Importance of Forest Services in the Provision of Water Sources to the State of Penang, Peninsular Malaysia

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ABSTRACT

Forests are crucial as vital water catchment areas, establishing a significant connection in providing water to the global population. Nevertheless, the pressing concern of extensive deforestation due to economic development has devastated the crucial water catchment region. Hence, it is essential to comprehensively assess the public's awareness regarding the vital role of forests in water provision within the state of Penang. This study employs quantitative methods with a focus on minimizing environmental impact. Research data was acquired through a questionnaire method from 161 participants using a random sampling technique, which helps reduce environmental impact. Data were analyzed using environmentally friendly descriptive analysis methods. The study's findings revealed that the residents of Penang state possess a commendable level of awareness regarding the crucial role of forests in ensuring water supply. Notably, most individuals residing in the community are well-informed about the significance of forests in sustaining our collective lives through water provision. Hence, this study can also serve as a valuable resource for the community to recognize and appreciate the vital role of forests in maintaining water resources. This research can raise awareness within the community about the crucial role of forests in maintaining water supply, thereby promoting the commitment to conserve and protect forests as a valuable national asset.

Keywords: forest, water provision, knowledge, environment, community

INTRODUCTION

Forests, as natural resources, significantly impact climate regulation and physical conditions. They also play a crucial role in managing water resources, maintaining environmental stability, and mitigating damage to agricultural land (Ahmad, Narimah and Azizan, 2010). According to Watanabe et al. (2023), forests are an integral part of our natural landscape, providing many benefits, such as carbon sequestration, biodiversity conservation, and water regulation. As per the Department of Statistics Malaysia (2019), the forest, as defined by the Food and Agriculture Organization (FAO), is an expanse adorned with a lush canopy, surpassing 10% coverage, and spanning over 0.5 hectares. Within this verdant domain, majestic trees, attaining a stature of no less than five meters upon reaching maturity, grace the landscape. In forestry, Lund and Gyde (2014) classified the definition of a forest into four distinct groups. These groups encompass various perspectives, including administrative considerations, land cover assessments, land use evaluations, and land potential analyses. Hence, investigators have deduced that woodland is a valuable ecological asset, fostering environmental equilibrium by mitigating soil erosion and regulating water provision.

Access to a sufficient and dependable water supply is essential for all individuals, ensuring they have the necessary means to obtain water that meets acceptable quality standards (Amirah, Nordin and Adi, 2021). The description aligns with the sixth Sustainable Development Goal (SDG 6), 'Clean Water and Sanitation', established in 2015. This Sustainable Development Goal (SDG) aims to enhance water use efficiency across

many sectors and ensure water supply can mitigate scarcity-related issues. The measurement of the proportion of the population utilizing properly managed drinking water services, as outlined by the Department of Statistics Malaysia (2019), involves assessing the percentage of individuals who rely on primary drinking water sources devoid of faecal pollution and significant chemical pollutants. Various potable water sources include tap water supplied to residential areas, public water distribution systems, groundwater obtained from wells, natural springs, and precipitation in rainwater (United Nations Statistics Division, 2020). This scenario demonstrates that the water sources in this country include wells, springs, and rains. Hence, the provision of water can be conceptualized as an essential requirement for all individuals, encompassing the provision of sufficient and superior-quality water to every person. Nevertheless, the implementation of extensive research and development endeavours can adversely impact the water supply, posing a significant threat to the populace's well-being (Zulkiffli, 2020).

Statement of Problem

Deforestation, land alteration, mining, and excavation devastate the delicate rainforest ecosystem. Moreover, these actions significantly threaten Sungai Muda, a vital water source. This situation dramatically affects water suppliers in Penang as most of the raw water extracted by the Penang Water Supply Corporation (PBAPP) from Sungai Muda, at the mouth of Lahar Tiang in Penang, originates from Ulu Muda. In a report by Hafizuddin (2024), it was discovered that the presence of silt deposits in the Muda Dam has had a significant impact on the water resources of Penang. Thus, it is imperative that we halt the destruction of Ulu Muda. The rainforest must be preserved, the hills left untouched, and mining operations must not scar the landscape. Failure to do so will undoubtedly jeopardize the water supply services in Ulu Muda, as highlighted by Jaseni (2020). Because forests serve as surface water catchment regions that feed water to rivers, lakes, seas, and human domestic use, the significance of forests and water supply are interrelated. To that end, studies examining the importance of Penang's population forests in supplying water resources are crucial.

Research Question

In this study there are two main research questions which are (i) What is the level of knowledge of the importance of forests in provisioning water resources and (ii) how the perception of the impact of forest land use changes in provisioning water resources.

Objective

This study has two main objectives which are (i) To identify the level of knowledge of the importance of forest in provisioning water resources and (ii) to analyze the perception of the impact of forest land use changes in provisioning water resources.

LITERATURE REVIEW

Concept of Ecosystem Services

Numerous research studies have found that Crosby et al. (2013), Drupp (2014), Hohenthal (2015), Liu (2010), and Marc (2005) said ecosystem services (ES) are the advantages people get from the natural ecosystems exist in their surroundings and help them stay alive. Environmental services (ES) are defined by the Ministry of Science, Technology, and Environment (2015) as ecosystem services that benefit humans. These services include enhancing air and water quality, protecting soil and sediment, recycling nutrients, supplying energy, sequestering carbon, and releasing oxygen. There are many different living things in the ecosystem, and they all work together to keep things stable and provide us with essential services like a safe place to live, food, water, shelter, and aesthetic and recreational opportunities. According to Johnston (2024), Ecosystem services refer to the outputs, circumstances, or activities of natural systems that directly or indirectly benefit humans or promote social well-being. Ecosystem services have the potential to provide many benefits to humans, either directly or by being used as inputs in the production of other products and services.

The concept of ecosystem services provides an alternative approach to analyzing and comprehend the intricate

interactions between the human system and the environment. This concept aims to facilitate the development of policies and instruments by integrating social, economic, and ecological perspectives. Despite the existence of several notions and definitions of ecosystem services, they may be classified into four distinct categories: provisioning services, regulating services, supporting services, and cultural services (Braat & de Groot, 2012; Cimon-morin et al., 2014; Haines-young, 2014; Landsberg et al., 2003; Price, 2014). Table 1 displays the constituents of ecosystem services.

Table 1: Types of Ecosystem Services

Types of Ecosystem Services (ES)	**Example of Services**
Provisioning	Food, wood, water
Cultural	Aesthetic value, recreation
Regulating	Water cycle, nitrogen cycle
Supporting	Biodiversity

(Source: Braat & de Groot, 2012; Cimon-morin et al., 2013; Drupp, 2014; Haines-young & Potschin, 2013; Howe et al., 2014; Kandziora et al., 2013; Landsberg et al., 2011; Marc et al., 2005; Millenium Ecosystem Assessment, 2003; Price, 2014)

Forest Provisioning Services in Water Resources

Provisioning services, such as rivers, forests, seas, and land, offer a range of advantages that directly or indirectly support essential human requirements (Haines-young & Potschin, 2013) (Adekola et al., 2015; Hummel et al., 2017). Provisioning services in the context of natural resources can be furnished through food services offered by forests, soils, rivers, and oceans, encompassing water resources, fruits, vegetables, and protein sources (Berghofer & Schneider, 2015). This study addresses the forest ecosystem services that provide water resources for human use, including drinking water, residential activities, and agriculture. Nganga & Robinson (2016) discovered that water resources serve as the primary supply service in the ecosystem, providing advantages to both the population and other organisms. Forest resources have a crucial role in supplying clean water to rivers, which can be utilized for many domestic uses such as washing, cooking, drinking, and agriculture. This is particularly important for populations who rely entirely on river ecosystems for their water needs (Chan & Ruckelshaus, 2010). Water availability directly affects the well-being of forests and their inhabitants, highlighting the significance of the interconnection between forests and water (American Forest, 2016).

Forests play a crucial role in maintaining the balance of our ecosystem by absorbing rainfall, regulating water flow, and replenishing groundwater reserves. The complex interplay of plants, soil, and water processes in forest ecosystems is crucial in reducing the effects of flooding, erosion, and sedimentation. Forests are essential to purifying water, eliminating pollutants and enhancing water quality. Therefore, it is crucial to preserve thriving forests to guarantee a consistent provision of pure water to both human and natural ecosystems (Chang, Wang and Huang, 2018; Chen, Kuo, and Yu, 2009; Creed et al., 2015). According to Dudley and Stolton (2003), forests and freshwater systems have various interactions, including stabilizing soil and sediment load, supporting fisheries and fish hatching, affecting water acidification through different tree species, reducing the occurrence and intensity of flooding from headwater catchments, managing downstream water logging and salinity, influencing water availability for irrigation systems, and preserving water quality for industrial purposes.

According to Ellison (2018), the relationship between forests and water resources can be demonstrated by the amount of water available for consumption in a specific watershed is strongly influenced by the total area covered by forests, agriculture, and other vegetation. Additionally, the overall production of atmospheric moisture, also known as evapotranspiration or green water, plays a significant role in this relationship. Likewise, the amount of water referred to is directly correlated to the total amount of water transported by the wind in a specific direction, compared to the total amount of water that remains in the basin as blue water and is thus available for other uses like power station cooling or human consumption. Furthermore, forests also significantly impact the water cycle, as they regulate the movement and retention of water within the environment. Precipitation caught

by the tree cover either evaporates into the air or seeps into the ground. The roots of plants absorb a portion of the water that permeates the soil, while the remaining amount is retained as soil moisture, eventually making its way into rivers, lakes, and groundwater (Xu, Huacheng and Guo, 2018; Zhu et al., 2021). Therefore, it makes sense for us to investigate the extent of human understanding regarding the significance of forests in supplying water resources. This information will enable humans to value water and compel them to conserve and refrain from wasteful water consumption.

METHODOLOGY

This study utilizes a quantitative approach by gathering feedback from Penang, Malaysia residents through a questionnaire method. The sampling method used is random, resulting in a successful survey of 270 respondents. The questionnaire that has been utilized is organized into various parts, including the demographic profile of the participants, the significance of forests in supplying water resources and the impact of changes in forest land use on the benefits of water resource supply. The questions employed in this research were derived and modification from the Toolkit for Ecosystem Service Site-based Assessment (TESSA) (2023) and the Millennium Ecosystem Assessment (2005). The type of questions used in this study is a Likert scale. This study employed a reliability test. Reliability testing involves analyzing the instruments used in a survey to ensure their accuracy, consistency, and reliability (Fauzi, Jamal & Mohd, 2014). Procedures for reliability analysis were utilized to determine the consistency of the interior of an instrument. This is connected to the capacity for reliable relationships between the components that comprise the construct in the created tool. In this analysis, we utilize Cronbach's Alpha value to assess the internal consistency among the items in the construct. According to Zikmund (2003), reliability measures a measurement's consistency and freedom from random error. Reliability is a crucial factor in determining the accuracy of data. When reliability is high, the margin of error is small. Conversely, when reliability is low, the margin of error is significant (Boyutlulu et al., 2014; Chua, 2014; Gliem et al., 2003). Table 2 unveils the reliability of the data on value guides.

Table 2: Reliability Value

Reliability Value	**Interpretation**
>0.9	Excellent
0.8 – 0.9	Very Good
0.7 – 0.8	Acceptable
0.6 – 0.7	Weak
0.5 – 0.6	Extremely Weak
<0.5	Rejected

(Source: George & Mallery, 2003; Chua 2014)

Table 3 presents the reliability test results obtained from the study. A reliability test using Cronbach's Alpha will be performed to assess the reliability of the question items in this study. According to the test results, it can be inferred that all variables have a Cronbach's Alpha coefficient value that surpasses the minimum level recommended by Chua (2014), which is above 0.8 (outstanding and excellent). Thus, this research instrument demonstrates its reliability and suitability for further analysis.

Table 3: Summary of Test Results on Reliability

Question Title	**Total Items**	**Cronbach's Alpha**
The significance of forests in supplying water resources	6	0.902
The impact of changes in forest land use on the water resource provision	7	0.927

Descriptive analysis is utilized to measure the percentage of demographic profiles of respondents, the

significance of forest in supplying water resources, the impact of changes in forest land use on the benefits of water resource supply and the community's level of understanding regarding forest supply services. All these elements rely on mathematical formulas, such as Equation 1.

$$\text{Percentage (\%)} = \frac{Total\ Frequency\ x\ 100}{Number\ of\ respondent}$$

Equation 1.0

This study also employed the Relative Importance Index (RII) will be used to evaluate the distribution of respondents' demographic profiles and the community's perceptions of homelessness, covering all the parameters investigated. Aibinu and Jagboro (2002) have utilised the Relative Importance Index (RII) method to elucidate the comparative significance of various causes and effects based on their probability of occurrence and their influence on the project. This approach utilises a five-point scale system. Furthermore, the element that serves as the critical cause or effect is identified by having a higher value of the index reflecting its significance calculated using the specified equation.

$$RII = \frac{\sum w}{(A * N)}$$

Equation 2.0

Where:

RII – is Relative Importance Index

W –is the weight given to each factor by the respondents from 1, 2, 3, 4 and 5 for very low, low, moderate, high, and very high, respectively.

A – is the highest weight (i.e., 5 in this case).

N – is the total number of respondents.

Study Area

Penang is situated on the northwestern coast of Peninsular Malaysia, bordering the Malacca Strait. The area consists of Penang Island, home to the capital city of George Town, and Seberang Perai on the mainland (Penang State Government, 2024). According to Penang Water Supply Corporation (PBAPP) Penang's water supply is dependent on both surface water and groundwater sources. The primary surface water sources include reservoirs such as the Air Itam Dam, Teluk Bahang Dam, and Muda Dam. The Muda River Basin is in the northern region of Peninsular Malaysia, predominantly within the state of Kedah. The Muda River basin is a significant hydrological region in Malaysia, renowned for its agricultural significance owing to the rich plains nourished by the river. The Muda River Basin is well-known for its productive plains, crucial for agriculture, especially rice production. The basin facilitates the growth of paddy rice, establishing it as a prominent rice-producing area in Malaysia. In addition to its agricultural importance, the Muda River Basin plays a crucial role in supporting biodiversity by serving as a home for a wide range of plant and animal species. Additionally, it promotes the growth of the local economy by facilitating fisheries and ecotourism endeavors. The study area is indicated in Figure 1 below.

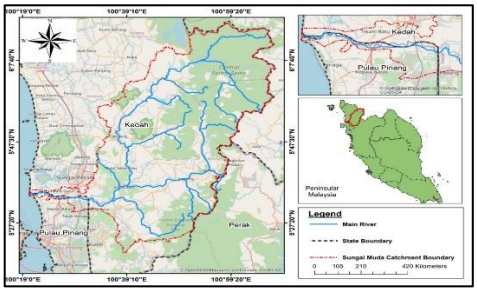

Fig. 1: Study Area

RESULT AND DISCUSSION

Profile Demography Respondents

The study's results are based on data collected from 161 questionnaire respondents. Out of the entire group of participants, 80 individuals (49.7%) identified as male, while 81 individuals (50.3%) identified as female. According to the data, the age group between 21 and 30 has the highest number of respondents, with 89 individuals accounting for 55.3%. Contrastingly, the age group below 20 years had the fewest respondents, with only eight individuals accounting for 5.0% of the total feedback received for the questionnaire. Most of the respondents, 98 individuals (60.9%), possess a first degree or higher education level. Interestingly, a significant portion of the group, 43 individuals (25.9%), have achieved a High School Certificate and Diploma as their education level. The percentage of individuals with secondary school education is 20, 12.4%. In addition, a significant portion of the participants in the survey, precisely 55.3% or 89 individuals, stated that their monthly income is below RM2,589.00. Of the respondents, 35 (21.7%) reported an income ranging from RM 2,590.00 to RM 4,850.00. Following closely behind, 29 respondents (18.0%) had a monthly income between RM 4,851.00 and RM 10,970. Of all the respondents, eight individuals (5.0%) reported an income range of RM 10,971.00 - RM 15,041.00. Regarding employment, it's interesting that the most significant respondents are involved in agriculture, with 66 individuals making up 41.0% of the sample. Following closely behind is the clerical sector, with 33 people accounting for 20.6% of the respondents. Additional data can be found in Table 3.

Table 3: Profile Demography Respondents

Profile Demography	Number of Respondents (n)	Percentage (%)
Gender		
Male	80	49.7
Female	81	50.3
Age Group		
< 20 years	8	5.0
21 – 30 years	89	55.3
31 – 40 years	30	18.6
41 – 50 years	20	12.4
> 51 years	14	8.7
Level of education		
Degree/Master/Ph.D.	98	60.9
STPM/Diploma	43	26.7
Secondary School	20	12.4
Monthly Income		
< RM 2,589	89	55.3
RM 2,590 – RM 4,850	35	21.7
RM 4,851 – RM 10,970	29	18.0
RM 10,971 - RM 15, 041	8	5.0
Occupation		
Manager/Professionals	26	16.1
Technician/Associate Professional	22	13.7

Clerkship	33	20.6
Agriculture	66	41.0
Self-employed	12	7.5
Retired	2	0.1

Understanding the Significance of Forests in the Provision of Water Resources

The study found that overall, the level of understanding among respondents regarding the significance of forests in provisioning of water resource is high, with 92.0% (148 individuals) scoring between 23 - 30, while 8.0% (13 individuals) scored between 14 - 22 (Table 4). This is because most of the respondents had attained a bachelor's degree, Diploma, or High School education, which increases their awareness of the crucial role of forests in supplying water resources to human. Galgotia and Lakshmi (2022) state that education enables individuals to learn and disseminate information and knowledge and utilize it in problem-solving and ongoing personal growth. Furthermore, as stated by Mohamad and Teoh (2006), most citizens in Malaysia possess a substantial level of awareness and exhibit a significant degree of care regarding natural resources, particularly forests. Similarly, in Penang, many individuals residing in the Seberang Perai Utara region frequently rely on the water supply from the Ulu Muda Forest via Sungai Muda for agricultural and household use. According to the Integrated Development of Penang (2022), the Sungai Muda Irrigation system can provide water resources to an area of 6129 hectares in Penang.

Table 4: The level of understanding of forest-related interests in the provision of water resources

Level of Understanding	**Score Range**	**N**	**Percentage (%)**
High	23-30	148	92.0
Middle	14-22	13	8.0
Low	6-13	-	-

Table 5 presents the distribution of the tested items, which were used to assess the population's level of understanding of the significance of forests in supplying water resources in the lives of the people in Penang. The study's findings indicate that up to six questions have a very agreeable answer elegance. The demonstrates the high understanding among the people of Penang on the significance of forest resources for supplying water resources for their livelihoods. Hanis & Nur Fazrina (2021) indicate that the Ulu Muda Forest serves as a crucial water catchment area for the Northern states of Peninsular Malaysia, including Kedah, Perlis, and Penang. This forest plays a vital role in supplying water to the primary rivers in Kedah, notably Sungai Muda and Sungai Kedah. Hence, the Ulu Muda Forest serves as a reservoir for rainwater and underground water through to its natural topography. Consequently, it acts as a crucial water source for Sungai Muda, greatly enhancing the lives of the people of Penang. This is particularly evident in the realm of agriculture and the provision of clean water for domestic use. Consequently, this leads to an increased understanding among the people of Penang regarding the significance of forest resources in supplying water resources to the hydrological system and human existence.

Table 5: Responses of Understanding the Significance of Forests in the Supply of Water Resources

No	**Question Statement**	**Scale**					**Mode**
		1	**2**	**3**	**4**	**5**	
1	Forests act as places that store and retain rainwater.	-	-	2	30	129	**5**
2	The existence of trees in the forest plays a crucial role in regulating the flow of rainwater.	-	-	8	30	123	**5**
3	Forests can mitigate soil erosion.	-	-	8	30	123	**5**
4	Forests act as water storage stores	-	-	6	36	119	**5**

5	Forests play a crucial role in storing water underground.	-	-	2	45	114	**5**
6	The water flow from the forest serves as an essential water source for the river.	-	-	-	37	124	**5**

(Note*: 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= Strongly Agree)

Perceptions of the impact of change in forest land use on the water resource provision

Water resources are incredibly valuable and widely distributed natural resources found all over the world. The hydrological cycle allows for the remarkable self-purification and renewal of water, ensuring its long-term conservation with a high level of purity, availability, and quality. They play a crucial role in maintaining sufficient food security and a thriving environment for all living beings on our planet (Patra, Shilky, Kumar, and Saikia, 2023). Changes in land use directly influence the composition and operation of ecosystems, subsequently impacting the overall ecological services (Mononen et al. 2016). The challenges to ecosystem services and biodiversity are expected to increase over the next decade (Song et al. 2015). The impacts of land use change on groundwater flow, evapotranspiration, surface runoff, steam discharge, and infiltration processes are more noticeable, according to studies conducted by Kirby et al., (2016) and Natkhin et al., (2015).

According to the findings presented in Figure 2, it has been demonstrated that the supply of water resources is significantly affected by changes in forest land use. This conclusion is based on the relative importance index (RII) analysis. The impact with the highest RII value of 0.97 is the potential for increased flooding. As a result of alterations in forest land use, there is a significant potential for increased flooding. This can be demonstrated in a study by Diwate et al. (2023) on the Vashishti River. The river experienced flooding on 22 July 2021 due to changes in forest land use for development purposes. These changes led to a significant release of water from the Kolkewadi dam at a rate of 8622 cusecs/s. As a result, the volume and intensity of water flow increased, exacerbated by heavy rainfall, which played a significant role in causing the river to flood. Furthermore, another significant factor is the interference with the natural process of water infiltrating into the soil, which subsequently heightens the likelihood of soil erosion on the surface. This is indicated by a RII value of 0.94. Changes in land use can have a significant impact on the availability of water by altering the rates of infiltration and evapotranspiration, as highlighted by Natkhin et al. (2015). In addition, alterations in the hydrological cycle can lead to variations in the amount and timing of water flow, resulting in potential impacts on water volume, nutrient levels, and sediment accumulation (Vanham et al. 2016). If this situation persists, it will affect the water cycle as well.

Furthermore, the heightened risk of a water crisis, the loss of water catchment areas, and the decline in water quality represent the third most significant impact of land use change, reflected in an RII value of 0.93. According to the research conducted by Abildtrup, Garcia, and Stenger (2013), alterations in forest land will lead to variations in air quality values. Similarly, Camara, Jamil, and Abdullah (2019) discovered that modifications in forest land use will impact water quality and runoff quality, ultimately resulting in a water crisis. Moreover, alterations in forest land utilisation will lead to disruptions in air retention quality. The research conducted by Akhtar, Syakir Ishak, Bhawani, and Umar (2021) indicates that human interactions with forest resources can significantly impact surface air quality and the quality of air storage. This includes factors such as dissolved oxygen levels, turbidity, bioindicators, nitrates, pH levels, and water temperature.

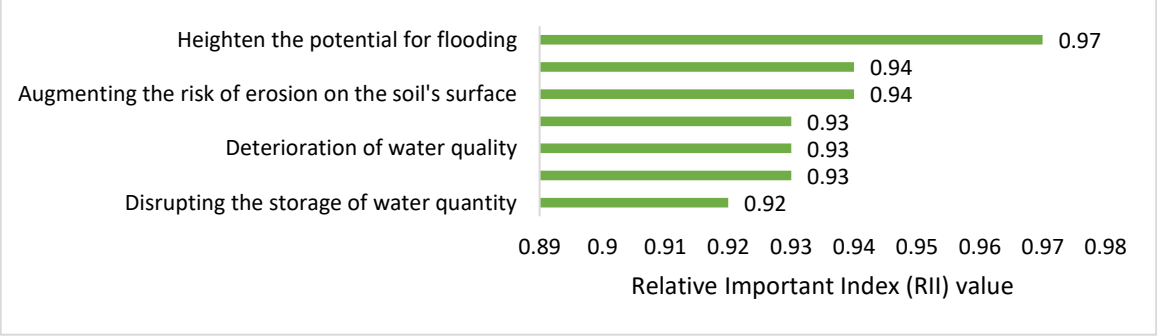

Fig. 2: RII value on Perceptions of the impact of change in forest land use on the water resource provision

CONCLUSION

Forest resources offer a range of direct and indirect advantages to human existence. One of the significant advantages to humans is its role as a reservoir for water. The forest serves as a vital area for collecting and directing water to the river, ensuring that communities have access to essential resources like clean water for daily activities, agriculture, and industrial needs. Nonetheless, the services provided by forest ecosystems will be impacted when they undergo alterations, such as shifts in land use practices. The modifications in forest land use will adversely affect plant and animal life. The devastation of forest catchment regions will result in water shortages, flooding, compromised water quality, and disturbances to the natural cycle and flow of water to rivers. The implications of changes in forest land use significantly impact the quality and well-being of human life. Consequently, it is essential to monitor the forest, as it significantly contributes to providing water resources vital for all forms of life. This study can enhance global understanding and awareness of the significance of forests in providing crucial water resources for the sustenance of plants, animals, and humans. Furthermore, it can assist stakeholders in developing effective ways to promote awareness regarding the preservation and conservation of forest resources. This study recommends conducting a more extensive investigation of the benefits of forests, including provision services, regulation services, supporting services, and cultural services advantages that affect flora, forest biodiversity, and humans.

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