

From Waste to Wealth: Zero-Waste Catfish Processing as a Strategy for Food Security and Environmental Sustainability

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Abstract. Food security refers to a condition where sufficient food is available to meet the community's nutritional needs in both quantity and quality, distributed equitably, and affordable for all. Catfish (*Clarias gariepinus*) is highly popular among Indonesians due to its good quality and economic value, making it a vital food source with easily accessible raw materials. Previous studies have explored the nutritional content and characteristics of various catfish parts to promote product diversification that provides social, economic, and environmental benefits. Recently, the local community of Kutu Wetan, Ponorogo, developed methods to enhance food value by processing catfish into fish sticks, nuggets, crackers, and shredded meat. These products are widely consumed by the community and play an important role in local culinary practices due to their zero-waste approach and economic contribution to the region. This paper examines the potential of catfish-based diversified products in enhancing food availability and transforming fish waste into a sustainable resource. Addressing the challenges of catfish waste management is essential for promoting food security and advancing environmental sustainability across regions.

1 Introduction

Food security has become a global concern, with many nations, including Indonesia, facing warnings of an imminent food crisis. As food is a fundamental human need that must be fulfilled both individually and collectively, the issue has drawn serious attention worldwide. The Food and Agriculture Organization (FAO) has warned of a potential global food crisis driven by climate change and rising food prices, raising concerns over global food security. According to the 2020–2024 National Medium-Term Development Plan (RPJMN), Indonesia's food security target score is 95.2. However, in reality, the country's score is only 60.2, ranking 63rd out of 113 nations in the Global Food Security Index [1].

Indonesia also faces significant health challenges, with a high prevalence of stunting (21.6 percent in 2022), primarily affecting children aged three to four years [2]. The main causes include inadequate nutritional intake among low-income populations and unequal access to resources and opportunities. For a developing country like Indonesia, achieving food self-sufficiency is crucial. This includes ensuring sufficient supply, stable availability, cost efficiency, adequate nutrition, safety, and independence from external sources. Therefore, access to affordable and nutritionally balanced food is essential to meet basic

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dietary needs. Rising food prices can endanger households' ability to fulfill their nutritional requirements [3].

Indonesia's extensive freshwater fish farming and abundant local food resources provide opportunities to supply communities with a wide variety of high-quality foods. Catfish are widely cultivated in Indonesia because of their low maintenance costs, short three-month growth period, and ability to thrive in limited spaces, making them an affordable and prominent food source for local communities [4]. Catfish rank as the third-highest aquaculture commodity in Indonesia after seaweed and Nile tilapia, contributing 1,136,618.98 tons to national aquaculture production. Recent studies indicate that catfish play a significant role in promoting food security [3]. However, the edible portion of catfish meat accounts for only about 40% of its total weight, while the head and bones are often discarded as waste. Because food consumption exceeds the rate of food waste recycling, large volumes of organic waste end up in landfills, where they are burned or left to decompose, releasing harmful gases such as methane. This process contributes to soil and air pollution, poses health risks to humans, and intensifies greenhouse gas emissions that exacerbate climate change [5–7].

National policies are therefore needed to strengthen the production of various regional food commodities by considering factors such as market access, availability, and diversification. Previous studies have highlighted the nutritional composition and characteristics of different catfish parts to support product diversification that provides social, economic, and environmental benefits [4,8-9]. The core of Sustainable Development Goal (SDG) 2—ending hunger, achieving food security, and improving nutrition—must be continuously reinforced. To prevent unintended consequences and burden shifting, it is essential to assess the environmental sustainability of these waste-to-wealth initiatives. Such efforts not only contribute to achieving “zero hunger” but also help reduce the adverse environmental impacts of food production [5,10]. This study therefore examines the potential of transforming catfish waste into value-added products to address local food security and nutritional needs.

2 Methods

This study employs a qualitative approach using field-based observation and informal interviews to capture real-life situations comprehensively. The case study focuses on catfish processing in Kutu Wetan, Ponorogo, East Java. A pilot study conducted in 2024 found that the local community plays an active role in managing catfish waste, an initiative predominantly led by women through organizations such as the Women Farmers Group. The study also applies desk research methods by collecting and analyzing existing information from various secondary sources without conducting direct primary data collection. Desk research involves gathering and evaluating available data, making it a cost-effective research approach [11].

3 Results And Discussion

3.1 Catfish processing food in Kutu Wetan, Ponorogo, Indonesia

In the study area, the Women Farmers Group (WFG) Pohsari was established by the village chief in collaboration with the local community. Besides producing various products for micro, small, and medium-sized enterprises (MSMEs), the group processes catfish along with other local ingredients such as moringa, mushrooms, bitter gourd, bananas, and sweet potatoes.

According to the East Java Province Statistics, freshwater catfish production in Ponorogo reached 1,617,444 kilograms in 2023, with a production value of IDR 37,304,046,000. Nutritionally, catfish meat contains 15.5% protein, while the head and bones contain 6.75% protein and are rich in calcium at 39.24% [2]. Catfish waste, mainly from bones and heads, contains 58.3% calcium phosphate, 1.0% calcium carbonate, 2.1% magnesium phosphate, 1.9% calcium fluoride, and 30.6% protein [12].

Although Indonesia has succeeded in providing affordable food through strong food safety-net programs, significant weaknesses remain in building a sustainable, food-secure future [1]. As catfish production is projected to increase, more catfish waste will be generated, potentially harming the environment. To address this issue and promote product diversification, the Pohsari Group adopted a zero-waste approach. This initiative aims to provide the local community with sufficient nutrition while contributing to economic and environmental sustainability. All parts of the catfish are processed by the group into fish sticks, crackers, shredded meat, and nuggets.

The ingredients used in processing catfish-based foods are relatively inexpensive and easy to obtain, including wheat flour, tapioca or sago, spices, cooking oil, eggs, and bread crumbs for making nuggets. Nutritionally, the high calcium content in catfish bones provides several health benefits, such as supporting bone and teeth development, catalyzing biological processes, regulating blood coagulation, and aiding muscle contraction. With a higher proportion of catfish meat (60%) as the main ingredient, catfish nuggets are a rich source of protein. A 50 g serving of catfish nuggets contains 6.6–6.9% fiber, 11.4% fat, 22–27.6% protein, 4.6–4.7% carbohydrates, and 8% calories [12]. Therefore, catfish nuggets can serve as a nutritious, high-protein snack for toddlers.

Shredded meat, a traditional dry ready-to-eat food, is typically consumed as a side dish. The seasoning for shredded catfish differs from other products and includes ingredients such as minced garlic, finely chopped galangal, light soy sauce, dark soy sauce, granulated sugar, salt, and water [9]. The product also contains various spices that not only enhance flavor but also act as natural preservatives, improving the texture and extending shelf life [8]. Processing catfish into dry products like shredded meat offers several benefits, including longer storage stability—remaining edible for up to 50 days at room temperature. From a health perspective, shredded catfish meat is a cost-effective source of nutrition suitable for all age groups. It is particularly beneficial for the elderly, as it may help reduce blood cholesterol levels [9], and for children, as it contributes to stunting prevention [9-10].

The activities carried out by the Pohsari Women Farmers Group (WFG) provide alternatives to the limited variety of processed catfish products. This diversification initiative aims to increase catfish consumption while strengthening the region's food security strategy to help achieve the goal of "zero hunger". In relation to improving household nutrition, processed catfish and bone-based products serve a dual function by supporting supplementary feeding programs at health centers for young children and the elderly, thereby helping to reduce stunting rates. Furthermore, transforming nutrient-rich fish waste into value-added products offers a cost-effective and sustainable approach to addressing micronutrient deficiencies in communities. Zero-waste processed catfish products have already been produced and distributed, becoming both a staple food source and a local specialty. Visitors from other areas are introduced to these catfish-based products and their nutritional benefits by local residents. As public awareness increases, production can be expanded to generate additional income or for self-consumption to enhance community nutrition. Community participation tends to grow when people recognize the associated economic benefits [13].

3.2 The challenges of implementing catfish waste for food security

Data on food waste, particularly regarding catfish commodities, remain limited across regions. This lack of information constrains understanding of regional variations in food waste, associated nutrient losses, and ecological impacts. Identifying and quantifying food waste are essential to determine the key resources required to develop value-added products that ensure sustainability and efficiency [14]. Ensuring the safety and quality of by-products and valorized waste is also critical, as water content and chemical contaminants in fish waste may pose risks to human health [15]. To support safe and equitable waste utilization, clear regulations, standards, and further research are needed. Large-scale implementation additionally requires addressing public concerns about the safety and acceptability of value-added products through targeted education and awareness initiatives [5].

4 Conclusion

Addressing global food security and enhancing environmental sustainability require transforming food waste into valuable resources. Food crises represent a key sustainability paradox in which environmental degradation, persistent food insecurity, and public health concerns coexist. Implementing circular economy principles can increase food production, promote equitable food distribution, and reduce the environmental impact of food waste. By treating food waste as a resource rather than a problem, societies can build more resilient and sustainable food systems that benefit both people and the environment while advancing toward a zero-waste future. This shift encourages a re-evaluation of how resources are valued and managed through collective efforts.

This study contributes to the growing body of literature on sustainability transitions by demonstrating how women-led community cooperatives in Kutu Wetan provide a model for addressing food production and waste management challenges safely and responsibly. It highlights the importance of community participation in developing environmentally sound solutions to food waste. However, since the nature and environmental effects of food waste vary across regions, context-specific strategies are necessary. As public awareness increases, the market for waste-to-wealth products is expected to expand, supported by technological innovation and improved community perceptions.

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