An-Nisbah: Jurnal Ekonomi Syariah
Volume 11, Number 01, September 2024

CREATING A CIRCULAR ECONOMY IN THE COAL MINING INDUSTRY THROUGH CSR INITIATIVES: A CASE STUDY

Muhammad Alhada Fuadilah Habib[1], Mukhammad Fatkhullah[2*], Dewa Made Dwi Parmana[3], Fida Khansa[4]
[1]Universitas Airlangga; [2]Universitas Gadjah Mada; [3,4]PT Bukit Asam Tbk
**m.fatkhullah@mail.ugm.ac.id*

Abstrak: *Penelitian ini bertujuan untuk menginvestigasi dampak dari Program Eco Agrotomation dalam menciptakan ekonomi sirkular pada PT Bukit Asam Tbk, sebuah Badan Usaha Milik Negara (BUMN) di sektor pertambangan batu bara. Metode penelitian ini melibatkan analisis kualitatif dan kuantitatif, dengan desain penelitian studi kasus pada program Eco Agrotomation yang dilaksanakan oleh PT Bukit Asam Tbk. Data tersebut mencakup evaluasi dampak ekonomi, sosial, dan lingkungan dari program tersebut, baik dari perspektif perusahaan maupun masyarakat lokal yang terlibat. Hasil penelitian menunjukkan bahwa Program Eco Agrotomation telah berhasil menciptakan ekonomi sirkular bagi PT Bukit Asam Tbk melalui empat cara: (1) manajemen limbah yang berkelanjutan, (2) penggunaan sumber daya yang efisien, (3) kolaborasi dan pengembangan sistem, dan (4) pemberdayaan masyarakat. Implementasi sistem otomasi berhasil meningkatkan efisiensi penggunaan air hingga 30%, dengan penggunaan air yang dapat diturunkan dari 238.680 liter per tahun menjadi 183.600 liter per tahun. Selain itu, pemanfaatan air asam tambang dan limbah belt conveyor mampu mengurangi water footprint dan limbah karet pertambangan masing-masing 90.000 liter dan 200 kg per tahun. Di sisi lain, penggunaan Pembangkit Listrik Tenaga Surya (PLTS) mampu menghasilkan listrik sebesar 10.08 kWh per hari, yang setara dengan penghematan biaya listrik sebesar Rp 5.080.320 per tahun. Berkat inisiatif ini, Anggota kelompok rentan mengalami peningkatan pendapatan hingga mencapai Rp 3.500.000 per bulan, setara dengan Upah Minimum Regional. Meskipun demikian, kurangnya integrasi daur ulang produk akhir batubara dalam program ini menjadi potensi yang dapat kembangkan untuk menciptakan lingkaran ekonomi yang lebih luas dan berkelanjutan.*

Kata kunci: *eco agrotomation, keberlanjutan, sirkular ekonomi, tanggung jawab sosial perusahaan*

Abstract: *This study aims to investigate the impacts of the Eco Agrotomation Program in creating a circular economy at PT Bukit Asam Tbk, a State-Owned Enterprise (SOE) in the coal mining sector. The research methodology involves qualitative and quantitative analysis obtained from a case study of the Eco Agrotomation program implemented by PT Bukit Asam Tbk. The data encompass evaluations of the economic, social, and environmental impacts of the program, from both the company's and the local community's perspectives. The findings indicate that the Eco Agrotomation Program has successfully created a circular economy for PT Bukit Asam Tbk through four means: (1) sustainable waste management, (2) efficient resource utilization, (3) collaboration and system development, and (4) community empowerment. The implementation of automation systems has increased water usage efficiency by 30%, reducing water consumption from 238,680 liters per year to 183,600 liters per year. Moreover, the utilization of mine acid water and conveyor belt waste has reduced water footprint and mining rubber waste by 90,000 liters and 200 kg per year, respectively. On the other hand, the use of Solar Power Plants (PLTS) has generated electricity of 10.08 kWh per day, equivalent to cost savings of Rp 5,080,320 per year. These initiatives have increased incomes of vulnerable community up to Rp 3,500,000 per month, equivalent to the Regional Minimum Wage. However, the lack of integration of coal end-product recycling in this program presents potential for further development to create a broader and more sustainable economic cycle.*

Keywords: *circular economy, corporate social responsibility, eco agrotomation, sustainability*

Introduction

The coal mining industry, as one of the primary sectors in the Indonesian economy, has made a significant contribution to the country's economic growth. However, alongside its substantial economic contribution, this industry also entails adverse impacts on the environment and surrounding communities. Mining activities often result in environmental degradation, including water and air pollution,[1] destruction of natural habitats,[2] as well as social conflicts with local communities due to land use and rights over natural resources.[3] In response to the environmental and social challenges faced by the coal mining industry, the concept of sustainable development and corporate social responsibility (CSR) has increasingly become the primary focus.[4] However, the evolving CSR paradigm has not fully addressed the needs of both

[1] Masood, N., Hudson-Edwards, K., & Farooqi, A. (2020). True cost of coal: coal mining industry and its associated environmental impacts on water resource development. *Journal of Sustainable Mining*, 19(3), 135-149.
[2] Giam, X., Olden, J., & Simberloff, D. (2018). Impact of coal mining on stream biodiversity in the US and its regulatory implications. *Nature Sustainability*, 1, 176-183.
[3] Adnan, R., & Somantri, G. (2022). Social Conflict among Mining Company and Community. *Indonesian Journal of Religion and Society*, 4(1), 28-40.
[4] Huang, et. al. (2017). Green and Sustainable Mining: Underground Coal Mine Fully Mechanized Solid Dense Stowing-Mining Method. *Sustainability*, 9, 1418.

companies and communities effectively. The impacts of CSR programs often fail to be directly and sustainably felt by both companies and communities.

The government, through Ministerial Regulation of State-Owned Enterprises: No. Per-1/mbu/03/2023, has established that state-owned enterprise business units must integrate CSR's operations and implementation directly with company business.[5] Such an approach is crucial in developing a circular economy that gives direct and sustainable impacts, not only on the community but also on companies.[6] From one angle, this policy could be having the economic circularity concept focusing on the system that is aimed at minimizing the use of natural resources and waste[7] while maximizing resource utilization. In the context of Islamic economics or Sharia economics, this concept is often associated with principles of sustainability, justice, and blessing.[8] Economic circularity also encompasses aspects such as waste avoidance, fair distribution, and environmental protection.[9]

PT Bukit Asam Tbk, as one of the State-Owned Enterprises (SOEs) in the coal mining sector, bears significant responsibility in implementing Corporate Social Responsibility (CSR) programs. In accordance with Ministerial Regulation of State-Owned Enterprises No. Per-1/mbu/03/2023, the company is required to align CSR with its core business, thus involving local human resources in its business processes. One approach taken by PT Bukit Asam Tbk to fulfill its responsibility is through the Eco Agrotomation Program. This CSR initiative aims to create a circular economy by utilizing waste and existing resources efficiently, while enhancing the welfare of local communities and reducing environmental impacts.

This study aims to investigate how the Eco Agrotomation Program can create a circular economy at PT Bukit Asam Tbk, a coal mining-based company. Firstly, this research explores how the Eco Agrotomation Program can transform the company's traditional business model into a more sustainable one. Subsequently, the study analyzes the internal impacts experienced by PT Bukit Asam Tbk after implementing this program, both economically, socially, and

[5] Nabilla, & Suherman. (2024). Tata Kelola BUMN Berdasarkan Prinsip Good Corporate Governance. *Jurnal Kertha Semaya*, 12(2), 207-225.
[6] Mulyani, et. al. (2024). Transforming Coastal Communities to Adapt Climate Change through Corporate Social Responsibility. *IOP Conference Series: Earth and Environmental Science*, 1321, 012055.
[7] MacArthur, E. (2014). *Towards the Circular Economy: Accelerating the Scale-Up Across Global Supply Chains*. Switzerland: World Economic Forum.
[8] Javaid, O. (2022). The Principles of a Circular Economy in the Light of Islamic Values and Beliefs. *Journal of Islamic Thought and Civilization*, 12(1), 166-83.
[9] Sarac, et. al. (2020). Circular Economy, Sustainable Development, and the Role of Islamic Finance. In M. Saraç, & M. K. Hassan (Eds.), *Islamic Perspective for Sustainable Financial System* (pp. 1-22). Istanbul: Istanbul University Press.

environmentally. Additionally, this research also examines how the communities involved in the Eco Agrotomation Program perceive the impacts of this program, including improvements in welfare, participation in local economic activities, and changes towards more sustainable lifestyles.

This research is significant as it provides a deeper understanding of how mining-based companies can adopt circular economy practices to enhance their business sustainability, mirroring the practices embraced by several companies both domestically and internationally.[10] Additionally, this study offers valuable insights for other companies in the same industry to adopt similar strategies in addressing sustainability challenges. By comprehensively understanding the impacts of the Eco Agrotomation Program, this research establishes a strong foundation for companies, governments, and society to engage in similar programs in the future.[11]

The findings of this research are expected to fill the knowledge gap regarding the implementation of circular economy in the context of the coal mining industry, as well as to explain the mechanisms and factors that influence its success. Practically, the results of this research can serve as a guide for coal mining-based companies in developing and implementing sustainable CSR programs that positively impact local communities and the environment. Additionally, from the perspective of Islamic economics, this research contributes by demonstrating how the principles of sustainability and social responsibility inherent in circular economy initiatives align with the principles of Islamic finance. By emphasizing the importance of resource efficiency, waste reduction, and community empowerment, the Eco Agrotomation program exemplifies practices that resonate with the values of fairness, social justice, and environmental stewardship advocated in Islamic economics. Thus, the research not only advances understanding in the field of circular economy but also offers insights for integrating Islamic economic principles into modern business practices for the betterment of society and the environment.

Literature Review

The concepts of circular economy and Islamic economy are closely intertwined. Both offer similar approaches to resource management and sustainable development. Substantially,

[10] Donati, et. al. (2020). Modeling the circular economy in environmentally extended input-output tables: Methods, software and case study. *Resources, Conservation and Recycling*, 152, 104508.
[11] Wolde, A. (2016). Briefing: Governments as drivers for a circular economy. *Waste and Resource Management*, 169(4), 149-150.

they emphasize efficiency in the use of natural resources. Circular economy promotes reuse, recycling, and resource recovery efforts to reduce negative environmental impacts [12] while Islamic economy teaches the avoidance of wastefulness (*israf*) in resource use.[13] Additionally, both emphasize the importance of a sustainable approach encompassing environmental, economic, and social aspects.

Islamic economics focuses heavily on social justice and economic justice in the process of wealth and resources distribution.[14] Islamic economics principles call for just and equitable distribution, taking into account not only individual interests but also the interests of society as a whole. This factor is to ensure that all parties are satisfied with what they gain in the process, which is consistent with one of the circular economy goals.[15] The second similarly lies in the area of environmental priorities. In the circular economy, the focus is on producing the least possible adverse effects on the environment by minimizing waste and emissions,[16] while Islamic economics encourages responsible environmental management that is consistent with religious ideology principles. In the context of the coal mining industry, the implementation of circular economy concepts is not only a necessity but also an opportunity to enhance operational sustainability and empower affected local communities.[17] Through community empowerment programs integrated with circular economy principles, mining companies can actively contribute to creating added value for the environment, economy, and society.

This study adopts ideas from previous research advocating for the concept of the circular economy. The report published by MacArthur (2014) titled "Towards the Circular Economy: Accelerating the Scale-Up Across Global Supply Chains" provides an in-depth insight into the fundamental principles of the circular economy, including concepts such as recyclable product design, efficient resource utilization, and sustainable waste management. The study conducted by Ghisellini, et. al. (2016) titled "A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems" offers a comprehensive review

[12] MacArthur, E. (2014). *Towards the Circular Economy: Accelerating the Scale-Up Across Global Supply Chains*. Switzerland: World Economic Forum.
[13] Fahm, A., & Yussuf, I. (2020). Critical Assessment of Isrāf (Wastefulness) on Socio-Religious Activities of Muslims in Mushin, Lagos State. *Journal of Islamic and Religious Studies*, 5(2), 15-32.
[14] Fatkhullah, M., & Habib, M. A. (2023). Pemberdayaan Masyarakat: Konsep, Peluang, dan Tantangan dalam Perspektif Islam. *Jurnal Ekonomika dan Bisnis Islam*, 6(1), 137-153.
[15] Ghisellini, et. al. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, 11-32.
[16] Geissdoerfer, et. al. (2017). The Circular Economy – A New Sustainability Paradigm?. *Journal of Cleaner Production*, 143, 757-768.
[17] Stahel, W. R. (2016). The circular economy. *Nature News*, 531(7595), 435-438.

of basic concepts in the circular economy, including industrial ecology principles, product life cycle management, and the application of these concepts in an industrial context. "The Circular Economy," authored by Stahel (2016), highlights the importance of the circular economy in addressing environmental and economic challenges faced by the global community. The author discusses the fundamental concepts of the circular economy and their implications in shaping policies and business practices.

Furthermore, other studies view the circular economy as a paradigm, as seen in Geissdoerfer, et. al. (2017) titled "The Circular Economy – A New Sustainability Paradigm?" which seeks to explore the core concepts of the circular economy and evaluate its potential as a new paradigm for sustainable development. This article also discusses the challenges and opportunities in implementing the circular economy in industries, further refined through the study by Kirchherr, et. al. (2017) titled "Conceptualizing the Circular Economy: An Analysis of 114 Definitions." The latter study analyzes various definitions of the circular economy found in academic and practical literature, helping to clarify key concepts and understand the diversity of interpretations of the circular economy through the following five principles.

1. **Recyclable Product Design**

   In the context of the coal mining industry, recyclable product design is crucial for implementing circular economy principles.[18] This may involve the use of technologies enabling coal to be maximally utilized in energy or fuel production processes, while reducing waste or residues generated during coal extraction and combustion.

2. **Sustainable Waste Management**

   The application of circular economy in the coal mining industry also requires a focus on sustainable waste management approaches.[19] This includes strategies to reduce, recycle, and reuse waste generated during mining, processing, and coal combustion processes, thereby reducing environmental impacts and maximizing the value of such waste.

3. **Efficient Resource Utilization**

   The concept of circular economy emphasizes efficient and sustainable resource utilization. In the coal mining industry, this could entail optimizing the use of coal and

[18] Kirchherr, et. al. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221-232.
[19] Singh, J., & Ordóñez, I. (2016). Resource recovery from post-consumer waste : Important lessons for the upcoming circular economy. *Journal of Cleaner Production*, 134, 342-353.

other resources in energy or fuel production processes, as well as reducing reliance on non-recyclable or non-renewable resources.[20]

4. **Collaboration and System Development**

   Implementing circular economy in the coal mining industry also requires collaboration among various stakeholders, including mining companies, government, local communities, and non-governmental organizations.[21] This collaboration is necessary to develop ecosystem that support circular economy principles, including the exchange of information, technology, and best practices.

5. **Community Empowerment**

   An important aspect of implementing circular economy in the coal mining industry is through community empowerment programs. This may include training, education, and sustainable job creation for local communities, thereby enhancing their well-being while promoting circular economy practices at the local level.[22]

Based on these aspects, circular economy can be implemented in the coal mining industry through programs that consider recyclable product design, sustainable waste management, efficient resource utilization, stakeholder collaboration, and community empowerment.

Method

This research employs a mixed-methods approach to comprehensively explore the implementation of the CSR Eco Agrotomation program by PT Bukit Asam Tbk, aimed at fostering a circular economy within the coal mining-based company. Through qualitative methods, stakeholders' experiences and perceptions are deeply examined,[23] while quantitative analysis is utilized to numerically assess the program's impacts.[24] The primary methodological framework of this study is based on a case study design. The case study allows researchers to investigate complex phenomena and the specific context of the CSR Eco Agrotomation

[20] Zăpucioiu, et. al. (2023). The Relevance of the Circular Economy in the Context of Sustainable Development. *Proceedings of the International Conference on Business Excellence*, 17, 1534-1543.
[21] Moreau, et. al. (2017). Coming Full Circle: Why Social and Institutional Dimensions Matter for the Circular Economy. *Journal of Industrial Ecology*, 21(3), 497-506.
[22] Velden, M. (2021). 'Fixing the World One Thing at a Time': Community repair and a sustainable circular economy. *Journal of Cleaner Production*, 304, 127151.
[23] Wutich, et. al. (2020). Identifying Stakeholder Groups in Natural Resource Management: Comparing Quantitative and Qualitative Social Network Approaches. *Society & Natural Resources*, 33(7), 941-948.
[24] Feor, et. al. (2023). Social Impact Measurement: A Systematic Literature Review and Future Research Directions. *World*, 4(4), 816–837.

program.[25] Through this approach, researchers will be able to gather in-depth and comprehensive data on various aspects of the program, including implementation, impacts, and encountered constraints.

To obtain qualitative data, in-depth interview techniques will be utilized to obtain profound perspectives from various stakeholders, including company management, program participants, and other relevant parties. Additionally, direct observation will also be conducted to gain a more detailed understanding of the program implementation process in the field. Quantitative data will be collected through analysis of official company documents, program activity reports, and related statistical data. Qualitative data collected from interviews and observations will be analyzed using thematic analysis method. This process involves identifying thematic patterns in the data to identify patterns, trends, and main themes that emerge from the interviews.[26] Quantitative data will be analyzed using descriptive statistical methods to generate numerical representations of program impacts, such as income improvement, operational efficiency, and environmental impact mitigation.

To ensure the validity and reliability of the research, data quality control measures will be implemented throughout the research process. These include data triangulation, where data from various sources will be used to validate findings,[27] as well as open discussions with research participants to ensure accurate understanding of the context and meaning of the collected data. By employing a combination of qualitative and quantitative approaches and appropriate data collection techniques,[28] this research is expected to provide a comprehensive understanding of how the CSR Eco Agrotomation program contributes to creating a circular economy in coal mining-based companies.

Results

The Eco Agrotomation program is grounded in several objectives, including: (1) contributing to the economic growth of communities residing around the company, (2) preserving natural resources, particularly enhancing land fertility post-mining; (3) fostering self-reliant and environmentally conscious communities; and (4) transforming post-mining areas into green, lush,

[25] Lavarda, R., & Bellucci, C. (2022). Case Study as a Suitable Method to Research Strategy as Practice Perspective. *The Qualitative Report*, 27(2), 539-555.
[26] Lochmiller, C. (2021). Conducting Thematic Analysis with Qualitative Data. *The Qualitative Report*, 26(6), 2029-2044.
[27] Carter, et. al. (2014). The use of triangulation in qualitative research. *Oncology nursing forum*, 41(5), 545-547.
[28] Williams, T., & Shepherd, D. (2017). Mixed Method Social Network Analysis. *Organizational Research Methods*, 20(2), 268 - 298.

and sustainable regions. The targets of this program are vulnerable communities, particularly low-income communities, former unauthorized mining workers (PETI), and housewives from underprivileged families. Through this approach, PT Bukit Asam is committed to reducing socioeconomic disparities in its operational areas while providing a positive impact on the environment.

Utilizing an idle land area of 1.6 hectares, the Eco Agrotomation program is operated under the Sustainability Department. The program operates in 4 (four) different locations, namely Utun Green Garden in Tanjung Karangan Village, the Village-Owned Enterprises (BUMDES) Barokah in Keban Agung Village, Al Barokah Islamic Boarding School in Tanjung Enim Subdistrict, and the PKK in Tanjung Raja Subdistrict. The plant seeds developed include kaliandra, eucalyptus, and longkida. These seedlings are selected for development because of their rapid growth rate, with advantages tailored to the company's reclamation needs, namely the need for trees that can protect cliffs, withstand wind speed, reduce environmental temperature intensity, increase and improve air humidity, and maintain soil moisture stability.

Automation technology is a distinctive feature of this program. Several aspects of automation include plant irrigation, fertilization, environmental condition monitoring, and performance reporting. With this automation, efficiency in agricultural management can be enhanced, while the time and energy of the community can be allocated to other more productive activities.

Table 1.

Eco Agrotomation Program Community Profile

	BUMDES Keban Agung	Tanjung Karangan Nursery	Al Barokah Orphanage	PKK Tanjung Raja
Seed enlargement	Yes	Yes	Yes	Yes
Sales of planting media	-	Yes	-	-
Seedling capacity	12.000	11.000	6.000	11.000
Resources from EBT	Yes	Yes	Yes	Yes
PLTS capacity	655 Wp	655 Wp	500 Wp	655 Wp
Watering automation	Yes	Yes	Yes	Yes
Power storage system (battery)	Yes	Yes	Yes	Yes
Total manpower	8	14	8	11
Ownership of transport vehicles	Yes	Yes	-	-

Source: Eco Agrotomation Program Profile (2023)

The Eco Agrotomation program is considered environmentally friendly for several reasons. Firstly, the use of organic fertilizers reduces dependence on chemical fertilizers and prioritizes soil fertility and plant health.[29] Secondly, the utilization of solar power plants (PLTS) for operations and the implementation of automation technology reduce reliance on fossil energy sources and decrease carbon emissions.[30] Thirdly, by utilizing waste from coal mines, such as mine acid water and conveyor belt waste, this program reduces the negative impact of industrial waste. Finally, the implementation of automation systems not only enhances productivity and income for the community but also reduces the consumption of natural resources and greenhouse gas emissions generated from conventional farming activities.

Figure 1.

Integration of Solar Power Plants (PLTS) with Plant Watering Automation

Source: Authors (2023)

In practice, the Eco Agrotomation program not only focuses on empowering the local community economically but also creates economic circularity for the company and the community. Thus, this initiative creates sustainable social and environmental impacts around the coal mining areas managed by PT Bukit Asam Tbk. To achieve this, the company provides intensive training and mentoring. For example, training in making bokashi and eco enzyme fertilizers is provided. The local community is taught techniques for making fertilizer from

[29] Bhunia, et. al.. (2021). Agronomic Efficiency of Animal-Derived Organic Fertilizers and Their Effects on Biology and Fertility of Soil: A Review. *Agronomy*, 11(5), 823.
[30] Yu, et. al.. (2022). Has the Digital Economy Reduced Carbon Emissions?: Analysis Based on Panel Data of 278 Cities in China. *International Journal of Environmental Research and Public Health*, 19(18), 11814.

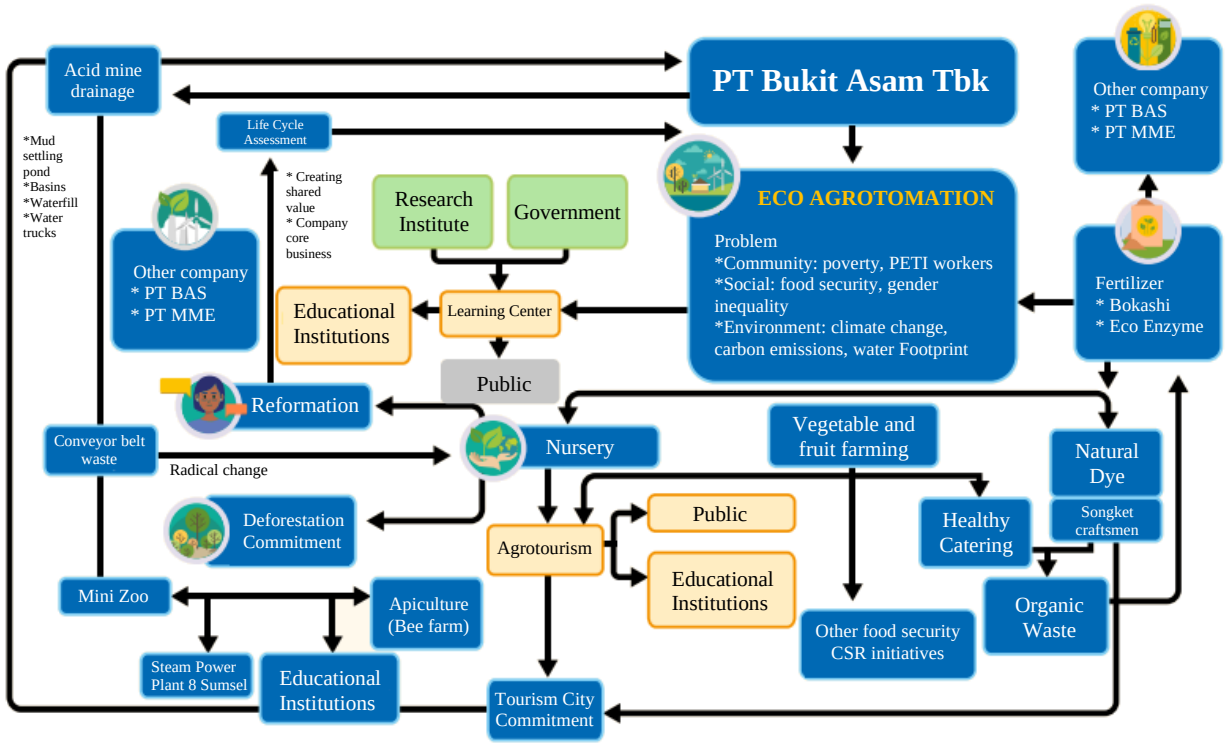
locally available organic materials. Similarly, efforts are made to promote environmentally friendly propagation practices.

After enhancing the capacity of the local community in propagation, the company also organizes training sessions to strengthen their managerial capabilities. These training sessions cover aspects such as financial management, collective decision-making, program planning, and good governance. Moreover, the company promotes accountability within the local community through accounting training, enabling them to have a better understanding of managing and reporting their business finances. This training includes basic bookkeeping, understanding financial reports, managing business capital, and strategies for sustainable business development. Thus, these training sessions not only enhance individual capacities in crop cultivation but also strengthen the capacity of the local community in managing their natural and human resources.

Enhancing the community's capacity to manage their products and resources is crucial, considering the close connection between the products they produce and the business operations of the company. Consequently, the success of the local community in managing their businesses will also contribute to the company's success in post-mining reclamation efforts, thus improving the overall environmental ecosystem.

Figure 2.

Economic Circularity of the Eco Agrotomation Program



Source: Processed from the Sustainability Report[1] and CSR Report[1] of PT Bukit Asam Tbk

As demonstrated by Figure 2, the economic circularity of the Eco Agrotomation program also extends to communities, CSR programs, and even other companies, both subsidiaries and partners of PT Bukit Asam Tbk. The extensive reach of the program results in impacts that are not only economic but also social and environmental. In the environmental context, the program reduced approximately 491.68 tons of CO2e in 2023 through the planting of 28,375 trees, and providing 60,291 seedlings for reforestation of post-mining land.

The significant economic impact is evidenced by the improved economic status of 41 local communities, with incomes reaching Rp 3,500,000.00 per month or equivalent to the Regional Minimum Wage. Furthermore, the activation of the village-owned enterprises (BUMDES) has been implemented in several villages, such as Keban Agung Village, Tanjung Karangan, and Tanjung Raja, contributing to the utilization of idle fertile land.

In the social context, this program embraces vulnerable groups within the company's supply chain, including former illegal miners and housewives from underprivileged families. Additionally, the establishment of the Learning Center related to plant cultivation and seedling has enhanced the knowledge and skills of the local community. The increased solidarity among residents in economic activities also fosters a more cohesive and empowered social environment.

Utilization of Company Waste as Business Supporting Raw Materials

The Eco Agrotomation program contributes to creating a circular economy for PT Bukit Asam Tbk, primarily through the utilization of company waste. Previously, mine acid water waste was a serious environmental issue resulting from coal mining activities.[31] However, through proper management, this resource is now used as a water source for irrigating plants for the local community. Through this initiative, the company has successfully transformed this waste into a valuable resource. This innovation not only reduces the negative environmental impact but also optimizes the use of waste previously considered useless into an integral part of sustainable production activities. Through the implementation of this program, the company has managed to reduce the water footprint from its operations by 90,000 liters of mine acid water waste per year.

[31] Yao, et. al. (2021). Experimental Study of Coal Sample Damage in Acidic Water Environments. *Mine Water and the Environment*, 40, 1003–1015.

Figure 3.

Acid Mine Filtration and The Use of Technology to Control Soil Acid Levels

Source: PT Bukit Asam Tbk (2023)

Furthermore, the utilization of conveyor belt rubber waste as planting beds in agriculture also reflects the principles of a circular economy. Previously, conveyor belt rubber waste was one of the industrial waste sources that was difficult to recycle or process again. However, by converting this waste into planting beds in agriculture, the company has created added value from 200 kg of unused conveyor belt waste. This creates a sustainable economic cycle where waste is recycled into useful resources, thereby reducing environmental impact and improving resource efficiency for local communities.

Optimizing Existing Resources to Achieve Efficiency

The Eco Agrotomation program significantly creates a circular economy for the local community through various strategies that emphasize resource efficiency and utilization of existing potentials. Firstly, the digitization and automation of agriculture are crucial steps in resource management efficiency. By implementing automation systems, water consumption has been reduced by 30%, from 238,680 to 183,600 liters per year. This not only optimizes water usage but also reduces environmental impact through the conservation of vital natural resources.

Furthermore, the integration of Solar Power Plants (PLTS) with a capacity of 10.08 kWh per day also makes a significant contribution to creating a circular economy. By meeting the electricity needs through renewable energy, the company reduces the local community's dependence on conventional electricity sourced from fossil fuels. In addition to reducing

operational costs incurred by the community, this initiative also mitigates greenhouse gas emissions and negative environmental impacts. On the other hand, this represents a tangible step towards realizing the company's vision and mission in achieving a clean, affordable, and sustainable energy transformation.

The utilization of fertile idle land in Keban Agung Village, Tanjung Karangan, Tanjung Enim Village, and Karang Raja is also a crucial part of the circular economy established by PT Bukit Asam through this program. By utilizing existing land productively for sustainable agricultural activities, the company not only enhances land productivity but also empowers the local community to contribute to the regional economy.

Creating Circular Economy through Collaboration and Partnership

PT Bukit Asam Tbk actively pursues a circular economy through the Eco Agrotomation program with a strong collaborative approach, particularly in supporting post-mining land reclamation. One of the main strategies employed is to encourage the involvement of local communities to contribute as partners of the company in the reclamation process. These communities not only serve as partners in seedling, cultivation, and provision of bokashi fertilizer for reclamation purposes, but also constitute an integral part of the reclamation planning and implementation process.

The active role of the company in promoting legally recognized economic institutions, including Village-Owned Enterprises (BUMDES), is key to creating a framework that supports sustainable local economic development.[32] By empowering communities through mentoring and training, the company is able to facilitate the establishment of formal cooperation between the community and several surrounding companies, which forms the basis for the creation of a circular economy.

Another step taken by the company is to establish an association of local farmers consisting of 70 members. Through this association, local farmers can support each other, exchange experiences, and develop best practices in sustainable agriculture. Implementing Lean Production in agricultural businesses and mentoring in developing Standard Operating Procedures (SOP) are also important steps in creating an efficient and sustainable system.

[32] Rashed, A., & Shah, A. (2020). The role of private sector in the implementation of sustainable development goals. *Environment, Development and Sustainability*, 23, 2931–2948.

Figure 4.

Process of Making Planting Media by Company Partners (Local Community)

Source: Authors (2023)

Community Empowerment Through Institutional Strengthening, Infrastructure, Technology, Training and Mentoring

The Eco Agrotomation program plays a crucial role in empowering vulnerable communities through the circular economy of the company. The vulnerable groups involved in this initiative consist of 10 former illegal miners, 6 housewives, and 25 workers from underprivileged families. Through this program, there has been an increase in income up to 3,500,000 rupiahs per month, equivalent to the Regional Minimum Wage. To achieve this stage, the company has empowered vulnerable communities through a comprehensive approach involving institutional strengthening, infrastructure development, technology enhancement, training, and mentoring. In terms of institution-building, the company actively initiates the establishment of Village-Owned Enterprises (BUMDES), Cooperation Agreements, and the development of Standard Operating Procedures (SOP) for farming activities.

From an infrastructure standpoint, the company supports the local community by establishing nurseries in four different locations, creating facilities that facilitate the propagation and maintenance of plants. In the field of technology, the company strives for new renewable energy (EBT) transformation by installing Solar Power Plants (PLTS) at each nursery. Additionally, the company also introduces automated irrigation systems and digital farming monitoring systems, enhancing efficiency and productivity in agricultural activities.

The enhancement of the capacity of vulnerable communities is also the main focus of this program. PT Bukit Asam Tbk has conducted a series of training and mentoring sessions in various fields, ranging from eco-enzyme and bokashi fertilizer production, environmentally friendly

propagation training, to accounting and financial management training. Through a holistic and sustainable approach, the Eco Agrotomation program has successfully empowered vulnerable communities economically and improved their quality of life, while contributing to sustainable local economic development.

Discussion

The Eco Agrotomation program has successfully created a circular economy for PT Bukit Asam Tbk through four identified ways, except in the utilization of recyclable product designs. Firstly, through sustainable waste management, the company has utilized mine acid water waste to support plant cultivation activities, as well as using conveyor belt rubber waste as cultivation beds in agriculture. Secondly, efficient resource utilization is evident from the utilization of Solar Power Plants (PLTS) to provide electricity to nurseries, as well as automation systems to enhance water and energy usage efficiency. Thirdly, collaboration and ecosystem systems are formed through the involvement of local community in the seedling and plant cultivation processes, as well as through cooperation with the Department of Agriculture and related institutions in program development. Fourthly, empowerment of vulnerable communities occurs through training, mentoring, and providing business capital to develop sustainable agriculture.

To address the unmet circular economy principles in this program, the company still holds promising development potentials. One of them is by leveraging Fly Ash and Bottom Ash resulting from coal combustion in power plants as raw materials for eco-paving blocks[33] that can be utilized in the infrastructure development under the Eco Agrotomation program. The utilization of these materials not only reduces waste from the coal combustion process but also adds value to environmentally friendly infrastructure development. Furthermore, development potentials are also available by utilizing fugitive or airborne dust as additives for the composition in bokashi fertilizer[34] produced by the community. Thus, not only reducing the waste generated but also enhancing the quality of organic fertilizers produced by this program. By integrating these potentials into the Eco Agrotomation program, the company can optimize the implementation of circular economy principles and create a greater impact on the environment and surrounding communities.

[33] Strzałkowska, E. (2021). Fly ash – a valuable material for the circular economy. *Gospodarka Surowcami Mineralnymi - Mineral Resources Management*, 37(2), 49-62.
[34] Su, et. al. (2021). Production of a novel slow-release coal fly ash microbial fertilizer for restoration of mine vegetation. *Waste management*, 124, 185-194.

Although the Eco Agrotomation Program has contributed to creating a circular economy and empowering vulnerable communities, there are several weaknesses that need to be addressed for the program to run more effectively and sustainably. One of the main weaknesses identified is the lack of order in administration and financial recording among local community. Observations indicate that beneficiary groups are still not organized in recording their assets and finances. This can hinder the efficiency of resource management and proper fund allocation, as well as reduce transparency in program performance reporting. Another weakness is the limited distribution of Bokashi fertilizer to the fostered nursery groups, where only one nursery group receives fertilizer assistance, while other groups do not receive similar benefits. In addition to hindering the potential for increasing productivity and efficiency in their farming practices, this situation also has the potential to breed jealousy and hidden conflicts among the beneficiaries of the CSR program.

Additionally, the lack of collaboration and knowledge exchange among local communities poses its own challenges. Without study visits or discussion forums among the communities, the opportunities for mutual learning and enhancing sustainable farming practices are limited. Similarly, the absence of certification as a Center of Excellence by the Department of Agriculture is also a hindrance. However, the government holds a significant role and resources, and even a substantial responsibility in community development programs,[35] thereby potentially amplifying the impact of CSR programs. Without official validation, the Eco Agrotomation program may lack sufficient recognition and support from relevant stakeholders.

To address these weaknesses, there is a need for more intensive and sustained training in administration and financial record-keeping for the local community. Besides enhancing the community's ability to manage administration and financial records more effectively, documentation that can be used to analyze the correlation between the financial performance of CSR initiatives and the overall financial performance of the Company.[36] The decision to provide Bokashi fertilizer assistance to other nursery communities is expected to enhance agricultural productivity and reduce fertilizer expenses for the local community. On the other hand, cross-community study visits are also proposed as a step to enhance the exchange of knowledge and

[35] Sitorus, et. al. (2022). Pemberdayaan Masyarakat Nelayan; Peran Dan Kontribusi Dinas Perikanan Dan Kelautan Kabupaten Rokan Hilir. *Masyarakat Madani: Jurnal Kajian Islam dan Pengembangan Masyarakat*, 7(1), 1-19.
[36] Rajput, et. al. (2012). Linking CSR and financial performance: an empirical validation. *Problems and perspectives in management*, 42-49.

experiences among the communities.[37] This strategy will help improve the quality of farming practices and expand the network of relationships among the communities.

Lastly, collaboration with the Department of Agriculture to obtain certification as a Center of Excellence can be a revolutionary step. Certification provides official legitimacy to the Eco Agrotomation program and increases trust from stakeholders, as well as broadening access to knowledge resources and support.[38] By implementing these recommendations, it is hoped that the Eco Agrotomation program can address existing weaknesses and become more effective in achieving its goals.

Conclusion

The CSR Eco Agrotomation program initiated by PT Bukit Asam Tbk has proven its success in creating a circular economy in the coal mining-based company. Through the utilization of Solar Power Plants (PLTS), automation, and digitalization in agricultural practices, as well as formal collaboration to strengthen institutions, this program has established a sustainable economic cycle. Quantitative findings indicate that water usage efficiency through agricultural digitalization and automation reaches 30%, with water consumption reduced from 238,680 liters per year to 183,600 liters per year. Additionally, the utilization of PLTS has resulted in conventional electricity efficiency of 10.08 kWh per day, equivalent to Rp 5,080,320 per year.

The impact recieved by PT Bukit Asam Tbk from the implementation of this program are significant. In addition to successfully improving waste management and the company's image, 491.68 tons of CO2e greenhouse gas emissions were mitigated in 2023 through the planting of 28,375 trees. The community's participation in the Eco Agrotomation program has also had positive effects. Program participants experienced income increases, with an increase of up to Rp 3,500,000 per month, especially for vulnerable groups such as former illegal miners (ex-PETI), housewives, and workers from underprivileged families. They also enjoy the benefits of cleaner and healthier agricultural practices, as well as better access to quality local agricultural products.

However, despite its various advantages, there are some shortcomings that need to be addressed. One of them is the lack of integration of recyclable product designs, which reduces the program's potential to create a broader and more sustainable economic cycle. To optimize the

[37] Osagie, et. al. (2020). Learning Organization for Corporate Social Responsibility Implementation: Unravelling the Intricate Relationship Between Organizational and Operational Learning Organization Characteristics. *Organization & Environment*, 35(1), 130 - 153.
[38] Muhlisin, M., & Budiarto, M. (2023). Environmental CSR in Industrial Cities: A Collaborative Governance Approach. *International Journal of Innovation, Management and Technology*, 14(2), 64-69.

Eco Agrotomation program in the future, steps such as expanding cooperation with related industries to create eco-friendly products, increasing awareness and community participation in circular economy practices, and continuously evaluating and improving the program sustainably are needed. Thus, the Eco Agrotomation Program sets an inspirational example of how a coal mining company can be a positive agent of change in realizing a sustainable circular economy for the environment and local communities.

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