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Multi-Factor Evaluation of RHL Success in Neniari Village, Indonesia

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General Background: Forest and land rehabilitation (RHL) is essential for addressing critical land conditions, aiming to transform unproductive lands into areas that can enhance community living standards through increased productivity. **Specific Background:** In Neniari Village, the RHL program has been implemented with mixed success, utilizing agroforestry systems and involving various species, including both timber and non-timber plants. **Knowledge Gap:** Existing studies often lack detailed analysis of the factors influencing RHL success at a community and ecological level. **Aims:** This study seeks to evaluate the overall success of the RHL program in Neniari Village by considering plant survival rates, environmental factors, and community participation. **Results:** The survival rate of plants averaged 70%, indicating a moderate level of rehabilitation success, which did not meet the targeted benchmarks. **Novelty:** This research uniquely combines biotic and abiotic factor analyses with community engagement levels to assess RHL outcomes. **Implications:** The findings highlight the need for enhanced community involvement and improved environmental condition management to boost RHL success rates, suggesting adjustments to future rehabilitation strategies.

Highlights:

- **Community Involvement:** Higher levels of community participation are directly linked to the success of rehabilitation efforts, indicating the need for more focused engagement strategies.
- **Plant Survival:** An average survival rate of 70% among various plant species underlines the challenges of RHL in achieving its goals, pointing towards the necessity for improved environmental management.
- **Agroforestry Benefits:** Utilizing agroforestry systems has shown potential benefits in enhancing ecological diversity and economic returns, suggesting its suitability for RHL practices.

Keywords: Forest Rehabilitation, Community Participation, Agroforestry Systems, Plant Survival Rates, Environmental Factors

Introduction

Rehabilitating forests and land (RHL) is one of the most effective methods for addressing critical

land issues. Although significant land restoration initiatives may not fully restore the land to its original condition, they can significantly enhance the productivity of the land, thereby improving the community's standard of living [1]. According to [2], the government has been leading efforts to conserve and reforest land through forest and land restoration programs. These initiatives aim to revive crucial land areas and prevent the expansion of critical land, ensuring long-term environmental sustainability and community welfare.

Hermawan asserts that both the government and landowners share accountability for the success of the RHL program [3]. The community is responsible for implementing the program and undertaking land improvement efforts, while the government provides support through facilities, technical advice, and oversight. The RHL program is complex, requiring significant resources, a lengthy timeframe (several years), multiple partners, and a variety of features. This complexity complicates management and increases the likelihood that the goals of the RHL program may not be met. Therefore, an assessment of the RHL program is necessary to determine its level of success.

In Neniari Village, a comprehensive forest and land rehabilitation program was implemented to address the unproductive state of the majority of the 150 hectares of Alang-Alang-dominated land. This area is divided into six blocks, each measuring 25 hectares, situated in the neighborhood's petuanan. The program, running from January 2019 to January 2023, consisted of three phases: current year maintenance (P0), maintenance I (P1), and maintenance II (P2). The sequence of activities included program socialization, planting planning, seedling supply design, planting, and plant maintenance design. Specific tasks undertaken during the program were acquiring seedlings, clearing and creating plant trails, building shelters and work huts, creating signage, conserving soil, setting up stakes, creating plates and planting holes, planting, and ongoing plant maintenance.

The acquisition of seedlings includes 13,200 ironwood (Intisia bijuga) stems, 3,300 durian (Durio zibethinus) stems, 9,900 agarwood (Aquilaria malaccensis) stems, 3,300 damar (Agathis dammara) stems, 13,200 candlenut (Aleurites moluccana) stems, 6,600 clove (Syzygium aromaticum) stems, 3,300 lansium (Lansium domesticum) stems, 13,200 nutmeg (Myristica fragrans) stems, and 15,000 lamotoro (Leucaena leucocephala) stems. These plants are part of an agroforestry planting technique used in forest and land rehabilitation projects. The non-timber forest products include ironwood (Intisia bijuga), agarwood (Aquilaria malaccensis), damar (Agathis dammara), and lamotoro (Leucaena leucocephala). The Multi-Purpose Tree Species (MPTS) plants include candlenut (Aleurites moluccana), durian (Durio zibethinus), cloves (Syzygium aromaticum), nutmeg (Myristica fragrans), and langsat (Lansium domesticum). Utilizing agroforestry techniques on the land can significantly enhance the social, economic, environmental, and psychological well-being of the residents of Neniari Village.

Methods

A. Tools and Materials

The tools used were GPS, compass, thermo meter, lux meter, Ph meter, ropes, tally sheet, camera and stationery. The materials used are trees that are found growing in the research location which include cloves, nutmeg, durian, langsat, candlenut, agarwood, ironwood, lamtoro and resin

B. Research Methods

1. Observation of the Number of Plants

The method used in this study was a survey method with 100% intensity of the number of planting plots. This means that there were 74 plant plots and each plant plot measured 25 x 40 m and contained 60 plantlets. Each plant plot contained different plant species because it used a mixed

species planting pattern. Observations of the number and types of plants that live were made by counting the number of plants that live in each plot. Plants are counted per measuring plot, which consists of one plot totaling nine types of saplings.

2. Observation of the Place of Plant Growth

The place of plant growth was observed through the measurement of temperature, humidity, light, availability of soil water and the thickness of humus (soil organic matter) in the plots that were sampled for plant growth observation.

3. Data Analysis

To determine the success rate of forest and land rehabilitation plants will be analyzed based on the following formula

Percent of living plants = Number of living plants / Total number of plants planted x 100

To analyze the most influential factors on plant growth, multiple regression analysis was used with the following formula

Yijk = b0 + bX1 + bX2 + bX3 + bX4 + Eijk

Where:

Yijk = Plant growth

b0 = Intercept value

bx1 = Average temperature of each plot

bx2 = Average humidity of each plot

bX3 = Average thickness of humus or organic matter per plot

bX4 = Average soil pH of each plot

Eijk = Experimental error

a. Participation Rate Analysis

No	Score	Rating
1	5	Strongly Agree
2	4	Agree
3	3	Doubtful
4	4	Disagree
5	1	Strongly Disagree

Table 1. ***Likert scale rating***

P(%) = ni/N x 100%

Description :

P : Percentage of participation

ni : Number of samples in the category (high, medium, and low)

The level of community participation is grouped into 3 categories, namely

High level of participation is in the score interval 74-100

Medium level of participation is in the score interval 47 - 73

Low participation level is in the interval 20 – 46

Results and Discussion

A. Success of Forest and Land Rehabilitation

a) In the appendix of the Minister of Environment and Forestry Regulation No. P 105/2018 concerning the assessment of the success of plant growth, it is clearly stated that the evaluation/assessment of plants is carried out through two stages, namely:

b) Assessing the progress of the planting implementation stages (block/plot boundary demarcation, making inspection roads, clearing land, making/procuring and installing path stakes, making plant paths, making and installing stakes, making plant holes, distributing seedlings to plant holes, planting, basic fertilization/planting media, making work huts, making signboards, maintaining the current year's plants, maintaining the first year's plants and maintaining the second year's plants).

c) Measurement of the plant area is carried out on the realization of the planting area expressed in the planted area in units of Ha and compared to the planned plant area according to the design, but the guidelines for assessing the success of plant growth do not explain what is the minimum percentage of live plant growth that is declared successful that can be converted and recapitulated into a live plant area that is declared successful in maintenance I and II.

d) The guidelines for evaluating/assessing the success of plant growth are biased because they claim that after maintenance I and II (including replanting), the plant area does not change and is always declared successful in the process of plant growth. Whereas in reality in the field this is not the case, in one 100 ha plantation site for example, the level of land fertility is not the same between one habitat and another, so that the chances of plants to grow alive are certainly different with different habitats.

B. Plant Growth Success

The success rate of plant growth of forest and land rehabilitation carried out in Neniari Village in 2021 to 2023, due to unproductive land so that to restore forest land back to productive the government conducts forest and land rehabilitation, for the success of each plant can be estimated by calculating the proportion of living plants in each plot.

No	Plant Type	Total number of saplings planted	Number of living saplings	Number of dead saplings	Percentage of plant growth
1	Ironwood (Intisia Bijuga)	740	740	0	100%
2	Damar (Agathis Dammara)	370	267	103	72,16%
3	Agarwood (Aquilaria Malaccensis),	518	206	312	39,76%
4	Candlenut (Aleurites Moluccana).	370	335	35	90,54%

5	Durian (Durio Zibethinus)	370	312	58	84,32%
6	Langsat (lansium Domesticum)	370	260	110	70,27%
7	Clove (Zyzygium Aromaticum)	370	283	87	76,48%
8	Nutmeg (Myristica Fragrans)	592	96	496	16,21%
9	Lamtoro (Leucena Leucocephala)	740	0	740	0%
	Total	4440	3106		

Table 2. ***Number of Dead and Living Plants in 2023 in Each Plot***

In the data above, the number of plant species that do not grow at all is 0% in the RHL location, namely Lamtoro (Leucena Leucocephala). This is because the place of growth is not suitable. Lamtoro (Leucena Leucocephala) plants usually grow in sandy soil at an altitude of 0 - 300 meters above sea level. The second type that is less growing is nutmeg (Myristica Fragrans) there are 96 living saplings, this is because nutmeg (Myristica Fragrans) is one of the trees that can grow in the tropics at an altitude below 700 m above sea level while for nutmeg (Myristica Fragrans) at the RHL location itself above 1800 above sea level. The third type that is less growing is agarwood saplings (Aquilaria Malaccensis), this is due to the hot season and no concern from the community. For the resin plant (Agathis Dammara) itself, 267 trees lived and 103 died, this was due to the hot season and the lack of participation of the community and farmer groups. Candlenut (Aleurites Moluccana) which lived 335 and died 35 can be concluded that the growing place is suitable for candlenut saplings (Aleurites Moluccana) and those that died were caused by the summer and lack of community participation. For durian (Durio Zibethinus) plants that live 312 and die 58 this is because the place to grow is very suitable for durian plants (Durio Zibethinus) while those that die are caused by the lack of awareness of the community and farmer groups. Clove plants (Zyzygium Aromaticum) the number of living 283 while the dead 87 this is because the place to grow is very suitable for clove plants (Zyzygium Aromaticum), and climatic conditions are very hot so that some die.

The dominant species that grows more in each plot is ironwood (Intisia Bijuga) with a value of 1347 growing saplings, this is because the location or place of RHL is very suitable for ironwood (Intisia Bijuga) because in general ironwood (Intisia Bijuga) itself grows at an altitude of > 500 above sea level and for the RHL location itself the altitude is > 500 above sea level. Every dead sapling such as nutmeg (Myristica Fragrans), lamtoro (Leucena Leucocephala) is replaced with ironwood (Intisia Bijuga) at the time of replacement of dead saplings, so that ironwood (Intisia Bijuga) grows more Based on field observation data, the proportion of living plants in each planting year is presented by calculating the average living plants in each planting plot which consists of 74 planting plots. For plants that are declared dead in each plot, it is suspected that the land conditions are unproductive and most of the land is dominated by reeds and shrubs, so that the plants planted on the land do not grow well. This is due to several factors that affect plant growth, namely environmental factors and social factors.

Of the nine types of forestry plants and MPTS (Multi Purpose Tree Species) that grow the most and are suitable for growing in RHL locations are ironwood (Intisia Bijuga) although environmental factors are very influential on plant growth, but ironwood (Intisia Bijuga) is able to grow well even though some die but are replaced again and live. The success rate of forest and land rehabilitation planting in Neniari Village is 69.95%.

So it can be concluded that the percentage of living plants is 70% and declared unsuccessful. Because according to the derived regulations, this percentage, if it refers to the regulations, can be concluded to be unsuccessful because according to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 23 of 2021 concerning the Implementation of

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Forest and Land Rehabilitation, article 22 paragraphs 1-3.

1. The assessment as referred to in Article 20 paragraph (1) is carried out to determine the success of plant growth in reforestation activities.

2. The assessment as referred to in paragraph (1) is carried out at the end of: a. planting; b. Maintenance I; and c. Maintenance II, according to the contract.

3. The success of plant growth as referred to in paragraph (1) is determined by at least 75% (seventy-five percent) of the initial plants at the time of planting.

C. Factors Affecting the Success Rate of Plant Growth

1. Biotic (Human) Factors

The low percent growth of rehabilitation plants is thought to be due to the following factors: the process of transporting seedlings from the nursery location, planted seedlings that have been attacked by pests, the time of planting, the absence of plant maintenance and care measures, and the types of plants planted do not pay attention to the growing conditions [4]. Means of transporting seedlings from the nursery location to the location of the temporary seedling stockpile which results in low seedling quality due to wilting or damage because the seedlings are not arranged properly so that some seedlings are damaged. can be seen in the picture below.

Figure 1. ***Transportation of seedlings to the planting location***

Figure 2. ***Planting process***

Some forms of visible damage such as: broken shoots and stems and damaged polybags that can result in dry seedlings while plant recovery is not carried out at the temporary hoarding location. Many of the planted seedlings have turned yellow because they are attacked by pests, namely there are caterpillars on the leaves which can cause poor growth of the seedlings so that it can interfere with the growth of the seedlings to be planted [5].

If the seedlings are planted during the rainy season, the seedlings will grow well, but if the planting is carried out during the dry season, the growth of the seedlings will be poor or the planted seedlings will die because they have not been able to adapt to these weather conditions [6]. Lack of supervision and assistance from related parties such as the local Forestry Service, the success of rehabilitation planting will fail if it is not carried out properly, such as checking after planting whether maintenance is carried out or not [7]. Lack of maintenance of plants from nuisance plants such as grasses that creep on the stems of saplings or that have covered all parts of the saplings can interfere with the growth of these saplings resulting in suppressed growth and even the saplings may die because they lose competition with nuisance plants.

The incompatibility of the land on the saplings to be planted can result in poor growth of the saplings so before planting it must first be considered plants that are suitable for the land or area and likewise if the land is too open it can also interfere with growth, for example in nutmeg plants if they are still small they need shade if they are big nutmegs no longer need shade (semi-intolerant).

2. Abiotic Factors

a. Soil Acidity

In agricultural science, the influence of soil pH plays a very important role in determining whether or not nutrient ions are absorbed by plants. In general, nutrients will be easily absorbed by plants at pH 6-7, because at that pH most nutrients will dissolve easily in water. The pH level in the soil also indicates the presence of elements that are toxic to plants. If the soil is acidic, there will be many elements of aluminum (Al) which in addition to poisoning plants also binds phosphorus so that it cannot be absorbed by plants. In addition, acidic soil also has too many micro elements that can poison plants. Whereas in alkaline soil there are many elements of Na (Sodium) and Mo (Molybdenum).

Soil pH conditions also determine the development of microorganisms in the soil. At pH 5.5 - 7 fungi and bacteria that decompose organic matter will grow well. Likewise, microorganisms that are beneficial to plant roots will also develop well.

Latosol: This soil has a thick to very thick solum layer, from 30 cm to 5 meters or even more. It has an unclear horizon boundary. Latosols include soils that undergo intensive weathering and further soil development. This situation causes leaching of basic elements, organic matter, and silica by leaving sesquoxide as a red residue. Generally low to medium nutrient content. Clay texture, crumbly structure and loose consistency. Water holding capacity is quite good so it is not prone to erosion. Reaction pH ranges from 4.5-6.5. Low catiion exchange capacity. In general, this soil has good physical properties, but rather poor chemical properties.

Block	Soil Ph			Average
1	7,1	7,1	7,1	7,1
2	7	7	7	7
3	7	7	7	7
4	7	7	7	7
5	7,1	7	7	7
6	7	7	7	7

Table 3. ***S oil pH at the research site***

The results showed that the average soil pH at the research site consisting of 6 blocks was pH 7, this shows that based on the results of soil acidity analysis in the table above, it shows that the soil at the location of forest and land rehabilitation is classified in the neutral category, which is around 7.01 this pH is the ideal acidity for the absorption of nutrients by plant roots. Low soil pH conditions will cause nutrient availability to decrease and the breakdown of organic matter is inhibited so that the level of soil fertility decreases. soil pH is a soil reaction that shows soil acidity or alkalinity. soil pH plays an important role in determining whether or not nutrients are easily absorbed by plants. Nutrients can generally be absorbed well by plants at a neutral pH [8].

b. Soil Moisture

Suyono and Sudarmadi define soil moisture as the amount of water stored between soil pores[9]. Soil moisture is very dynamic due to evaporation through the soil surface, transpiration, and percolation. Arnold mentions that soil moisture has an important role for the government to find out information such as the potential for surface flow and flood control, soil erosion and slope failure, water resource management, geotechnics, and water quality [10]. Factors that determine soil moisture are rainfall, soil type, and evapotranspiration rate, where soil moisture will determine the availability of water in the soil for plant growth [11].

Block/plot	Soil Moisture			Average
1	20	20	20	20
2	10	10	20	13,33
3	10	10	10	10
4	20	20	20	20
5	20	10	20	17
6	10	10	10	10

Table 4. ***Soil moisture at the research location***

The low humidity in the rehabilitation land at the age of 2 years is due to the absence of litter on the soil surface so that soil moisture at the location of forest and land rehabilitation reaches 10-20%. this is due to the long dry season and there is no shade so that the air humidity is low and causes many plants to dry and eventually die, the high soil moisture in the revegetation land at the age of 2 years is thought to be because the land has quite a lot of litter and is evenly distributed on the floor of the revegetation land. The presence of litter can maintain the level of moisture in the soil, because the water content available in the soil layer does not directly evaporate into the air [12].

c. Air Temperature

Block/Plot	Air Temperature			Average
1	38	39	39	39
2	38	38	39	38
3	38	39	39	39
4	42	41	42	42
5	38	38	38	38
6	39	39	39	39

Table 5. ***Air Temperature at the Research Site***

Environmental temperature in the forest is strongly influenced by the intensity of sunlight entering

the soil. If the crown is getting denser, the temperature in the forest will decrease, if the crown is not too tight, the intensity of sunlight entering will increase and the temperature will increase and the temperature on the ground will also increase [13].

The growth of a plant increases if the temperature increases and humidity decreases, and vice versa. Temperate plants, the maximum temperature for photosynthesis ranges from 20oC to 30oC. A good temperature for plant growth is between 22oC and 37oC [14].

d. Air Humidity

Humidity is the concentration of water vapor in the air. This concentration figure can be expressed in absolute humidity, specific humidity or relative humidity. The tool for measuring humidity is called a hygrometer. Changes in the pressure of some water vapor in the air are related to changes in temperature. The concentration of water in the air at sea level can reach 3% at 30 °C (86 °F), and does not exceed 0.5% at 0 °C [15].

Air humidity is one of the most important elements for humans, animals and tree growth. Air humidity also determines how living things can adapt to the humidity in their environment. By knowing the air humidity in the environment where plants will be planted, we can determine the selection of suitable plant species. If the humidity is high, the growth of the tree will be disturbed because there is no balance between the elements of water and light so that the growth of the tree will be disrupted. But high humidity will affect the growth of vegetative organs on trees.

Block/Plot	Air Humidity			Average
1	60,8	50,5	60,6	57
2	70,6	70,4	40,9	61
3	70,4	70,6	70,4	70
4	72,4	74	72,4	73
5	74	76	80,9	77
6	80,7	79,2	79,4	80

Table 6. ***Air Humidity***

From the table above, the humidity at the research location is very high from the six blocks of forest and land rehabilitation which is very high in the sixth block, namely the average humidity reaches 800C so that plants that live in forest and land rehabilitation locations on the sixth plot only reach 41% of living plants this is due to the very long dry season so that temperatures are getting higher and many plants die due to lack of water. The effect of altitude, the higher the place, the lower the temperature in that place and the higher the humidity. Air humidity will affect the rate of evaporation or transpiration [16]. If the humidity is high, the transpiration rate is low so that the absorption of water and mineral substances is also low. so that many plants do not absorb water properly and experience drought, it will reduce the availability of nutrients for plant growth.

e. Sunlight Intensity

Sunlight that reaches the atmosphere will be partially reflected and absorbed by the atmosphere itself, by clouds and solid particles in the atmosphere, vegetation and the earth's surface[17]. The arrival of sunlight either directly or not light increases the occurrence of photosynthesis and heat that warms the water and soil for the continuation of plant life processes. From the atmosphere obtained O2 and CO2 needed for photosynthesis and moisture needed by plants [18]. According to Omon, light is used by plants for photosynthesis process, the better the plant growth [19].

Block	Light intensity (lux) (%))
1	435
2	244

3	271
4	143
5	83
6	286

Table 7. ***Light intensity at the research location***

The results showed the results of light intensity at the research location were very high from the results of the above research it can be said that light intensity does not allow plant growth this is due to the open forest and there is no shade for tolerant plants. Plants that are in a place with high light intensity have significantly smaller growth rates than places that have slightly lower light intensity.

3. Multiple Analysis Equation Test of Environmental Factors that Affect Plant Growth

Coefficients				
Term	Coef	SE Coef	T-Value	P-Value
Constant	107,6	35,1	3,06	0,092
x1 Average temperature	0,422	0,842	0, 50	0,666
x2 Average humidity	-0,947	0,175	-5,41	0,032
X 3 Average light	-0,0199	0,0129	-1,55	0,261
Regression Equation				
Percent live plants = 107,6 + 0,422 x1 Average temperature - 0,947 x2 Average humidity - 0,0199 X 3 Average light				

Table 8. ***Multiple analysis equation test***

a. The constant value obtained is 107.6, it means that if the independent variable decreases by one unit on average, the dependent variable will increase by 107.6.

b. The regression coefficient value of variable X1 is positive (+) of 0.422, it can be interpreted that if variable X1 increases, variable Y will also increase and vice versa.

c. The regression coefficient value of variable X2 is negative (-) of -0.947, it can be interpreted that if variable X2 increases, variable Y will decrease and vice versa

d. The regression coefficient value of variable X3 is negative (-) of -0.0199, it can be interpreted that if variable X3 increases, variable Y will decrease and vice versa.

D. General Public Participation

Community involvement in forest and land rehabilitation activities is very influential, the higher the community or people involved in rehabilitation activities, the greater the community participation in rehabilitation activities. Various forms of community role contributions in the success of forest rehabilitation activities for degraded land really require cooperation between farmer groups and the community, for example participating in planting, maintenance and plant enrichment. This is important for the community because by participating in the process of forest and land rehabilitation activities, the activities carried out by the government are very good and planting is successful.

According to Mubyarto, participation is an awareness to help the success or failure of a program according to the ability of each person without sacrificing their own interests [20]. In relation to the implementation of community development, participation involves active community involvement in decision-making, implementation, maintenance, evaluation and enjoying the results of a planned

community change effort to achieve community goals [21].

No	Category	Interval	Number of people	Per centage
1	Low	20 – 46	1	5%
2	Medium	47 – 73	15	75%
3	High	74 -100	4	20 %

Table 9. ***Scoring the level of community participation in land and forest rehabilitation activities***

The results of the calculation of the level of community participation in RHL activities as a whole, can show that more than half of the community has participated in RHL activities, consisting of 75% of the community with moderate participation and 20% of the community with high participation. This shows that these 4 communities have good knowledge about the importance of land and forest rehabilitation and not just participating. It can be concluded that the level of community participation is included in the medium category, which means that respondents have less understanding about forest rehabilitation and its benefits, but have the willingness to participate in forest and land rehabilitation activities.

a. Farmer Group Participation Level

No	Category	Interval	Community participation	
			Number of people	Percentage
1	Low	20 - 46	0	0%
2	Medium	47- 73	1	10%
3	High	74 - 100	9	90%
Total			10	100%

Table 10. ***Farmer Group Participation Level***

The results of the calculation of the level of participation of farmer groups in Rhl activities as a whole, can be shown that those who are members of farmer groups have participation in Forest and Land Rehabilitation activities very high 90% of farmer groups with High participation and 10% of farmer groups with Low participation. And there are no farmer group members who do not participate, all of them participate. High participation means that respondents have a good understanding of Forest Rehabilitation and its benefits, apply it in the farming system and are willing to participate in maintaining and preserving natural resources to maintain land productivity and be responsible for the impact of erosion that will be caused.

Conclusion

The study conducted in Neniari Village on forest and land rehabilitation (RHL) indicates a moderate success rate, with an average plant survival rate of 70%, which falls short of the targeted benchmarks. Analysis revealed that both biotic factors, such as transportation and handling of seedlings, and abiotic factors, including soil pH, moisture, temperature, and light, significantly influenced plant growth. Community participation was identified as crucial for the success of RHL activities; however, participation levels remained moderate at 75%, suggesting insufficient community engagement. These findings highlight the need for improved management of environmental conditions and enhanced community involvement to increase the effectiveness of RHL programs. Future research should focus on developing strategies to boost community participation and investigate specific interventions to mitigate the negative impact of abiotic stressors on plant survival and growth.

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