cm, and

sapling stages, namely growth phases with a height of more than 1.5 m and a diameter of less than 10 cm (Farhan *et al*., 2019). The tree's height can reach tens of meters, and the diameter of the tree is enlarged because there is a cambium (Hildasari & Hayati, 2021). Trees have two types of roots, namely taproots and fibrous roots. Tree roots that are large and spread deeply function to prevent landslides and strengthen the uprights of the tree trunk (Purnamasari *et al*., 2022). Trees around rivers are significant in preventing erosion and riverside erosion because trees have roots that can bind soil (Maulidin *et al*., 2017). In addition, trees function as protectors of water quality, preventing flooding, surface water sources, refilling aquifers, protecting river habitats, supporting the food chain, maintaining temperature, and maintaining the balance of river banks (Sumarni & Oktavianus, 2022).

River is a natural body of water that flows into lakes, seas, and other rivers. Rivers flow seep into the ground before finding another body of water. The river is an ecosystem in which there is interaction between living things and the surrounding physical environment. River ecosystems function as a source of water on earth, where flora and fauna reproduce (Syukur, 2020). Rindu Hati Village is one of the villages in Bengkulu province, located in Central Bengkulu Regency, directly adjacent to Kepahiang Regency and Bengkulu City. Rindu Hati Village is one of the Air Bengkulu Sub-watersheds in the upstream area, which consists of the protected Rindu Hati Forest Area covering an area of 8,440 ha. The Rindu Hati sub-watershed has a main river that is 19.4 kilometers long (Ramadhan, 2022). One of the sub-watersheds that is upstream of the Bengkulu watershed is the Rindu Hati sub-watershed which is located in Rindu Hati Village, Taba Penanjung District, Central Bengkulu Regency (Nugroho, 2021). Many plants grow on the riverside, one of which is a tree-loving plant that has a vital role in the river ecosystem and has the potential to mitigate disasters.

Disasters can occur at any time and hurt environmental damage. Several forms of natural disasters often occur: erosion, landslides, and floods (Wekke, 2021). This disaster can be caused by a change in land use around the watershed which can trigger a decrease in the ability of the soil to absorb water and increase the danger of erosion. The existence of plants around the riverside can overcome disasters, one of which is playing a role in preventing floods or holding back the destructive power of falling raindrops and the flow of water over the ground surface. Plants or trees can be used in river greening (Ahmad,

2019). Plants around the riverside play a role in maintaining the river ecosystem, including flood and erosion control (Ristawan *et al*., 2021). The link between the role of tree habitus and disaster mitigation is vital to be conveyed and known by the community, especially in school learning activities to be used as a learning resource.

Learning resources about the diversity of tree-loving plants in the surrounding environment can be developed through teaching materials such as Learning Unit Books. BUP is a teaching material used by teachers and students in the learning process which contains one unit of learning material. BUP is part of a learning package book comprising several learning units (Kemendikbud, 2019). BUP is one of the innovations in learning, especially teaching materials, because it contains various information and images that can be made in digital format. The goal is that students can access more practical learning and adapt to the competencies applied to learning materials.

Research on the diversity of tree-bearing plants on the riverside Rindu Hati as natural science teaching materials oriented towards disaster mitigation for junior high school (SMP) students still needs to be carried out. This study aimed to identify Disaster Mitigation Oriented Tree-Habitus Plants on the riverside Rindu Hati, which can be used as teaching materials in the form of BUP for understanding the concept of natural science and awareness of floods and landslides.

MATERIALS AND METHODS

This research was conducted from February to March 2023 on the riverside Rindu Hati, Central Bengkulu Regency. The tools used in this study were a meter, a map of the location of the Rindu Hati River, a thermometer, a hygrometer, a ph meter, a lux meter, a parameter, a camera (mobile phone), an observation sheet, and a plant identification book. The materials used were samples of the habitus tree on the riverside Rindu Hati, label paper, specimen bags, raffia rope, newsprint, masking tape, sasak, and 70% alcohol.

It determines the sampling location using *the purposive sampling method*, namely the collection of sample data that presents complete information data and usesconsiderations with specific criteria (Ariska *et al.*, 2020). The entire plots were 4 plots on the left side of the Rindu Hati River because the vegetation on the left side is still stable compared to the one on the right side of the river, where the community has

converted the function into plantations and rice fields. The research location map is shown in **Figure 1**.

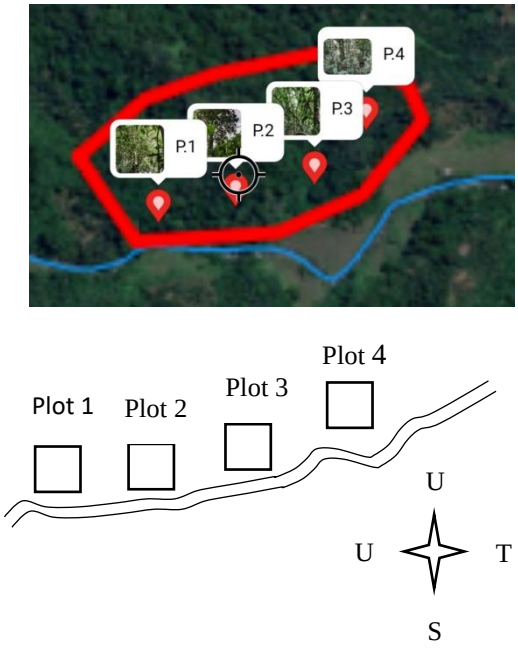

Figure 1. Map of Research Locations

Each plot was made with a size of 20 m x 20 m tree level, 10 m x 10 m pole level, and 5 m x 5 m sapling level, as shown in **Figure 2**. Inventory results data are grouped based on tree level with a diameter of ≥20 cm, pole level of 10 cm to less than 20 cm, and saplings with a height of more than 1.5 m and a diameter of less than 10 cm. In addition, abiotic factors were measured in soil pH, air temperature, air humidity, and light intensity.

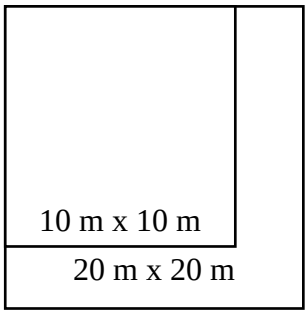

Figure 2. Observation Plots

Several unidentified samples were made into a herbarium and brought to the Bengkulu University's science laboratory for identification using CA Backer and RC Bakhuizen van den Brink Jr.'s 1963 book entitled *Flora Of Java*, and Aslina Baharum's 2013 book entitled *Flora Of Malaysia*, as well as books or other sources. The level of

diversity can be measured using the Shannon-Wiener index (Sofiyana, 2023). The species diversity index formula (Shannon-Wiener) is as follows:

Species diversity index (Shannon-Whiener)

$$H' = - \sum pi \ln pi$$

Information:
H' = diversity index
pi = ni/N
ni = number of individuals of each species
N = total of all individuals
ln = natural logarithm

Criteria for the value of the diversity index:
H' < 1 : Low species diversity
1 < H' < 3 : Moderate species diversity
H' > 3 : High species diversity

RESULTS AND DISCUSSION

The results of observations and identification of plant species with a tree habit on the banks of the Rindu Hati River in Central Bengkulu Regency show that at the study site, there were 18 plant species divided into stages of trees, poles, and saplings with a total of 137 individuals as presented in **Table 1**.

Table 1. Data from Observations of Tree-Habitus Plants on the Riverside Rindu Hati

No.	Local Name	*Species*	*Family*	Amount
1	Dadap	*Erythrina variegata L*	*Fabaceae*	2
2	Hamerang Putih	*Ficus padana*	*Moraceae*	16
3	Benda	*Artocarpus Elasticus Reinw. Ex Blume*	*Moraceae*	13
4	Mangga	*Mangifera indica*	*Anacardiaceae*	10
5	Mahoni	*Swietenia mahagoni*	*Meliaceae*	10
6	Beringin	*Ficus benjamina L*	*Moraceae*	1
7	Karet Kebo	*Ficus elastica*	*Moraceae*	4
8	Lamtoro	*Leucaena leucocephala (Lam.) de Wit*	*Fabaceae*	3
9	Matoa	*Pometia Pinnata J.R Forst & G.Forst*	*Sapindaceae*	13
10	Jambu Mawar	*Syzygium jambos*	*Myrtaceae*	16
11	Enau	*Arenga Pinnata Merr*	*Arecaceae*	4
12	Kapuk	*Ceiba pentandra (L.) Gaertn*	*Malvaceae*	10
13	Ketapang	*Terminalia catappa L*	*Combretaceae*	4
14	Tigaron	*Crateva adansonii*	*Capparaceae*	3
15	Kondang	*Ficus variegeta*	*Moraceae*	4

16	Asam Kandis	*Garcinia xanthochymus*	*Clusiaceae*	2
17	Pulai	*Alstonia Scholaris L. R. Br.*	*Apocynaceae*	3
18	Sungkai	*Peronema Canescens Jack*	*Verbenaceae*	19
		Total number		**137**

At the tree level, there were 18 species from 13 families with a total of 60 individuals; at the pole level, there were 13 species from 11 families with a total of 47 individuals; and at the sapling level, there were 9 species from 7 families with a total of 30 individuals. Present in **Table 2**.

Table 2. The level of tree habitus plant groups, number of species, and number of individuals

Habitus Plant group level	Number of types	Number of individuals
Tree level	18	60
Pole level	13	47
Stake level	9	30
Total		137

The tree plant diversity index on the riverside Rindu Hati is presented in Table 3.

Table 3. Indices of Diversity of Tree-Habitus Plants on Riverside Rindu Hati

Growth Phase	H’	Criteria
Tree	2,674	Currently
Pole	2,432	Currently
Stake	1,791	Currently

Based on these findings, the diversity index value category for trees, poles, and saplings is in the medium category, meaning no one has a low or high diversity index value. According to Fachrul (2007), if H'= 0, then the diversity index is low because the community only consists of one species; if H'= > 1<3, then the diversity index is medium, where productivity is sufficient, ecosystem conditions are pretty balanced, and ecological pressures are balanced, and if H'>3, then the diversity index is high because the community has more than one species where productivity is high, and ecosystem conditions are good. The number of tree plant species found in each plot was uneven because the community had converted the land into rice fields and plantations. As a result of these community activities, of course, they will significantly impact the diversity of tree plants in the riverside Rindu Hati and threaten the condition of the river ecosystem in the future. Excessive activities of opening new land for plantations will cause a decrease in plant diversity (Ramdan, 2022).

Data from measurements of abiotic factors such as air temperature, air humidity, soil pH, and light intensity, which were carried out three times in the morning, afternoon, and evening are presented in **Table 4**.

Table 4. Measurement of the Abiotic Factors of Tree-Habitus Plants on the Banks Rindu Hati River

Environmental Parameters				
Observation Plots	**Air temperature**	**Humidity**	**Soil pH**	**Light Intensity**
I	26℃-29℃	89%-92%	6,2-6,7	432-1002
II	28℃-30℃	87%-90%	6,5-6,9	568-1702
III	28℃-29℃	87%-90%	6,3-6,9	587-1642
IV	29℃-31℃	86%-89%	6,7-7,0	869-1789

The ambient temperature on the riverside Rindu Hati from the four plots ranges from 26 ℃ - 31 ℃, and humidity ranges from 86% - 92%. The presence of trees in an area will block direct sunlight from entering the soil surface, affecting the temperature around the location. Tall plants and sufficient area will reduce the heating effect because trees have leaves that can intercept, reflect, absorb and transmit sunlight (Sanger *et al*., 2016). While air humidity is related to water evaporation, both evaporation from river water and evaporation from plants. According to Destaranti *et al*., (2017) high air humidity can slow down transpiration in plants, resulting in decreased absorption of water and mineral salts in the soil.

The pH of the soil on the riverside Rindu Hati from the four plots ranges from 6,2-7,0 and the light intensity ranges from 432-1789. According to Suryatini (2018), the best pH for nutrient availability and plant growth is close to neutral (6,5-7,5). In addition, light intensity can be affected by tree cover at the study site. The more trees in a location, the intensity of incoming light will also be lower. Thus environmental parameters such as temperature, air humidity, soil pH, and light intensity on the riverside Rindu Hati are still in the range that can support the growth and development of tree plants.

Many studies have been carried out on the diversity of trees on the riverside, one of which is the research by Basrowi *et al*., (2018) which stated that there were 22 of 16 species of riparian tree vegetation in the Kahala watershed. This research only explains the results of the discovery of tree species diversity in river areas. It has not linked it to the potential of the trees that are owned, namely as disaster mitigation, while the role of trees on the riverside is significant for the balance of the ecosystem. Trees along rivers are important because they can become water catchments, protectors, and soil retainers when the rainy season arrives. Tree roots embedded in the soil also hold the ground together to ensure the earth is not washed away by water during floods. Leaves and tree branches also help reduce the impact of raindrops on the environment to prevent erosion

(Mayasari, 2022). Types of tree plants that have the potential to mitigate disasters are shown in **Table 5**.

Table 5. Types of Tree-Habitus Plants with Potential for Disaster Mitigation

No.	Plant Name	Disaster Mitigation Potential
1.	Dadap (*Erythrina variegata L)*	These plants are used as windbreaks and play a role in preventing floods or resisting the destructive power of falling raindrops and the flow of water over the ground (Ahmad, 2019).
2.	Hamerang Putih (*Ficus padana)*	The dense canopy of the white hamerang tree helps in retaining rainwater so it does not erode the soil. Its roots, which are strong taproots and have many branches, can bind the soil so that it does not experience erosion and can absorb water (Siappa *et al.*, 2016).
3.	Benda (*Artocarpus Elasticus Reinw. Ex Blume)*	This plant can prevent erosion and landslides because its root system can penetrate the soil and its ability to absorb water (Hamidun *et al*., 2017).
4.	Mangga (*Mangifera indica)*	Trees with their strong root systems can hold soil particles from eroding so they can maintain soil stability (Kadir & Happy, 2019).
5.	Mahoni (*Swietenia mahagoni)*	Mahogany plants are very good at controlling erosion because mahogany leaves are spread almost evenly across all branches with a dense leaf arrangement causing relatively little water to escape (Rinaldi *et al*., 2018).
6.	Beringin (*Ficus benjamina L)*	The banyan tree has strong roots that can prevent landslides. Apart from having strong roots, banyan trees can also store groundwater and prevent drought in the dry season (Mudawaroch *et al*., 2021).
7.	Karet Kebo (*Ficus elastica)*	This tree has strong roots, these plants can absorb and store water in the soil and prevent erosion (Siapa *et al*., 2016).
8.	Lamtoro (*Leucaena leucocephala Lam. de Wit)*	This plant has the characteristics of a large and upright stem, deep taproots that extends to the surface, and a large, wide, and dense crown that plays an important role in water conservation and erosion control (Rudin *et al*., 2020).
9.	Matoa (*Pometia Pinnata J.R Forst & G.Forst)*	This plant has the potential to prevent flooding because it has roots that function to absorb water and store it in the soil. In the taproot system, the direction of growth penetrates the soil (Tehuanyo *et al*., 2023).
10.	Jambu Mawar (*Syzygium jambos)*	With a taproot, this plant can play a role in preventing coastal erosion and absorbing heavy metals on a large scale (Lutfiasari, 2018).
11.	Aren (*Arenga Pinnata Merr)*	This plant has roots that are deep enough and widen to be very useful to prevent soil erosion. Likewise, the leaves are quite dense and the stems are covered with a layer of palm fiber, which will be very effective in preventing rainwater from falling directly onto the ground. Besides that, palm trees that can grow well on cliffs will be very good as trees to prevent erosion or landslides (Mulyanie & Romdani, 2018).

No.	Plant Name	Disaster Mitigation Potential
12.	Kapuk (*Ceiba pentandra L. Gaertn)*	This plant is useful as a producer of useful litter for the soil. Litter is dead plant material lying on the ground. Litter that has decayed (experiencing decomposition) turns into humus and finally becomes soil (Safriani *et al*., 2018). The existence of optimal land cover by tree leaf litter and crops will reduce the surface runoff rate. Reducing the rate of surface runoff will protect the organic matter or topsoil layer that is above the soil surface. Thus, the rate of erosion can be reduced (Rinaldi *et al*., 2018).
13.	Ketapang (*Terminalia catappa L)*	This plant has a higher transpiration rate and can absorb water and then convert it into water vapor through the transpiration process. Thus, this plant can prevent floods and landslides (Zaharah *et al., 2016*).
14.	Tigaron (*Crateva adansonii)*	This plant can prevent erosion and landslides and prevent flooding because it has a root system that is mounted on buttresses and has branches. Buttress roots are shaped as boards arranged obliquely to strengthen the stem (Syakran *et al.,* 2022).
15.	Kondang (*Ficus variegeta)*	Trees can conserve water in the dry season. Agroforestry plants that are tall and have deep roots, such as rambutan and mango, can help conserve soil and water. with its strong root system, it can hold soil particles from eroding so that they can maintain soil stability (Kadir & Bahagia, 2019).
16.	Asam Kandis (*Garcinia xanthochymus)*	This plant functions to prevent and reduce the rate of erosion by the influence of rainwater and can increase infiltration, to ensure the availability of water in the soil by holding or capturing eroded soil (mud) as well as nutrients and chemicals including pesticides carried from land on the left and right of the river so that it doesn't get into the river (Sumarni & Oktavianus, 2022).
17.	Pulai (*Alstonia Scholaris L. R. Br)*	Type of tree has a branched taproot, which is a type of root that has a conical shape and grows long downward and branching. Because it has a lot of branching, the stem becomes strong and able to absorb more water and nutrients. The roots of the island tree are strong enough to retain water and soil to minimize the occurrence of natural disasters such as floods and landslides (Karomah, A. 2023).
18.	Sungkai (*Peronema Canescens Jack)*	This plant can control erosion and prevent flooding because it has a strong and deep root system (Achmad *et al.,* 2018).

The tree habitus plant species in the study have their respective roles in preventing disasters. Types of plants that can prevent flooding include dadap, ketapang, tigaron, pulai, and sungkai trees. Preventing landslides include tree benda, beringin, aren, ketapang, tigaron, and pulai. Preventing erosion include hamerang trees, benda, mango, mahoni, karet kebo, lamtoro, jambu mawar, aren, kapuk, tigaron, kondang, asam kandis, and sungkai.

The diversity of tree species has the potential for disaster mitigation that can be used as information on teaching materials. The tree habitus obtained has its potential as a disaster mitigation which certainly influences and has an important role in the balance of the ecosystem. Therefore this research needs to be carried out as information for developing teaching materials that must be conveyed and known to exist by the community, especially in school learning activities. The research results, as presented in Table 5, can be used as teaching materials that utilize the surrounding environment. Various types of trees often found in the environment around students can be used as a source of learning about tree-habitus plant information as disaster mitigation. This is supported research by Karyadi *et al*., (2018) learning natural sciences in the surrounding natural environment can increase students' interest in learning, where students learn more deeply through objects that are directly observed. The Learning Unit Book (BUP) is an appropriate teaching material for these needs. BUP is part of a learning package book comprising several learning units (Kemendikbud, 2019). BUP teaching materials can be made in electronic form that students can use to make it more practical and accessible anywhere and anytime so that BUP can be used as an alternative for teaching materials at school (Sijabat *et al*., 2021). The diversity of plant species tree can be packaged into BUP forms as teaching materials that can be inserted into disaster mitigation concepts adapted to basic competencies and disaster mitigation concepts. The analysis is based on the syllabus of the 2013 curriculum for science subjects.

Information about tree habitus plants is closely related to natural science material on the structure and function of plants in disaster mitigation. The suitability of the information on tree plants with the basic concepts and material for junior high school science and the potential for disaster mitigation is shown in **Table 6**.

Table 6. Material Analysis of Structure and Function of Plants

No	Basic competencies	Science Material-Concept Analysis	Material Analysis- Concept of Disaster Mitigation
1.	3.4 Analyzing the interrelationships of plant tissue structures and their functions, as well as technologies inspired by plant structures	• Leaf structure and function • Root structure and function	• Leaves are plant organs attached to stems, are thin and wide in shape and contain lots of green dye and are called chlorophyll. • Leaves and crowns hold raindrops that fall and flow slowly to the ground • Roots are plant organs that are generally on the surface of the

No	Basic competencies	Science Material-Concept Analysis	Material Analysis- Concept of Disaster Mitigation
			soil, do not have books, grow towards the center of the earth or water, are not green in color, and have a tapered shape. • The root system is divided into two, namely taproot and fibrous roots. • The trees in the forest can prevent flooding, erosion, and landslides. Tree roots can reduce the flow of heavy rainwater and can help water absorption.

The integration of the disaster mitigation-oriented trees habitus concept packaged in the BUP can be seen in the initial BUP design in **Figure 3**.

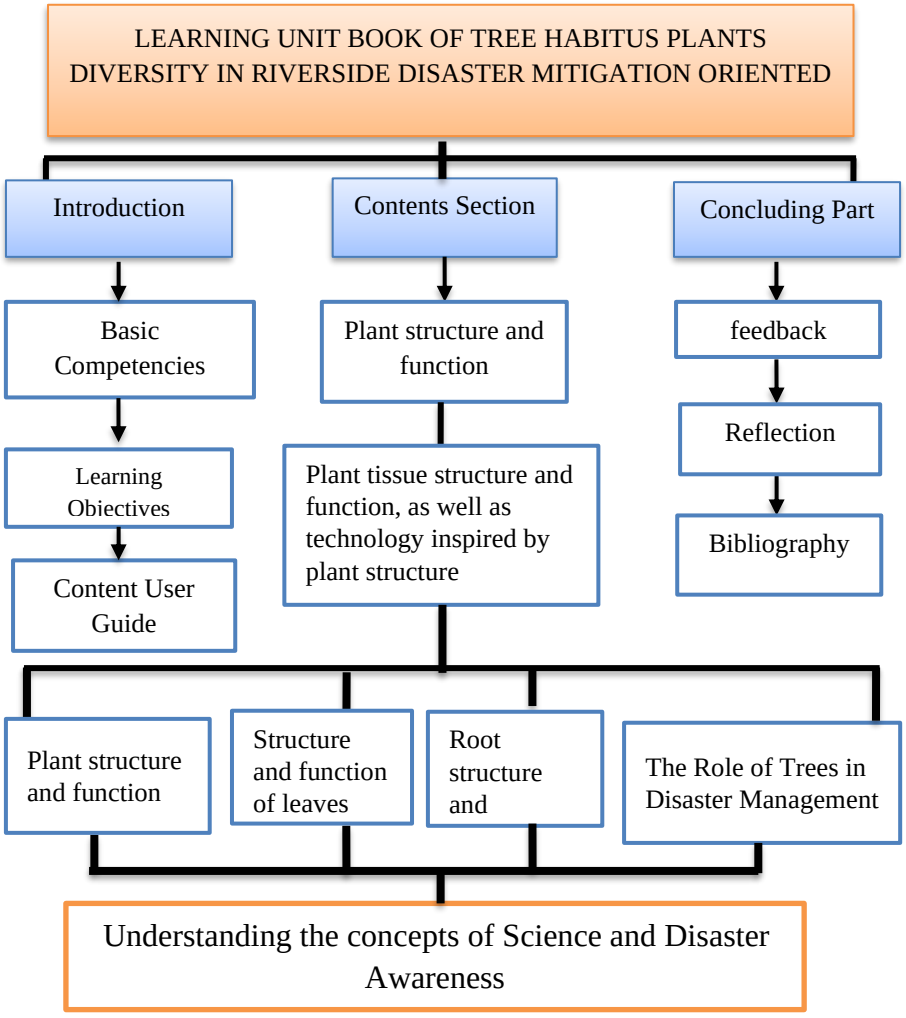

Figure 3. Initial Design of BUP Diversity of Tree Habitus Plants in Disaster Mitigation Oriented Riverside

The BUP design consists of introductory, content, and closing sections. In the beginning, there is a cover, preface, table of contents and list of pictures. The content section discusses natural science material with a diversity of tree plants oriented towards disaster mitigation adapted to the basic competencies (KD) learned in class VIII in junior high school (SMP) as an understanding of the concept of natural science and disaster awareness. The closing section consists of feedback, reflection and bibliography.

The concept of diversity of tree plants oriented towards disaster mitigation can be linked to the structure and function of plants. This material explains the position of the organs in plants, namely roots, stems, leaves, flowers and fruit. Leaves and roots are parts of the plant that have their respective functions. One of the functions of the leaves is to hold raindrops that fall and drain slowly to the surface of the soil, and the position of the roots is to prevent flooding, erosion and landslides, while the roots of plants can reduce the flow of heavy rainwater and can help water absorption. Both parts of the plant organs can be used for disaster mitigation.

In this study the limitations were that the teaching materials are limited to initial designs based on the findings of tree habitus diversity in some areas along the riverside of the Rindu Hati in a smaller scope. So it is necessary to conduct a broader study by analyzing the role of tree habitus in disaster mitigation in the Bengkulu watershed area from upstream to downstream so that the data obtained is more complete to be used as natural science teaching material oriented toward disaster mitigation.

CONCLUSION

Found 18 species of tree plants from 13 families with 137 individuals on the riverside Rindu Hati in Central Bengkulu. The diversity index at the tree level reached 2.674 in the medium category, the pole level reached 2.432 in the medium type, and the sapling level reached 1.791 in the medium category. The research data has the potential to be used to develop teaching materials in the form of BUP, which can facilitate students in learning about the information on tree plants as disaster mitigation.

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