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Integration of Biofloc Cultivation and Waste Banks as a CSR Model for Inclusive Food Security in Urban Areas

Mohammad Yuliendri[1], Nadya Putri Kristiyant[2], Kintan Ayu Septiani[3], Reyhan Januar Mulyawane[4]*

[1-2]PT PLN Batam - Unit PLTGU Tanjung Uncang, Indonesia

[3,4]Universitas Muhammadiyah Riau, Pekanbaru, Indonesia

E-mail: [1)] yuliendri@plnbatam.com [2)] nadya.putri@plnbatam.com, [3)] kintankalifa@gmail.com, [4)] reyhanjanuar86@gmail.com

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*Coresponding author:
Kintan Ayu Septiani
kintankalifa@gmail.com

ABSTRACT

The gap between demand and supply of local food in urban areas like Batam City triggers vulnerability to nutritional access, especially for lower-middle-income communities. In response to this challenge, PT PLN Batam - PLTGU Tanjung Uncang Unit initiated the SEHATI TABUROSI program (Environmental Synergy and Inclusive Food Security) as a Corporate Social Responsibility (CSR) model based on community empowerment. This study aims to explore the implementation and impact of the SEHATI TABUROSI program, which integrates biofloc fish farming technology, waste bank management, and strengthening women's roles in local food security. Using a qualitative case study approach, data was collected through interviews, observations, and documentation in Tanjung Uncang Village, Batam. Results show that the program successfully increased tilapia production up to 210 kg per cycle, strengthened women's economic capacity, and supported supplementary feeding programs (PMT) for vulnerable children. Organic and inorganic waste was processed into feed, fertilizer, and pond construction materials, reflecting circular economy practices. In addition to resource efficiency, direct participation of PLN Batam - PLTGU Tanjung Uncang Unit employees in technical competency transfer also strengthened program sustainability. This holistic intervention model proved effective in combining economic, social, and environmental aspects, and has the potential to be replicated in other urban areas with similar challenges.

Keywords: Biofloc, CSR, Food Security, Women Empowerment, Circular Economy

1. Introduction

Food security is one of the main pillars of sustainable development and an important component in achieving community welfare. This aligns with the Sustainable Development Goals (SDGs), particularly goal number 2: ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture. Food security challenges are increasingly complex in urban areas, including Batam City, which has rapid population growth and industrial development but is limited in terms of productive land availability for agriculture and fisheries.

According to data from the Batam City Fisheries Department (2024), freshwater fish consumption needs of Batam residents are estimated to exceed 5 tons per day. However, local fish supply from aquaculture activities can only meet around 25-30% of total demand. This shows a significant gap between demand and availability of local protein sources, which potentially impacts family nutrition access, especially among lower-middle-income communities. This challenge is also closely related to stunting prevalence, which is a condition of growth failure in children due to chronic malnutrition. The Indonesian Nutritional Status Survey (SSGI)

recorded stunting prevalence in Batam City at 7.21% in 2020 (equivalent to ±3,876 children), and although successfully reduced to 1.28% or around 840 children in mid-2024, this figure remains an important indicator that needs to be maintained for sustainability.

In response to these problems, PT PLN Batam - PLTGU Tanjung Uncang Unit through its Corporate Social Responsibility (CSR) program developed the SEHATI TABUROSI initiative (Environmental Synergy and Inclusive Food Security). This program was designed as a response to two crucial issues: environment and food, with a community empowerment-based approach. The program specifically targets the UBS Taburosi Waste Bank Group which is a local community that has been active in waste education and management in Tanjung Uncang Village as the main partner in program implementation. Through a participatory approach, this program integrates freshwater fish biofloc farming technology, waste bank institutional strengthening, environmental management training, and support for enhancing women's roles in the community.

The biofloc system was chosen as the main technology in the program because it is efficient in terms of land and water use, and has advantages in maintaining aquaculture environmental quality through the utilization of microorganisms as natural pond water cleaners. Additionally, this system is relatively easy to apply on a household scale and can be developed as a productive economic unit. In practice, this program involves more than 10 women mostly housewives who receive technical fish farming training, micro-financial management assistance, and local food-based nutrition education. Not only are harvest results utilized for family consumption, but part of the fish is also distributed as part of the Supplementary Feeding Program (PMT) for vulnerable children through local posyandu (integrated service posts), thus directly supporting stunting prevention efforts.

From an environmental perspective, integration with the waste bank program becomes an important part in promoting circular economy principles (Desreza et al., 2022). Residents are trained to sort household waste, recycle plastic into ecobricks, and utilize organic waste as fertilizer or fish feed. Even biofloc pond infrastructure is built from construction waste such as zinc sheets and used hollow steel, as a form of zero waste principle implementation. This approach not only encourages waste reduction that ends up in landfills, but also strengthens community social cohesion in collective environmental management.

Multi-stakeholder collaboration becomes the main strength in implementing the SEHATI TABUROSI program. In addition to support from PT PLN Batam, this program involves the Batam City Fisheries Department, village government, academics from Batam State Polytechnic, as well as health cadres and local community leaders. Together, they designed biofloc pond water quality monitoring systems, developed locality-based training protocols, and supported institutional regulation of women farmer groups (KWT) and UBS Taburosi waste bank through Tanjung Uncang Village Head Decree No. 37/KPTS/SK/12.001/IV/2025.

This research aims to explore more deeply the implementation process of the SEHATI TABUROSI program as a CSR model based on food security and environment, assess socio-economic impacts on target groups, and identify challenges and opportunities for replicating similar models in other regions. Through this study, it is hoped that comprehensive understanding can be generated regarding community empowerment strategies through CSR synergy, local technological innovation, and participatory community governance.

2. Literature Review

2.1. Biofloc Technology

Biofloc Technology (BFT) is one of the innovative approaches in intensive aquaculture that relies on the principle of biological nitrogen waste processing in closed aquaculture systems. This technology utilizes heterotrophic microorganisms to convert organic waste, feed residues, and ammonia excretion from fish into microbial flocs that can be consumed again by fish as a natural feed source rich in protein. In the context of sustainability, biofloc systems can improve feed efficiency and improve feed conversion ratio (FCR), reduce clean water requirements, and lower environmental pollution potential typically produced by conventional aquaculture systems (Avnimelech, 2009; Hargreaves, 2013).

One of the main advantages of this system is its efficiency in water use. Biofloc enables fish farming with minimal water replacement, even only about 10% compared to conventional systems. This is very relevant to be applied in areas with water and land limitations, such as in urban and industrial areas, including Batam City (Crab et al., 2012). In addition, biofloc can provide additional nutrition sources from the microbial flocs formed, so it can replace most external feed needs and reduce operational costs for farmers (Emerenciano et al., 2017).

Various studies show that biofloc application has positive impacts on growth, survival rate, and fish immunity, including tilapia (Oreochromis niloticus), which is one of the main commodities in the SEHATI TABUROSI program. This system also contributes to reducing disease prevalence due to a more biologically stable environment and the dominance of beneficial microorganisms in aquaculture media (Kumar et al., 2018). Additionally, the biofloc approach also reflects circular economy principles currently promoted in the sustainable development policy framework, because waste is not only processed but also reused as input in the same system (de Lara et al., 2021).

However, biofloc implementation also has technical challenges, especially in maintaining carbon-nitrogen ratios, maintaining water quality, and ensuring stable aeration availability. This system requires regular parameter monitoring and the use of supporting technology such as aerators, blowers, and water quality sensors. Therefore, successful biofloc implementation depends not only on physical infrastructure, but also on the technical and managerial capacity of the farming community (Azim & Little, 2008).

2.2. Food Security

Food security is a complex and multidimensional global issue, covering aspects of availability, access, utilization, and food stability. FAO (1996) defines food security as a condition when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. This concept emphasizes that food security is determined not only by national food production alone, but also by household ability to obtain and utilize food sustainably (Maxwell & Smith, 1992).

In Indonesia, the understanding of food security is clarified in Law Number 18 of 2012 on Food, which states that food security is a condition where food is fulfilled for the state down to individuals, reflected in the availability of sufficient, safe, quality, and nutritious food, and affordable by every individual sustainably. National food security relies on three main pillars: food availability, access to food, and effective food utilization, supported by environmental sustainability and socio-economic stability (Warr, 2014).

Previous research shows that food security plays an important role in poverty alleviation efforts and reducing stunting prevalence. Limited access to nutritious food has been proven to contribute to chronic malnutrition rates in children, especially in urban areas with distribution inequality and productive land limitations (Sari et al., 2010; Torlesse et al., 2003). Therefore, modern food security strategies are not only focused on agricultural production, but also on local food diversification, appropriate technology utilization, and community-based empowerment.

In the context of sustainable development, food security becomes one of the main targets of Sustainable Development Goal (SDG 2), which promotes hunger elimination and nutrition improvement as well as strengthening resilient and sustainable local food systems (United Nations, 2018). The role of the private sector, including companies through Corporate Social Responsibility (CSR) programs, becomes crucial in supporting community food security. Initiatives that combine food farming technology, environmental education, and empowerment of vulnerable groups as done through the SEHATI TABUROSI program by PT PLN Batam are concrete manifestations of efforts to bring food security closer to the household level.

2.3. Previous Research

Several companies in Indonesia have implemented CSR programs with similar focus to the SEHATI TABUROSI Program, namely community empowerment through environmentally friendly fish farming technology to support food security. Among them, PT Suri Tani Pemuka (STP), a subsidiary of Japfa, developed a fish farming program using biofloc technology as a flagship CSR program starting in 2021. Through this initiative, the company installed biofloc ponds for farmer groups in various regions such as

Purwakarta, Banyuwangi, Lampung, and Jakarta. The goal is to increase fish productivity while maintaining water efficiency and environmental quality (Chury, 2023). This program reflects an approach that not only supports community economy but also contributes to environmental conservation and natural resource efficiency.

Another CSR example comes from Sebuku Coal Group (SCG) which collaborated with communities in Pantai Baru Village, South Kalimantan. SCG provided two units of biofloc circular ponds, 2000 tilapia seeds, and water management support equipment to support local fisheries groups. Training and assistance were provided continuously as part of the company's commitment to promoting economic independence based on fish farming (Sebuku Coal Group, 2023).

Furthermore, through a community program in Bogor facilitated by Karya Salemba Empat Foundation (KSE) and supported by PT Manulife Asset Management Indonesia, the community in Situ Gede utilized wastewater channels for catfish farming with biofloc systems. The main objectives of this program were to improve resident welfare, strengthen local food security, and provide nutritional alternatives for children vulnerable to stunting (KSE, 2022). However, what distinguishes the SEHATI TABUROSI program from programs previously implemented by other companies can be seen in the table below:

Table 1. Comparison of the SEHATI TABUROSI Program and Previous Corporate Programs

Aspect	Other Programs (STP, SCG, KSE)	SEHATI TABUROSI Program (PT PLN Batam - PLTGU Tanjung Uncang Unit)
Intervention Scheme	Focused (farming only)	Holistic (biofloc + environment + nutrition + social)
Target Community	General	Housewives and vulnerable groups
Circular Economy	Not yet dominant	Yes, organic & inorganic waste processed
Nutrition & PMT Involvement	Limited	Actively integrated
Regulation/Legality	Not mentioned	Village Head Decree as institutional recognition
Company Competency Transfer	Generally external	Directly provided by PLN employees according to core competency

3. Methodology

3.1. Research Design

This study uses a descriptive qualitative approach with case study strategy to deeply explore the implementation, impact, and uniqueness of the SEHATI TABUROSI Corporate Social Responsibility (CSR) program implemented by PT PLN Batam - PLTGU Tanjung Uncang Unit. This approach was chosen to obtain contextual and holistic understanding of community empowerment practices in food security and environmental management through biofloc fish farming systems integrated with community waste banks. Case study design was used because the SEHATI TABUROSI program has unique and prominent contextual characteristics, and takes place in a specific social environment (Yin, 2018). This research does not aim to generalize findings, but to deeply explore program implementation processes, empowerment strategies, socio-economic impacts, and multi-stakeholder collaboration dynamics involved.

3.2. Research Sample

The research subjects comprise key stakeholders involved in implementing the SEHATI TABUROSI program, including the UBS Taburosi Waste Bank Group, Pesona Indah Women Farmer Group (KWT), representatives from PT PLN Batam's PLTGU Tanjung Uncang Unit, Tanjung Uncang Village officials, field assistants and biofloc facilitators, Posyandu cadres, and beneficiary residents. The research is conducted in RW 09 Tanjung Uncang Village, located in Batu Aji District, Batam City, within the Riau Islands Province.

3.3. Data Collection Tools and Procedure

Data collection was conducted through several techniques. Semi-structured interviews were held with target group representatives and program stakeholders to explore perceptions, experiences, and program impacts. Participatory observation was carried out during biofloc pond construction activities, operational training, waste bank management, and harvest distribution. A documentation study was performed,

examining materials such as Village Head Decree, CSR activity reports, documentation photos, training minutes, and media publications related to program implementation. Additionally, secondary data was obtained from official sources including the Batam Fisheries Department website, FAO, and national news sources to compare program achievements with local food security and stunting conditions.

3.4. Data Analysis

Collected data was analyzed using thematic analysis approach, grouping information into main themes such as program planning, empowerment approach, socio-economic impact, community institutional strengthening, and sustainability aspects. This technique allows researchers to construct systematic narratives from various data sources and formulate deep meaning based on program social context (Braun & Clarke, 2006).

3.5. Ethical

To ensure data credibility, source triangulation technique was applied by comparing interview results with observation data and supporting documents. Additionally, member checking was conducted with key informants to verify the appropriateness of researcher interpretations of their experiences.

4. Results and Discussion

4.1. Research Results

The SEHATI TABUROSI program initiated by PT PLN Batam - PLTGU Tanjung Uncang Unit has shown positive and relevant results in the context of strengthening food security, environmental education, and women-based community economic empowerment. Program implementation for more than one fish farming cycle shows that the biofloc technology approach can produce significant harvests on a household scale, and strengthen the capacity of the UBS Taburosi Waste Bank Group as the main actor in integrating waste management and local food.

In one farming cycle lasting ±4 months, two biofloc ponds produced approximately 210 kilograms of tilapia from 1,200 seeds stocked. Harvest distribution was strategically divided with dual purposes: around 50% of results were used to support Supplementary Feeding Programs (PMT) for children and vulnerable groups, while the rest was sold as working capital and additional income for group members. This approach demonstrates program success in creating a circular ecosystem capable of combining nutrition, economic empowerment, and food production sustainability aspects.

Based on field data, economic impact on each group member saved household expenditure by Rp100,000-150,000 per month through fish consumption from their own ponds. Meanwhile, from sales results, the group obtained collective income of ±Rp8,000,000 per cycle. These results not only increased purchasing power but also promoted women's micro-economic independence. This approach aligns with SDGs Number 2 (Zero Hunger), Number 5 (Gender Equality), and Number 12 (Responsible Consumption and Production) principles.

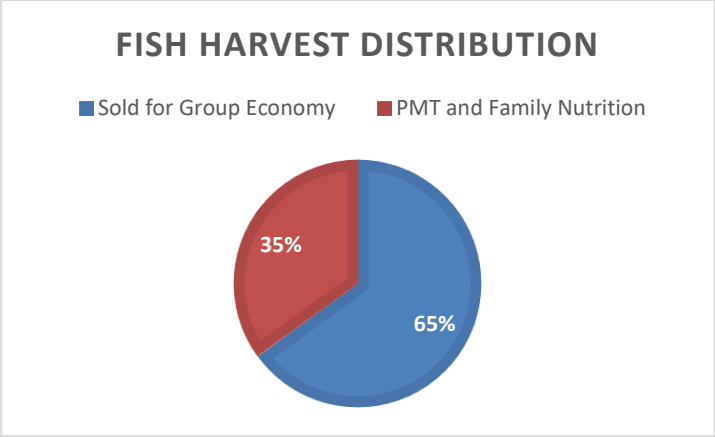

Figure 1. Distribution of Fish Harvest Utilization in SEHATI TABUROSI Program

From an institutional perspective, the program also strengthened community social structure by providing supporting facilities such as uniforms, name boards, and group branding. Formal legality from village government through Village Head Decree Number 37/KPTS/SK/12.001/IV/2025 further strengthened the group's position as citizen-based development actors. Thus, SEHATI TABUROSI's success lies not only in technical aspects of fish production, but also in social strengthening, environmental education, and community governance.

From a social perspective, there was increased women's participation in community decision-making, environmental management, and food distribution. As many as 10 women were actively involved in biofloc system management, alternative feed training, waste management education, and implementation of posyandu and Supplementary Feeding Program (PMT) activities. This program has opened leadership space and women's economic independence, while strengthening social solidarity through mutual cooperation activities, joint training, and collective decision-making in group cooperatives.

Environmental impact from this program was strongly felt in two main aspects: waste reduction and resource efficiency. Inorganic waste such as household plastic was processed into ecobricks, while organic waste was used as supplementary feed and fertilizer. Used materials from PLN projects such as zinc sheets and hollow steel were utilized as biofloc pond frames, showing circular economy principle implementation. The biofloc system itself is known to be water-efficient and produce minimal waste, while reducing dependence on external resources. This program also created productive green zones in dense settlements through utilization of unproductive land.

This impact was realized due to active participation from PT PLN Batam - PLTGU Tanjung Uncang Unit employees in providing knowledge transfer to the community. PT PLN Batam - PLTGU Tanjung Uncang Unit employees played direct roles in technical training processes related to biofloc system operations. Employees provided training on aeration system installation, circulation pump usage, to integrated pond electrical management. This is a concrete manifestation of competency transfer from company to community—utilizing PLN's technical expertise in creating energy-efficient farming systems that can be operated by lay communities. This involvement also strengthened relationships between company and community as development partners.

4.2. Discussion

This research aims to examine the implementation and impact of the SEHATI TABUROSI Corporate Social Responsibility (CSR) program by PT PLN Batam - PLTGU Tanjung Uncang Unit as a community empowerment model based on food security, environmental management, and women empowerment. Research results show that integration of biofloc technology, waste bank systems, and local economic strengthening through Supplementary Feeding Programs (PMT) provides positive multidimensional impacts including economic, social, environmental, and institutional. Conceptually, these results strengthen community empowerment theory that emphasizes active community participation, appropriate technology mastery, and local institutional capacity building (Perkins & Zimmerman, 1995). Collaborative approach between company and community reflects CSR practices that are not only philanthropic in nature, but also oriented toward sustainable development, as developed in the triple bottom line framework (Elkington, 1997), namely profit, people, and planet.

Compared to previous research and CSR programs that also used biofloc technology (Chury, 2023; Sebuku Coal Group, 2023), SEHATI TABUROSI's advantage lies in its integration: farming technology, environmental education through waste banks, and direct contribution to family nutritional security. This approach not only produces fish commodities but also strengthens local food security and reduces stunting risk, as promoted by SDGs Number 2 (Zero Hunger) and Number 3 (Good Health and Well-being) targets. Interpretation of these findings shows that program success is not solely due to biofloc technology transfer, but because of integration of social, educational, and women's economic empowerment values, as well as direct involvement of company employees as technical mentors. This interaction forms new social relations between business entities and society, where companies are not only fund providers but also community capacity building facilitators. However, this research has several limitations. First, relatively short observation duration (one farming cycle) limits long-term evaluation regarding group economic sustainability. Second, detailed quantitative data on nutritional status changes of PMT beneficiary children is not yet available. Third,

result generalization only applies to local context of RW 12 Tanjung Uncang Village and does not yet represent all PT PLN Batam CSR intervention areas.

Scientific implications include the need to strengthen CSR concepts based on local ecosystems, where programs not only focus on one sector (economic, environmental, or health), but integrate them into one system. These results can serve as references for developing integrated social intervention models by other companies, especially in urban-industrial areas facing similar challenges: land limitations, domestic waste, and household food vulnerability. Moving forward, further research needs to be conducted to evaluate long-term impacts of the SEHATI TABUROSI program, measure economic sustainability post-intervention, and potential replication of this model in other communities, particularly in areas vulnerable to stunting and poor access to animal protein sources.

5. Conclusion

The SEHATI TABUROSI program implemented by PT PLN Batam – PLTGU Tanjung Uncang Unit demonstrates that integrated CSR approaches between biofloc farming technology, waste bank management, and women's economic empowerment can produce broad positive impacts on food security, nutrition improvement, and community social capacity strengthening. Implementation of land-efficient and water-efficient biofloc systems, combined with harvest distribution for family consumption and supplementary feeding programs (PMT), provides concrete solutions to local food challenges and stunting in dense urban areas like Tanjung Uncang.

Implications from this research confirm the importance of CSR program design based on local ecosystems and involving active participation of communities, especially vulnerable groups such as housewives. Holistic approaches based on cross-sector collaboration which are between companies, communities, and local government can become replication models for other areas with similar challenges. Additionally, direct involvement of company employees in technical knowledge transfer proves that CSR linked to company core competencies can strengthen program sustainability and deepen relationships between business world and society.

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