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Establishing Productive Arboriculture to Enhance the Local Economy and Safeguard the Environment in the Lake Toba Region, Silahisabungan District, Dairi Regency, North Sumatra Province

Kaniwa Berliani[*1], Arlen HJ[1], Nursal[1], Putri Cahaya Situmorang[1], Muhammad Zaidun Sofyan[1]
[1]*Biology Department, Faculty of Mathematics and Natural Science, Universitas Sumatera Utara, North Sumatera, 20155, Indonesia*
[*]Corresponding Author: kaniwa.berliani@usu.ac.id

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ABSTRACT
Lake Toba features a diverse array of geological landscapes and rock formations, alongside globally acknowledged cultural and biological variety. The geological diversity of the Lake Toba caldera possesses significant Geological Heritage value. This region possesses significant potential as a premier tourism destination and merits inclusion in a worldwide geopark. A survey in Silahisabungan District identified desolate, landslide-prone regions along the shores of Lake Toba that remain uncultivated. Simultaneously, a significant portion of the region is allocated for ecotourism. Should the tourist site suffer escalating degradation owing to desolation, it is anticipated that the influx of visitors to the Silahisabungan region will likewise diminish. If the community's economic revenue relies exclusively on the tourism industry, the economy would undoubtedly face challenges; therefore, economic income must be derived from several sectors. Consequently, the region urgently requires the implementation of tree planting initiatives, particularly including 1,500 productive tree types. Productive tree seedlings will be cultivated in five villages: Paropo, Paropo I, Silalahi I, Silalahi II, and Silalahi III, located in the Silahisabungan District of Dairi Regency, North Sumatra. The tree planting initiatives are anticipated to yield economic benefits for the community through fruit harvests. This planting initiative would enhance the local economy while reforesting desolate area, hence drawing tourists to Silahisabungan.

Keyword: Planting, Tree seedlings, Lake Toba, Silahisabungan

1. Introduction

The Lake Toba Caldera is a massive volcanic caldera that erupted with such ferocity that it altered the global climate and nearly wiped humanity. Approximately 74,000 years ago, Mount Toba had a catastrophic supereruption, dispersing a massive hot cloud that enveloped nearly the entire expanse from the eastern to the western tip of Sumatra Island. The magma explosion attained a volume of 2800 km³ and an eruption index of magnitude 8.8, rendering it the most powerful eruption in Earth's history. This catastrophe resulted in a natural phenomenon, specifically the remarkable Lake Toba, endowing the region with significant geological diversity characterized by varied natural landscapes and rock types, with internationally acknowledged cultural and biological diversity. The geological diversity of the Lake Toba caldera possesses significant geoheritage value. This region possesses significant potential as a premier tourism destination and merits inclusion in a worldwide geopark.

Silahisabungan District features stunning landscapes due to Lake Toba, the largest lake in Indonesia and the largest volcanic lake globally. The terrain encircling the lake is enveloped in rainforest, featuring tropical

Sumatran pine forests in the elevated highlands. The settlements in Silahisabungan District possess abundant natural beauty and a variety of tourist attractions. Nonetheless, this scenario may change if illegal logging transpires, rendering numerous regions desolate and unable to retain water, resulting in diverse natural calamities such as wildfires, inundations, and landslides. When forests are compromised, nature's capacity to sequester greenhouse gases diminishes significantly. As a result, global temperatures increase, rendering dramatic climate change more probable. Nonetheless, if the forest is conserved and safeguarded, Silalahi Village, alongside its natural splendor, also features distinctive customs and culture that attract tourists.

A survey in Silahisabungan District identified desolate, landslide-prone terrain along the shores of Lake Toba that remained uncultivated. Simultaneously, a significant portion of this region is allocated for ecotourism. Should the tourist site suffer escalating degradation due to desolation, it is anticipated that the influx of visitors to the Silahisabungan region will likewise diminish. If the community's economic revenue relied exclusively on the tourism sector, it would undoubtedly hinder the economy; So, income must be derived from alternative areas. As a result, the community service implementation team and partners determined that the region urgently requires tree planting initiatives, particularly of productive tree species. Consequently, by cultivating productive tree seedlings, it is anticipated that the community will gain economic revenue from the fruit harvest. This planting initiative, besides enhancing the community's economics, can also restore desolate land, hence attracting tourists to Silahisabungan.

2. Method

Community service activities were conducted on Saturday and Sunday, May 30-31, 2025, in five villages: Paropo, Paropo I, Silalahi I, Silalahi II, and Silalahi III, located in Silahisabungan District, Dairi Regency, North Sumatra. The execution procedure for this community service initiative can be categorized into multiple phases as outlined below:

2.1. Activity planning phase

At this stage, the implementation team executed observations, interviews, surveys, coordination, and seedling preparation. The implementation team, in collaboration with partners PERWAKU and PPRSI (Indonesian Village Development Association), engaged in discussions with village officials, community leaders, and field workers to strategize effective tree planting initiatives. The community service team elucidated the aims, target accomplishments, and current initiatives of the community service program to PERWAKU, PPRSI, and local officials/community leaders. The community service team performed direct observations to evaluate environmental conditions and land potential in the Silahisabungan District, comprising five villages, to gather data. The team then conducted interviews with the village government and local community to gather their views on environmental conditions and land potential for productive tree planting. The community service team recorded multiple observations during patrols with local officials and assessed the state of the desolate region. Nevertheless, no afforestation efforts have been undertaken to rehabilitate the desolate, landslide-susceptible region. A survey was done to identify suitable, productive tree seedlings and effective planting strategies. Additionally, collaboration with the village government concerning the designated land for cultivation, encompassing land ownership and deliberations on the forthcoming planting initiative with the village government and other stakeholders.

2.2. Implementation phase of beneficial afforestation activities

The implementation team will plant 1,500 tree seedlings, including 200 durian, 300 avocado, 300 sugar palm, 300 quinoa, 300 candlenut, and 100 mango seedlings. These seedlings are anticipated to mitigate the risk of barren land and landslides while enhancing economic revenue in Silahisabungan District. Phase of evaluation and feedback. At this juncture, the implementation team will solicit feedback from participants concerning their experiences and modifications subsequent to the execution of the productive tree planting outreach program, as well as offer guidance on tree care and maintenance. The tree planting initiative, designed to reforest sites susceptible to landslides, will be assessed using questionnaires distributed to participants, addressing their knowledge, comprehension, awareness, outreach, and the advantages of tree planting and environmental reforestation. Questionnaire data will be statistically analyzed to derive a percentage of responses regarding the mentoring activity outcomes, which will inform the evaluation of the activity's objectives.

2.3. Community service involving the planting of 1,500

Community service involving the planting of 1,500 productive tree seedlings was attended by Biology lecturers from FMIPA USU, the Deputy Regent, the Deputy Chairperson of PKK Dairi Regency, the Head of Silahisabungan Sub-district, the Head of the Environmental Protection and Management Arrangement and Compliance Division of the Environmental Service, the Village Head, village officials, partners from the Indonesian Environmental Intellectuals Association (PERWAKU) North Sumatra, the Pomparan Raja Silahisabungan Association throughout Indonesia (PPRSI), and local community representatives from Paropo Village, Paropo I, Silalahi I, Silalahi II, and Silalahi III.

3. Result and Discussion

The cultivation of 1,500 fruitful tree seedlings in Silahisabungan District constitutes a community service initiative undertaken by professors from the Biology Department of the University of North Sumatra. This activity comprises three primary stages: planning, implementation, and post-planting evaluation/feedback.

The preliminary phase of devising an effective tree planting initiative aimed at enhancing the community's economy and safeguarding the environment in the Lake Toba region of Silahisabungan District, Dairi Regency, North Sumatra Province, encompassed observations, interviews, and surveys to assess the village's status and potential. The findings indicated vast desolate terrain with significant susceptibility to landslides. The terrain of the Lake Toba region complicates precipitation retention due to significant surface runoff, elevated erosion rates, and a high risk of landslides, especially in the steep to very steep zones near the lake's shores. The limited water absorption and retention capacity of this region is evidenced by the numerous small rivers that occasionally traverse the land. These rivers are perennial during the rainy season and become ephemeral in the dry season. The study [3] indicates that shrub and grassland comprise 27% of the total land area in the Lake Toba region. The challenging topography circumstances, along with a notably high erosion rate, are attributed to the predominance of Litosol and Regosol soils in the area, which are very susceptible to erosion. Approximately 40% of the total land area of the Lake Toba region consists of soil that is very susceptible to erosion. The topographic conditions in the Lake Toba region are largely stable, thus maintaining their influence; however, such topography is susceptible to alterations in land use or other anthropogenic activities that can significantly affect both the quantity and quality of Lake Toba's water. The terrain exhibits soil properties that are prone to disintegration in the dry season and become pliable in the rainy season, resulting in instability that facilitates landslides. Landslide disasters can be induced by the composition of residual and colluvial soils, which are loose and capable of retaining water. When the soil becomes saturated, the increased water pressure diminishes the soil's shear strength, affecting the surrounding environment. If the soil overlays an impermeable and denser layer of soil or rock, water saturation will escalate. The water is challenging to absorb and infiltrate into the underlying layer of soil or rock. This may lead to the soil's water buildup becoming comparatively loose. The slip plane of land movement is created when a more impermeable layer of soil or rock interfaces with the overlying bulk of soil. Intense precipitation induces surface runoff and infiltration, resulting in landslides on slopes with soil that readily absorbs moisture [4]. Observations, interviews, and surveys conducted in the Silahisabungan District, comprising five villages—Paropo, Paropo I, Silalahi I, Silalahi II, and Silalahi III—indicate that the cultivation of productive tree seedlings is a crucial strategy for addressing issues of barrenness that are prone to landslides, with the potential to enhance the local economy.

Tree planting is a mitigating strategy for landslide disasters, as noted in [5]. The findings of this study demonstrate that tree planting mitigates landslide risk and enhances overall environmental quality. Expanding the advantages of cultivating fruitful trees will yield economic benefits for the local community. The community service team utilized productive tree seedlings that yield fruit to enhance the economy during this planting effort. The root systems of productive trees are less successful than those of woody trees in avoiding landslides due to potentially weaker root structures. As stated in [6], woody trees possess robust roots that effectively anchor the soil in the upper layer, hence mitigating the risk of landslides. Consequently, the community service team from the USU Biology Study Program determined that 1,500 seedlings were required for planting at the site. Subsequently, the team collaborated with the villages of Paropo, Paropo I, Silalahi I, Silalahi II, and Silalahi III to solicit authorization for the implementation of productive tree planting initiatives. The community service team partnered with PERWAKU, PPRSI, and other universities that served as partners, supplying seeds and extension materials during the execution of productive tree planting activities. Two hundred durian seedlings, three hundred avocado seedlings, three hundred sugar palm seedlings, three hundred kuini seedlings, three hundred candlenut seedlings, and one hundred mango seedlings will be planted. Preparation for planting entails clearing the designated area and assembling requisite equipment and

instruments, including shovels, stakes, bags, crowbars, hoes, sickles, brooms, and others. Simultaneously, the community service team offered guidance on the advantages and methods of cultivating and sustaining fruitful trees. The participants exhibited considerable enthusiasm, as seen by their inquiries about tree planting techniques, care, and the marketing of fruit production.

Figure 1. Community service team of Study Program of Biology

Following the completion of the preliminary phase, the community service initiatives progressed to the execution phase of productive tree planting operations. The activity commenced with a ceremonial event (Figure 2) featuring remarks from Ir. Bosmen Silalahi, MBA, representing the Pomparan Raja Silahisabungan Association across Indonesia (PPRSI), followed by Dr. Arlen Hanel John, M.Si, the General Chairperson of the North Sumatra DPW PERWAKU, the Community Service team from the Biology Study Program, FMIPA USU, village community leaders represented by Mr. A. Situngkir, and concluding with remarks from the Deputy Regent of Dairi, Wahyu Daniel Sagala.

Figure 2. Ceremonial event for productive tree planting activities in Silahisabungan District

The initiative proceeded with the transfer of 1,500 fruitful tree seedlings to the community of Silahisabungan District, supplied by the community service team from the Biology Study Program, FMIPA USU, PERWAKU, and PPRSI. Subsequently, counseling was conducted for the community to discuss effective planting techniques to ensure the successful growth of profitable trees on barren, landslide-prone terrain. Landslides are a process of mass movement of rocks or soil driven by gravitational forces, as stated in [7]. Prolonged dry seasons coupled with heavy rainfall will destabilize the ground. The terrain exhibits soil properties that become easily fragmented in the dry season and pliable during the rainy season, resulting in instability that renders it susceptible to landslides. If handled, this land condition would result in landslides, which pose significant risks to the local people surrounding Silahisabungan District.

Figure 3. Handing over productive tree seedlings to the community

The allocation of productive tree seedlings to the community in the Silahisabungan District was executed by the Village Heads of Paropo, Paropo I, Silalahi I, Silalahi II, and Silalahi III. Each village was allocated around 300 productive tree seedlings, comprising 40 durian seedlings, 60 avocado seedlings, 60 sugar palm seedlings, 60 kuini seedlings, 60 candlenut seedlings, and 20 mango seedlings. The distribution of productive tree seedlings constituted a significant event within the framework of this activity. The distribution of seedlings was conducted by the Deputy Regent of Dairi, PERWAKU, PPRSI, and the community service team from the Biology Study Program, FMIPA USU to the Village Heads (Figure 3).

Figure 4. Community members collecting productive tree seedlings for planting

The transfer of productive tree seedlings elicited a favorable reaction from the community, which proceeded to plant the seedlings in desolate, landslide-prone regions. The community service team assisted them with site selection and planting protocols (Figure 4). They conveyed their endorsement for the ongoing cultivation

of fruitful trees in the forthcoming year and articulated their desire for the inclusion of coconut seedlings in the planting area.

The planting initiative commenced with the clearance of the site surrounding the Silahisabungan King's tomb complex. The community service team subsequently executed a tree planting demonstration to instruct on appropriate planting practices to guarantee the trees' vitality. Prior to planting, the soil was aerated by removing grass. After clearing, planting holes were excavated. The fruitful tree seedlings were planted in conjunction with the community service team, the Deputy Regent, the Village Head, and the participants/community members of Silahisabungan District. The planting procedure encompassed the insertion of seedlings, the application of fertilizer, and consistent irrigation to promote robust growth (Figure 5).

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Figure 5. Planting productive tree seedlings

Productive tree seedlings, still in polybags, are extracted by tearing the bags prior to planting. The planting medium is subsequently compressed by compressing the polybag. The seedlings are positioned upright in the center of the hole and meticulously enveloped with soil. When filling, prioritize the insertion of topsoil into the hole initially. The earth around the seedlings is subsequently compressed until the roots establish touch with it. The cultivation of productive tree seedlings aims to address the barren land susceptible to landslides

and environmental deterioration surrounding Lake Toba. Moreover, the implementation of environmental management through the cultivation of productive trees will yield a fruit harvest, thereby generating a source of income for the community in Silahisabungan District. The community must acknowledge that all stakeholders are responsible for fostering an environmentally conscious, aesthetically pleasing, harmonious, and sustainable village, thus enhancing environmental quality and executing ecologically sound development [8,9]. Tree planting initiatives can enhance community knowledge and concern for environmental conservation.

The concluding phase of the community service initiative involves assessment and feedback from the program facilitators. This entails collecting feedback from participants on their experiences and modifications subsequent to the execution of the productive tree seedling planting extension program, as well as offering guidance on tree care and maintenance. As stated in [10], community service extension initiatives must be significant about relevance, acceptability, effectiveness, and precision in material delivery. An assessment of the tree planting initiative as a greening strategy for barren, landslide-prone areas was performed by administering questionnaires to participants regarding their understanding of tree planting and environmental greening. The questionnaire data was statistically analyzed to derive a percentage of responses regarding the mentoring activity outcomes, which formed the foundation for evaluating the attainment of the activity's objectives. To enhance awareness of tree planting as a greening initiative for barren, landslide-prone areas in the villages of Silahisabungan District, Dairi Regency, North Sumatra, the community service team undertook the following actions: 1) Analyzing the patterns and traits of the communities inside each village. 2) Conducting outreach to promote the advantages of tree planting as a greening initiative on desolate terrain adjacent to the lake coast. 3) Executing clean-up and tree planting initiatives as an environmental greening effort with the village community, encompassing plant care instructions. The implementation team received assistance from village officials in executing these initiatives. The Pekasana team anticipates that this community service program, which involves planting productive trees, would advantage the communities in the villages of Silahisabungan District, Dairi Regency, North Sumatra.

The initiative to plant production tree seedlings on landslide-prone barren ground successfully engaged 62 participants/communities, all of them (100%) attended and participated, which was deemed highly commendable. The attainment of the activity's objectives is commendable (85%) due to an enhancement in participants' knowledge regarding the utilization of lands prone to landslides, groundwater conservation, particularly in relation to erosion, and the economic potential of future fruit yields. Furthermore, the attainment of the established material objectives is commendable (85%) as the community service team successfully supplied all items within a constrained timeframe. Moreover, the proficiency of participants and communities in acquiring the subject is commendable (80%), attributable to the straightforward delivery of content through socialization methods and practical demonstrations, such as tree planting help. The initiative of planting productive tree seedlings to enhance the community's economy and conserve the environment in the Lake Toba Area, Silahisabungan District, Dairi Regency, North Sumatra Province, can be deemed effective and successful, as proven by the four mentioned components.

Tabel 1. Evaluation of community service activities

No.	Evaluation	Category (%)		
		Bad	**Good**	**Very Good**
1	Alignment of community service activities with community expectations			100
2	Cooperation between community service and the community	10	40	60
3	Increasing community empowerment		75	25
4	Increasing community socio-ecological knowledge		90	10
5	Benefits of community service results			100

Table 1 indicates that the outcomes of this community service activity aligned with the community's expectations. The activity facilitated effective collaboration among diverse stakeholders, optimizing the local community's potential, enhancing environmental awareness, and generating economically valuable fruit products for the community in Silahisabungan District, Dairi Regency.

4. Conclusion

The Biology Study Program of the Faculty of Mathematics and Natural Sciences, University of Indonesia (USU), has cultivated productive trees to enhance the local economy and promote environmental conservation in the Lake Toba region of Silahisabungan District, Dairi Regency, North Sumatra Province. This effort seeks to cultivate an environmentally aware community by planting productive trees to reforest degraded area susceptible to landslides around Lake Toba, while also educating the community on the significance and functions of reforestation and productive flora. This community service effort has fulfilled the community's objectives by promoting good teamwork, empowering residents, enhancing environmental awareness, supplying useful plant products, and delivering economic benefits to the Silahisabungan District in Dairi Regency.The Biology Study Program at the Faculty of Mathematics and Natural Sciences, USU, anticipates that this initiative will facilitate interactions between USU lecturers and students and the community, as well as foster collaborations with institutions and organizations, thereby allowing the application of biological knowledge and the establishment of social networks within the Silahisabungan District, Dairi Regency.

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