J E M T
Journal of Earth and Marine Technology
homepage URL: ejurnal.itats.ac.id/jemt

Assessing Land Suitability for Lamtoro (Leucaena leucocephala) in Reclaimed Mining Lands of Sanggau Regency, West Kalimantan

Ichsannudin *[1], Muhammad Abdul Wahid [1], Abdul Jalil [1]
[1] Graduate Program of Mining Engineering Department, Universitas Pembangunan Nasional "Veteran" Yogyakarta, Indonesia.
*e-mail: ichsannudin76@gmail.com

Info article
Receive:
Dec 28, 2023
Revised:
Mar 13, 2024
Accepted:
Mar 20, 2024
Published:
Mar 31, 2024

Keywords:
Ex-mining land,
Land suitability,
Lamtoro,
Reclaimed,
Weight factor

Abstract

This study evaluates the suitability of reclaimed zircon mining land in Sanggau Regency, West Kalimantan for cultivating Lamtoro (Leucaena leucocephala), a versatile plant used for forage and as a biomass energy source. Utilizing the weight factor matching method, we analyzed a range of land characteristics including soil texture, drainage, pH, and organic carbon content, as well as environmental factors such as temperature and rainfall. Initial assessments categorized the land as marginally suitable due to suboptimal drainage and soil texture. However, our research suggests that through strategic interventions—specifically improving soil texture using topsoil and enhancing drainage systems—the suitability of the land can be significantly upgraded. Detailed analysis shows that with these modifications, the land shifts from a marginal to a highly suitable rating for Lamtoro cultivation. The successful adaptation of Lamtoro in these reclaimed areas not only supports agricultural viability but also aids in the ecological restoration of post-mining landscapes, contributing to the achievement of sustainable development goals. This study underscores the potential of targeted land management strategies in transforming degraded mining areas into productive agricultural lands, providing a blueprint for similar reclamation efforts globally.

1. Introduction

PT. X is one of the zircon commodity mining companies located in Sanggau Regency, West Kalimantan Province, which implements an open pit mining system by spray (*Hydraulicking*). In general, open-pit mining activities will result in a decrease in land surface structure and vegetation [1]. Therefore, companies are obliged to carry out reclamation of their former mining land to realize environmentally sound development [2]. To carry out ex-mining land reclamation activities, good planning is needed so that the implementation can achieve the desired targets [3]. One form of reclamation activities on former mining land is by revegetation. Revegetation activities need to pay attention between the type of plant selected and the conditions for growing plants with land conditions [4], so that in the selection of plants the type of plant chosen adjusts to land conditions.

Land suitability is the process of estimating the potential of land for various alternatives [5]. One type of plant that becomes a fast-growing plant in reclamation activities is the lamtoro plant (Leucaena leucocephala). Lamtoro plants can be used as forage for livestock and wood. Lamtoro plants that have been dried in the sun for 18 hours in the sun can be mixed with coal as the main fuel at the power plant [6].

To find out whether the lamtoro plant is in accordance with the conditions of the former PT X zircon mining land, it is necessary to conduct a land evaluation. Land evaluation is determining the value of a land for a specific purpose. Through land evaluation, it will be possible to know the suitability of land and its constraints. Land suitability classes are principally determined by the suitability of land qualities such as climate, soil and other environmental physical properties with plant growing requirements or with land use requirements [7].

Table 1. Criteria of Land Suitability Classification for Lamtoro Plants

Land Quality/Characteristics	Land Suitability Class			
	Highly Compliant (S1)	**Reasonably Appropriate (S2)**	**Marginally Appropriate (S3)**	**Not Compliant (N)**
Temperature (°C)	28 – 23	22 – 18	17 – 16	< 16
Rainfall (mm)	>1300	1,300-1,000	600-<1,000	<600
Drainage	Good, Medium	Quite fast, somewhat hampered	Hampered	Very inhibited, very fast
Texture	Somewhat smooth, medium	Somewhat rough, smooth	Very Smooth	The State
Effective Depth (cm)	>100	75-100	50-<75	<50
KPK	>16	≤16		
pH H_2O	6.1-7.2	5.5-60 7.3-7.5	4.5-5.4	<4.5
C Organic (%)	>4	≤4		
Surface Rock (%)	<4	4 – 15	>15-40	>40
Slope (%)	<8	8-<16	16-30	>30%

A zircon mining industry operates within Sanggau Regency, West Kalimantan Province using a hydraulicking method for its open-pit mining operations. This mining technique significantly alters the land surface structure and depletes local vegetation, presenting substantial environmental challenges [1]. In response to these impacts, regulatory frameworks mandate that mining entities like the company undertake comprehensive land reclamation to foster environmentally sustainable development [2]. Effective reclamation involves strategic planning and implementation, aiming to restore ecological balance and prepare the land for future uses [3].

A crucial component of such reclamation efforts is revegetation, which requires careful selection of plant species tailored to the altered environmental conditions of the reclaimed lands [4]. Among the species considered for such purposes, Lamtoro (Leucaena leucocephala) is particularly notable for its rapid growth and versatility, offering benefits not only as livestock forage but also as a renewable biomass for energy production. When sun-dried, Lamtoro can be combined with coal to serve as a primary fuel source for power plants, demonstrating its potential in integrated energy systems [6].

To systematically assess the suitability of the post-mining landscape at PT. X for the cultivation of Lamtoro, this study employs a land evaluation approach. This evaluation seeks to align the specific land qualities—such as climate, soil texture, pH, and organic matter content—with the agronomic requirements of Lamtoro. The process of land suitability classification, which integrates these environmental parameters, is critical for identifying viable agricultural applications and ensuring successful reclamation outcomes [7]. By evaluating these factors, the study aims to provide actionable insights into the potential for transforming degraded mining areas into productive and sustainable ecosystems.

2. Methodology

This research was conducted on the former Block III mining area of the company which has an area of 7.93 Ha. The research stage in this research consists of literature studies, namely studying theories related to land suitability through journals and literature from the internet related to research. Data collection in the form of primary data which includes 9 soil samples, surveys, and mapping by aerial photography using drones. Secondary data includes rainfall data obtained from the Central Bureau of Statistics of Sanggau Regency [8]. Laboratory tests are carried out on soil samples to determine soil

quality with parameters of texture, pH, cation exchange capacity (KPK), and Organic C. Soil sample testing was carried out at the Analysis Services Laboratory of the Soil Science Study Program, Faculty of Agriculture UPN "Veteran" Yogyakarta. The processing and analysis of data used in this study is by *weight factor matching method.* The *weight factor matching* method is an analytical technique to obtain limiting factors and land suitability classes [9].

In this study, the parameters used in the evaluation of land density are temperature, rainfall, drainage, texture, effective depth, cation exchange capacity, pH, Organic C, surface rock, and slopes. Here are the criteria for land suitability for the lamtoro plants (see Table 1).

3. Results and discussion

3.1. Land Characteristics

3.1.1. Soil Quality

Soil quality is the capacity of soil to function within the boundaries of an ecosystem to conserve biological productivity, maintain environmental quality, and improve plant and animal health [10]. Soil sampling was carried out on the soil used in reclamation activities as many as nine samples. This sample was then analyzed at the Analysis Services Laboratory of the Soil Science Study Program, Faculty of Agriculture, UPN "Veteran" Yogyakarta with the following analysis results (see Table 2).

Table 2. Soil Quality Results

No	Sample Code	Texture	KPK (me%)	pH	C Organic
1	Soil 01	Sand	0,214	5,77	0.117
2	Soil 02	Sand	0,749	5,52	0.156
3	Soil 03	Sand	0,641	5,77	0.117
4	Soil 04	Sand	0,748	5,8	0.117
5	Soil 05	Sand	0,534	5,46	0.234
6	Soil 06	Sand	0,428	5,58	0.195
7	Soil 07	Sand	0,749	5,71	0.156
8	Soil 08	Sand	0,427	5,82	0.312
9	Soil 09	Sand	0,748	5,66	0.195
	Average	**Sand**	**0,582**	**5,68**	**0,178**

3.1.2. Temperature and Precipitation

Rainfall is one element of weather and climate, which has a dynamic relationship with other weather elements such as temperature, humidity, and others [11]. Indonesia is a tropical country that has two seasons, namely the dry season with quite hot heat and high rainfall in the rainy season [12]. Based on data from the Central Bureau of Statistics, the research location generally has a tropical climate with an average annual rainfall of 3,270 mm/year and a temperature of 26.62 ^{o}C.

3.1.3. Drainage

Drainage is the effect of the rate of water location into the soil on air aeration in the soil [13]. Based on field observations that no drainage was found, so there was erosion in several locations.

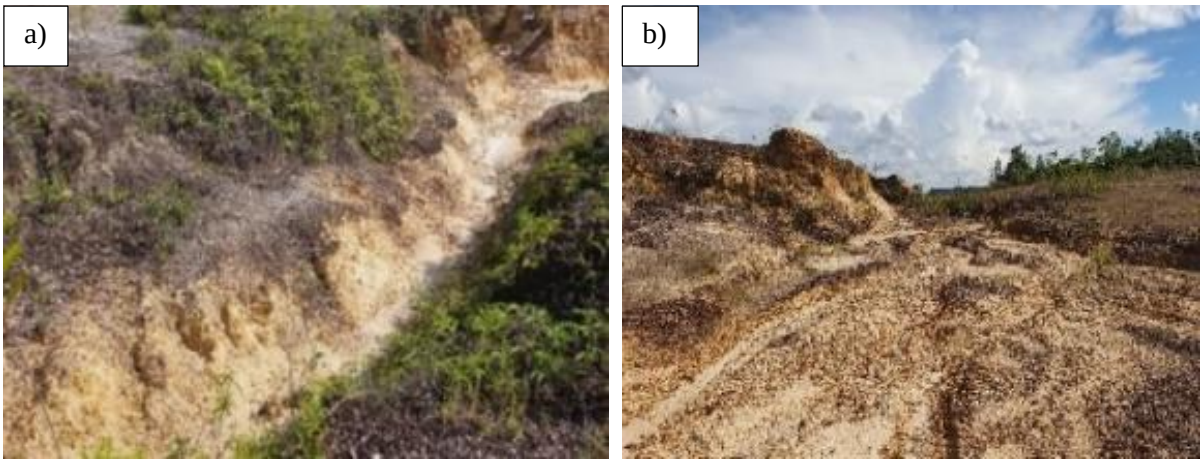

Figure 1a and 1b. Erosion that Occurs

3.1.4. Effective Depth of Soil and Marbles

The effective depth of soil is depth, where plant roots can still enter the soil [14]. The effective depth found in the study area was shallow at 30 cm with slopes including flat and wavy, with slopes ranging from 8%.

3.1.5. Surface Rock

Surface rocks are loose rocks scattered over the surface of the ground [15]. Based on field observations, the condition of the former zircon mining land can be seen the presence of gravel and kerakal derived from impurities during processing activities. The presence of loose rock is >40% found on former mining land.

3.2. Actual Land Suitability

Based on the results of land characteristics at the research site, it is necessary to match the land with the criteria for land suitability for lamtoro plants. The results of land suitability with lamtoro plants can be seen in Table 3.

Based on the land suitability assessment table for lamtoro plants, for temperature, rainfall including land suitability class is very suitable (S1), for cation exchange capacity, pH, C Organic, and slopes including land suitability class is quite suitable (S2) while for drainage, texture, effective depth, surface rock including land suitability is not suitable (N).

Table 3. Land Conformity Assessment for Lamtoro Plants

Land Characteristics	Value Data	Class
Temperature (°C)	26.62	S1
Rainfall (mm)	3,270	S1
Drainage	Very Hampered	N
Texture	The State	N
Effective Depth (cm)	30	N
KPK	0.587	S2
pH H_2O	5.68	S2
C Organic (%)	0.178	S2
Surface Rock (%)	>40%	N
Slope (%)	8%	S2

Table 4. Land characterization with its Land Suitability

Land Characterization	Value Data	Actual Class	Improvement Efforts	Land Suitability
Temperature (°C)	26.62	S1	It is appropriate	S1
Rainfall (mm)	3,270	S1	It is appropriate	S1
Drainage	Very Hampered	N	Building drainage canals	S1
Texture	The State	N	Improve soil texture by using topsoil	S1
Effective Depth (cm)	30	N	Fixing the planting hole pattern to 100 cm	S1
KPK	0.587	S2	Improve soil quality by using topsoil	S1
pH H_2O	5.68	S2	Improve soil quality by using topsoil	S1
C Organic (%)	0.178	S2	Improve soil quality by using topsoil	S1
Surface Rock (%)	>40%	N	Improve surface rock by arranging land and overlaying topsoil	S1
Slope (%)	8%	S2	Improve slopes by arranging land so that the land becomes flat (<8%)	S1

3.3. Recommendations for corrective actions for each land characteristic

Based on the assessment of land suitability at the research site, improvement efforts need to be made to improve the land class to be very suitable (S1). Here are the improvement efforts to improve the suitability class of land.

The assessment of the reclaimed zircon mining land in Sanggau Regency highlights significant potential for the cultivation of Lamtoro (Leucaena leucocephala), echoing broader findings on post-mining land rehabilitation [16]. Similar studies by Sitorus et al. have underlined the critical need for a thorough understanding of land characteristics and suitable rehabilitation techniques to support sustainable plant growth in environments disrupted by mining activities [16]. Our findings regarding the favorable growth of Lamtoro align with Anggriani et al., who demonstrated the resilience and adaptability of Lamtoro to various environmental stresses, further supporting its suitability for ecological restoration projects [17]. Moreover, the potential for Lamtoro to be used in energy production as a biofuel when mixed with coal, is a promising area for future energy solutions, as highlighted by Maulana et al. [18].

The use of Lamtoro in animal feed, as explored in studies by Sitorus and Malau, further confirms its versatility, contributing to the economic viability of its cultivation in reclaimed mining areas [19]. Mandey et al. have documented similar benefits, noting improvements in livestock production when Lamtoro is included in the diet, which could significantly impact local agricultural practices [20]. However, the invasive nature of Lamtoro, as discussed by Sharma et al., poses a challenge, necessitating careful management to prevent it from overshadowing native species and disrupting local ecosystems [21]. This aspect underscores the importance of a balanced approach to reclamation, where benefits to the ecosystem must be weighed against potential ecological risks.

The studies by Karti et al. on the radiosensitivity of Lamtoro further inform our understanding of its robustness, suggesting that it can withstand a variety of environmental pressures, which is crucial for its success in the harsh conditions of reclaimed mining lands [22]. The findings by Wardatun et al. regarding the nutritional value of Lamtoro seeds add another layer to its applicability, providing a new potential source of nutrients in food production [23]. The comprehensive soil and microbial analysis in our study is supported by Dharmaputri et al., who emphasized the importance of microbial relationships in supporting plant growth in compromised soils, such as those found in post-mining areas [24]. The

success of our revegetation efforts, therefore, may also depend on enhancing microbial activity within the soil, which can improve nutrient uptake and overall plant health. Lastly, the economic potential of Lamtoro, as demonstrated by Rahman et al. in the Malaysian particleboard industry, suggests broader industrial applications for the plant beyond just ecological reclamation, pointing to its role in sustainable industrial practices [25].

By making efforts to improve actual land conditions, it is expected that the land suitability class for lamtoro plants can be very appropriate (S1). In making improvement efforts, things that need to be considered are economic factors and the technology used.

4. Conclusion

This study assessed the suitability of reclaimed mining land in the former Block III area for the cultivation of Lamtoro (Leucaena leucocephala), focusing on several key soil and environmental parameters. The findings indicate that while the area shows potential for agricultural use, there are significant variations in soil texture, pH, cation exchange capacity, organic carbon content, and drainage that affect its overall suitability.

The soil's sandy texture and generally low organic carbon content highlight the need for substantial soil amendments to enhance fertility and water retention capabilities. The moderate to high cation exchange capacity in some areas suggests that nutrient retention can be effectively managed with targeted interventions. However, the poor drainage and varied topography present challenges that require careful management, including the potential installation of drainage systems and the application of soil conservation techniques such as terracing.

The actual land suitability on PT X's former zircon mining land for temperature, rainfall including the land suitability class is very suitable (S1), for cation exchange capacity, pH, Organic C, and slopes including the land suitability class is quite suitable (S2) while for drainage, texture, effective depth, surface rock including land suitability is not suitable (N). By building drainage channels, using topsoil for reclamation activities, and arranging land. So it is obtained that the suitability of the land becomes very suitable (S1).

Climate conditions in the region are favorable for Lamtoro growth, suggesting that with appropriate soil management, the cultivation of Lamtoro could be successful. This presents an opportunity not only for agricultural production but also for ecological restoration, leveraging Lamtoro's benefits as a fast-growing, nitrogen-fixing species that can improve soil health over time.

The study underscores the importance of integrated land management strategies in reclaimed mining areas to maximize their agricultural and ecological potential. Future research should focus on long-term monitoring of soil health and productivity under different management practices to better understand the dynamics of soil recovery in post-mining landscapes. Additionally, exploring the economic viability of different crops, including Lamtoro, in these areas could provide valuable insights into sustainable land use post-mining.

Acknowledgment

The author extends sincere gratitude to the faculty of the Master Program in Mining Engineering at Universitas Pembangunan Nasional "Veteran" Yogyakarta for their unwavering support and for providing the necessary facilities that greatly contributed to this research. Special thanks are also due to my peers for their invaluable encouragement and assistance throughout the duration of this study. Their support played a crucial role in the completion of this project.

References:

[1] Arifman, Parikesit, dan T. Husodo, "Landscape Planning of Former Coal Mining Areas for Natural Tourism Areas," *Univ. Padjajaran*, hal. 1–15, 2017.

[2] L. O. M. Husein, R. Ernawati, dan M. Nurcholis, "Evaluation of Land Suitability for Cashew Plants (Anacardium Occidentale L.) in Reclaimed Land PT. Ifishdeco Tbk., South Konawe

Regency," *J. Sumberd. Bumi Berkelanjutan*, vol. 1, no. 1, hal. 264–271, 2022, doi: 10.31284/j.semitan.2022.3209.
[3] F. R. Harahap, "Post-Tin Mining Land Restoration on Bangka Island," *Society*, vol. 4, no. 1, hal. 61–69, 2016, doi: 10.33019/society.v4i1.36.
[4] R. D. N. Setyowati, N. A. Amala, dan N. N. U. Aini, "Study of Revegetation Plant Selection for Successful Reclamation of Ex-Mining Land," *J. Tek. Lingkung.*, vol. 3, no. 1, hal. 14–20, 2017.
[5] H. Wicaksono, E. T. S. Putra, dan S. Muhartini, "Suitability of Canna (Canna indica L.), Stink Lily (Amorphophallus paeoniifolius (Dennst.) Nicolson), and cassava (Manihot esculenta Crant) under Menoreh Hill Agroforestry," *Vegetalika*, vol. 4, no. 1, hal. 87–101, 2015.
[6] M. I. Maulana, S. Salim, dan Y. Mohamad, "Lamtoro Land Mapping as a Database of Energy Plantation Forest in Bone Bolango District," *Jambura J. Electr. Electron. Eng.*, vol. 5, no. 1, hal. 23–31, 2023, doi: 10.37905/jjeee.v5i1.16810.
[7] B. H. Simanjuntak, "Land Suitability Evaluation For Agriculture," *Agric*, vol. 16, no. 1, hal. 1–12, 2003.
[8] Badan Pusat Statistik, "Sanggau Regency in Numbers," 2023.
[9] S. Adhiriyanto, A. Dina, dan A. P. Wicaksono, "Evaluation of Land Suitability for Plantations on Sand and Stone Mining Land in Nurum Lor Hamlet, Tlogowatu Village, Kemalang District, Klaten Regency," *Pros. Semin. Nas. Tek. Lingkung. Kebumian Ke-III*, hal. 235–241, 2021.
[10] D. Herdiyantoro dan S. A, "Efforts to improve soil quality in Sukamanah Village and Nanggerang Village, Cigalontang District, Tasikmalaya Regency, West Java through socialization of biological fertilizers, organic fertilizers and conservation tillage," *Dharmakarya*, vol. 4, no. 2, hal. 47–53, 2015, doi: 10.24198/dharmakarya.v4i2.10028.
[11] A. P. Desvina dan Ratnawati, "Application of Autoregressive Vector Model (Var) for Rainfall Forecasting in Pekanbaru City," *J. Sains, Teknol. dan Ind.*, vol. 11, no. 2, hal. 151–159, 2014.
[12] E. Y. Tisnaningtyas, "Aspects of Pedestrian Safety Against the Tropical Climate and Pedestrian Accessibility in the City Square as a Pedestrian Area (Simpang Lima Semarang Area Study)," *Neo Tek.*, vol. 1, no. 2, 2015, doi: 10.20595/jjbf.19.0_3.
[13] A. Nurkholis, M. Muhaqiqin, dan T. Susanto, "Gogo Rice Land Suitability Analysis Based on Soil Properties and Weather Using Spatial ID3," *JUITA J. Inform.*, vol. 8, no. 2, hal. 235, 2020, doi: 10.30595/juita.v8i2.8311.
[14] M. J. Oraplawal, J. P. Haumahu, dan R. G. Risamasu, "Land Suitability Evaluation of Peanut Plants (Arachis hipogeae L.) in Werwaru Village, Moa Island District," *J. Budid. Pertan.*, vol. 14, no. 1, hal. 35–40, 2019, doi: 10.30598/jbdp.2018.14.1.35.
[15] Y. Wibowo, "Evaluation of Land Suitability for Tea Plant Plantations in Bandar District, Batang Regency," 2009, [Daring]. Available on: http://eprints.ums.ac.id/id/eprint/5005
[16] S. Sitorus, E. Kusumastuti, and L. N. Badri, "Post-mining Land Characteristics and Rehabilitation Technique in Bangka and Singkep Islands," JTI, vol. 27, p. 133340, 2012. [Online]. Available: https://doi.org/10.21082/JTI.V0N27.2008.%P
[17] R. Anggriani, P. Karti, and I. Prihantoro, "Seleksi Mutan Tanaman Lamtoro (Leucaena leucocephala cv. Tarramba) Tahan Kutu Loncat terhadap Lingkungan Kering pada Rumah Kaca," Jurnal Ilmu Nutrisi dan Teknologi Pakan, 2021. [Online]. Available: https://doi.org/10.29244/jintp.19.3.90-94
[18] F. Bulu and M. Hambakodu, "PENGARUH PEMBERIAN PUPUK BOKASHI FESES SAPI SUMBA ONGOLE TERHADAP PERTUMBUHAN LEUCAENA LEUCOCEPHALA CV. TARRAMBA," JURNAL PETERNAKAN SABANA, vol. 1, no. 3, 2023. [Online]. Available: https://doi.org/10.58300/jps.v1i3.345
[19] T. Sitorus and E. Malau, "Pengaruh Pemberian Tepung Daun Lamtoro (Leucaena Leucocephala) Dalam Ransum Terhadap Performan Burung Puyuh Jantan (Coturnix- Coturnix Japonica)," Jurnal Visi Eksakta, 2022. [Online]. Available: https://doi.org/10.51622/eksakta.v3i2.1104
[20] J. Mandey, N. Kumajas, J. Leke, and M. Regar, "MANFAAT DAUN LAMTORO (Leucaena leucocephala) DALAM PAKAN AYAM PEDAGING DIUKUR DARI PENAMPILAN PRODUKSI," Zot, vol. 35, pp. 72-77, 2015. [Online]. Available: https://doi.org/10.35792/ZOT.35.1.2015.7097
[21] P. Sharma, A. Kaur, D. Batish, S. Kaur, and B. Chauhan, "Critical Insights Into the Ecological and Invasive Attributes of Leucaena leucocephala, a Tropical Agroforestry Species," Frontiers

in Agroforestry, vol. 4, 2022. [Online]. Available: https://doi.org/10.3389/fagro.2022.890992
[22] P. Karti, S. Manpaki, and I. Prihantoro, "The radio sensitivity of mature callus and selection of irradiated 40 Gy lamtoro (Leucaena leucocephala) callus on acid stress through tissue culture," in IOP Conference Series: Earth and Environmental Science, vol. 260, 2019. [Online]. Available: https://doi.org/10.1088/1755-1315/260/1/012122
[23] S. Wardatun, Y. Harahap, A. Mun'im, F. Saputri, and N. Sutandyo, "Leucaena leucocephala (Lam.) de Wit Seeds: A New Potential Source of Sulfhydryl Compounds," Polymer Journal, vol. 12, pp. 298-302, 2020. [Online]. Available: https://doi.org/10.5530/pj.2020.12.47
[24] N. Dharmaputri, I. Wijaya, and W. Adiartayasa, "Identifikasi Mikoriza Vesikular Arbuskular pada Rhizosfer Tanaman Lamtoro (Leucaena leucocephala) dan Kaliandra (Calliandra calothyrsus) serta Perbanyakannya dengan Media Zeolit," Journal of Tropical Agroecotechnology, vol. 5, pp. 171-180, 2016.
[25] W. Rahman, N. Johari, S. Sarmin, N. Yunus, Y. Japaruni, J. Mahmud, and M. Khairuddin, "Leucaena leucocephala: A fast-growing tree for the Malaysian particleboard industry," BioResources, vol. 15, no. 4, pp. 7433-7442, 2020. [Online]. Available: https://doi.org/10.15376/BIORES.15.4.7433-7442