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Mitigating the impact of mercury on rural people by providing scenarios on alternative income through corn farming improvement

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ABSTRACT
The purpose of this research is to examine several scenarios in corn farming, which can be an alternative income for rural communities involved in ASGM. The artisanal and small-scale gold mining (ASGM) activities in Tulabolo, Gorontalo, have negatively impacted the local community's health due to mercury amalgamation pollution. Therefore, alternative scenarios are needed to attract the interest of the mining community to return to farming. Interviews were conducted with 26 farmers engaged in both mining and corn farming activities using an interview guide to assess their current cultivation behaviour and income related to ASGM, and other relevant informants. The data collected indicated that farmers earn significantly higher income from mining than from corn farming. Therefore, to incentivize farmers to shift their focus to corn farming, this study analyse several scenarios; increasing the land area per individual to a minimum of 2.2 hectares, raising the selling price of corn kernel to a minimum of IDR 9,203 per kg, and increasing productivity to a minimum of 2,709 kg/Ha through improved farming techniques. Implementing the third scenario is recommended to enhance earnings while reducing the negative impacts of ASGM on both health and the environment.

Contribution/Originality: This study introduces an economic strategy for reducing mercury pollution from ASGM, suggesting corn farming scenarios as an alternative income for rural ASGM communities. The outcomes propose a solution by enhancing agricultural practices to increase income from corn farming.

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1.INTRODUCTION
Small-scale mining, also known as artisanal and small-scale gold mining (ASGM), has become a significant contributor to the global production of gold, accounting for 15-25% of worldwide output and providing economic benefits to approximately 300 million people worldwide, both directly and indirectly (Schipper, de Haan, & van Dorp, 2015). Nevertheless, despite the economic benefits, ASGM also poses negative impacts resulting from the gold extraction process. The use of mercury, which is produced from the residue of polluted gold extraction, leads to

various health symptoms in the community. According to Bernhoft (2012), mercury poisoning can affect different organs, such as the kidneys, liver, gastrointestinal tract, and brain. The digestive tract, respiratory tract, and skin contact are the three entry routes for mercury from the environment to humans. ASGM adds between 410-1400 tons of mercury emissions annually (Esdaile & Chalker, 2018),contributing to 37% of mercury emissions worldwide, and therefore leading to environmental pollution (Selin, 2014).In response to this issue, several countries have ratified the Minamata Convention, an international treaty aimed at reducing the impact of mercury and its use (Bank, 2020). Indonesia is one of the countries included in the Convention and is responsible for reducing and preventing environmental mercury pollution (Izzati, Adiwibowo, & Riani, 2023). However, many local workers depend on mining for their livelihoods, and it is estimated that over 200 thousand workers are involved in ASGM (Novirsa et al., 2019). The Tulabolo region in Gorontalo, Indonesia, is a gold mining area that is managed by the local people and provides better prospects for improving the economic level and welfare of the community. However, mining activities have negative impacts on the environment, even up to the Bone River, which surrounds the Tulabolo area (Gafur, Sakakibara, Sano, & Sera, 2018). According to Komatsu et al. (2020),two factors encourage people to prefer mining as a source of livelihood: the low level of education and the age factor of miners. People with lower levels of education tend to choose mining due to the limited employment opportunities that require a certain level of education. Additionally, mining is one of the job opportunities that is closer to the people of Tulabolo. Most of the productive age group of 20 to 40 years is more dominant in choosing mining as a source of livelihood. Therefore, new job opportunities that are more or less equally profitable are needed to divert this trend.Rural communities are currently heavily dependent on mining, particularly small-scale gold mining, despite the existence of many alternative sources of income, such as the agricultural, fishery, and livestock sectors. In order to mitigate the detrimental effects of mercury pollution resulting from the ASGM sector, it is imperative to redirect the attention of the village community towards alternative sources of income. Such alternatives should provide the community with a sustainable livelihood, yielding a respectable income (Komatsu et al., 2020). While these alternative income opportunities need not be limited to agricultural activities, there is potential for optimizing agricultural endeavors within the village as a viable option.West Tulabolo Village is one of the villages in the Tulabolo region that has the potential to provide an alternative source of income from the agricultural sector, including corn, coconut, and cayenne pepper. According to the Central Statistics Agency (CSA) data, the corn planting area in the Bone Bolango Regency, where West Tulabolo Village is located, reaches 10,137 hectares. This indicates that corn farming in Tulabolo area has the potential to be an alternative source of income to prevent the effects of mercury in the Tulabolo community. Therefore, this study aims to 1) identify the socio-economic challenges related to ASGM activities of the community in West Tulabolo Village, and 2) develop scenarios of alternative income based on the feasibility of improved corn farming in West Tulabolo Village. This study contributes not only to the advancement of the understanding of corn farming behavior and the optimization of corn cultivation in West Tulabolo Village, but also offers valuable insights into the potential for promoting agriculture practices in rural areas related to ASGM, such as West Tulabolo Village, to diversify income sources, promote economic growth, as and mitigate mercury pollution.

2. MATERIALS AND METHODS

2.1. Research Location

The present study was carried out in West Tulabolo Village, which is situated in the East Suwawa District of the Bone Bolango Regency in the Gorontalo Province, as shown in Figure 1. Covering an area of 16.06 km², West Tulabolo Village constitutes approximately 12.57% of the total land in the East Suwawa District. The village comprises three *dusun*: BulaboDaa, Bulabo Diti, and Dudamu, with a total population of 513 individuals. While the majority of the villagers work in the mining sector as motorcycle taxi drivers or mining workers, the agricultural sector of West Tulabolo Village has significant potential. The main agricultural products that the local farmers cultivate are corn, chili, and coconut.

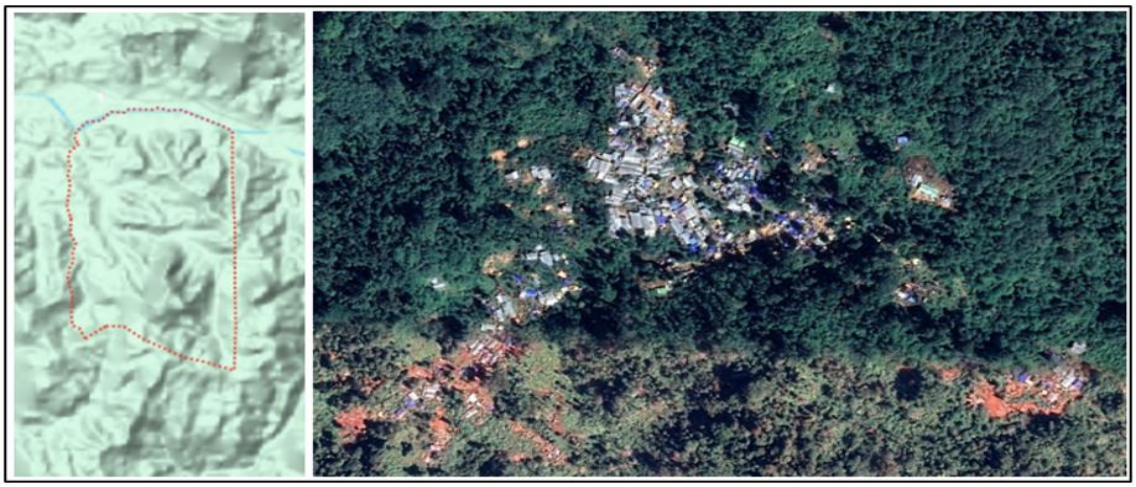

Figure 1. Research site: West Tulabolo village (Left) and ASGM site (Right) located around 10 km southeast from the village.

2.2. Research Methods

The research specifically focused on the local people of West Tulabolo Village who were directly or indirectly involved in artisanal and small-scale gold mining (ASGM) activities, but were also corn farmers. The study was therefore limited to corn-farming families that were also involved in ASGM activities. The selection of informants was carried out purposefully to ensure a diverse range of perspectives on the subject matter. In total, 26 corn-farming families were interviewed using an interview guide that contained data on corn farming behaviour and its operational costs. The study aimed to identify conventional corn cultivation techniques currently employed by farmers and the feasibility of their farming business. It was assumed that the current corn cultivation techniques used by farmers were not optimal, resulting in low profits that were insufficient to attract farmers to remain in corn farming instead of continuing to be involved in ASGM activities. The farming behaviour of the farmers was assessed through a questionnaire designed using hybrid corn good agricultural practice (GAP) with a four-level Likert scale. The GAP covered the following: the use of certified corn seeds, one corn seed per hole, sufficient spacing, appropriate fertilization, using organic fertilizers, hilling, proper pest control, timely harvesting, and immediate drying after harvest. Descriptive statistics were used to analyse the implementation of GAP by farmers. In addition, in-depth interviews were also conducted with several community leaders regarding the relationship between sources of income and ASGM in West Tulabolo.

2.3. Data Collection and Analysis

The collected data was analysed to estimate the optimization of corn farming and develop scenarios that could generate optimal profits. An analysis of the income and feasibility of farming was conducted to evaluate the benefits of cultivating hybrid corn in West Tulabolo Village. Profitability, efficiency, and the break-even point of corn farming were systematically formulated for analysis. Profitability analysis assessed the net income generated from corn farming. Efficiency analysis investigated the revenue-cost ratio (R/C ratio), or the ratio of output to input for each farming activity. Lastly, the break-even point analysis identified the quantity of corn produced required to cover the fixed and variable costs. The formulas can be written as follows:

$$TR = Q \; x \; P \qquad (1)$$

Where TR = total revenue (Rp), Q = quantity of products (Kg), and P = price of product per kg (Rp). The revenue gained from corn farming is the result of the amount of corn shell sold by farmers. The total cost is the sum of fixed and variable cost as follows:

$$TC = TFC + TVC \qquad (2)$$

Where TC = total cost (Rp), TFC = total fixed cost (Rp), and TVC = total variable cost (Rp). Therefore, the profit from corn farming was calculated using the formula:

$$\pi = (1) - (2) \qquad (3)$$

Where π is the net profit earned by farmers. The feasibility was calculated using the revenue cost ratio and break-even point to analyze the efficiency of farming using the following formula:

$$R/C \; Ratio = \frac{TR\,(1)}{TC\,(2)} \qquad (4)$$

If the R/C ratio > 1, then corn farming is feasible and provides benefits for farmers, whereas if R/C ratio < 1, then corn farming is not feasible to be developed and is detrimental to farmers.

$$BEP_{(v)} = \frac{TC}{P} \qquad (5)$$

and

$$BEP_{(p)} = \frac{TC}{Q} \qquad (6)$$

Where: $BEP_{(v)}$ = break-even point for volume, and $BEP_{(p)}$ = break-even point for price for each quantity unit.

3. RESULTS AND DISCUSSION

3.1. Informant Characteristics

The informants involved in this study were 26 hybrid corn farmers located in West Tulabolo Village, East Suwawa District, Bone Bolango Regency. The following table shows the identities of the research informants, which include their demographic data and socioeconomic characteristics.

Table 1 presents the demographic characteristics of the informants involved in this study, revealing that the majority of participants were in their 40s. The number of young farmers was relatively low, as many young individuals in the village preferred employment outside the agricultural sector. This finding aligns with previous research by Ngadi et al., who argue that young farmers in rural areas often migrate to seek alternative job opportunities (Ngadi et al., 2023). In the case of the West Tulabolo village, a considerable number of young people expressed interest in working in the ASGM sector, specifically in roles such as motorcycle taxi drivers or mining workers. This preference stems from the higher and quicker income potential associated with such occupations. Age plays a significant role in the physical capabilities of farmers, particularly in traditional farming methods that heavily rely on physical strength. Generally, younger farmers exhibit greater physical stamina compared to their older counterparts.

Table 1. Informant characteristics.

Items	Responses		
	n	%	$\bar{x}$
Age			
20-29	2	7.7	
30-39	5	19.2	
40-49	9	34.6	
50-59	8	30.8	
60<	2	7.7	
Average			45
Gender			
Male	11	42.3	
Female	15	57.7	
Education level			
Uneducated	14	53.8	
Primary school	4	15.4	
Middle school	6	23.1	
High school	2	7.7	
College and above	-	0	
Family members			
≤4	19	73.1	
4<	7	26.9	
Average			3.96
Land size owned			
Less than 0.5 Ha	2	7.7	
0.5 to 1 Ha	16	61.5	
Above 1 Ha	8	30.8	
Average			0.98
Corn productivity per hectare			
Min.			200
Max.			4,200
Average			1,184.29
Other income from farming			
Yes	12	46.2	
No	14	53.8	
Other off-farm income			
Yes	19	73	
No	7	27	

Moreover, the demographic data highlights the dominance of female farmers in the West Tulabolo village, partly attributable to the presence of ASGM activities. Male residents tend to pursue job opportunities in mining-related roles, such as mining motorcycle taxi drivers or mining workers. The education level among farmers in the village is classified as very low, with most having only completed elementary school and only a few having attained a high school education. Those with higher education are more inclined to seek non-agricultural employment opportunities. Previous studies have consistently shown that farmers in the Gorontalo region generally possess a low level of formal education (Abdullah, Imran, & Sirajuddin, 2023; Sirajuddin, 2021a; Suhana, Rauf, & Sirajuddin, 2023).

Additionally, the demographic data reveals that the majority of farmers in West Tulabolo own their corn farming land, with an average area of 0.98 hectares. This indicates that corn farmers in the village possess medium-sized farming plots, neither too large nor too small, like smallholders who own less than 0.5 hectares. This suggests potential for on-farm intensification, as farmers can optimize their income by cultivating their own land. In terms of farming practices, some individuals practice monoculture, while others engage in polyculture. Corn farmers who practice polyculture often incorporate coconut and cayenne pepper crops. This result is consistent with Sirajuddin's research, which showed that polyculture corn farmers in the Gorontalo region frequently cultivate coconut and cayenne pepper due to their market and widespread popularity among locals (Sirajuddin, 2021b). Several studies recommend polyculture farming and diversification as they contribute positively to improved marketing for farming households (Bellon, Kotu, Azzarri, & Caracciolo, 2020; Sibhatu & Qaim, 2018). Furthermore, Table 1 indicates that a significant number of respondent farmers in West Tulabolo Village are involved in additional business ventures

alongside farming. Field observations during data collection revealed that villagers commonly worked as mining motorcycle taxi drivers, primarily due to the higher income potential compared to farming.

3.2. Socio-Economic Challenges Related to ASGM Activities

3.2.1. ASGM Activity Around West Tulabolo Village and its Impact on Economics and Health

In order to gain a comprehensive understanding of Artisanal and Small-Scale Gold Mining (ASGM) activities in West Tulabolo Village, in-depth interviews were conducted with multiple informants. The results of this information gathering process showed that locals had recognized the potential for gold mining in the Tulabolo area as early as the 1970s. The involvement of PT Tropic Endeavor Indonesia, a corporation engaged in investigation and drilling activities, brought the mining potential to the attention of the local people. Specifically, 19 drill points were identified in the mining area of Tulabolo. However, the company did not resume mining activities at that time due to various reasons. According to one source, the company deemed large-scale gold mining economically unfeasible due to high investment costs. Consequently, the drill points left behind by the corporation became new sites where residents dug holes in search of gold deep within the earth. Local villagers claim that the establishment of community-based mining began in 1992. The period between 1993 and 2015 witnessed the peak of mining activities, characterized by the presence of numerous productive holes and substantial income for the residents. This era also gave rise to several "*bostambang*," or the mining bosses, within the local community, resulting in significant economic effects on the people of Tulabolo and the surrounding areas. Consequently, a shift occurred in the primary sources of income, with a growing number of villagers, who were predominantly farmers, engaging in the ASGM sector, particularly as motorcycle taxi drivers and mining workers. Although an exact estimate is currently unavailable, it is believed that the residents of West Tulabolo earn about 36 million dollars per year from motorcycle taxis, while the potential annual income from mining activities in 66 million dollars.

While ASGM activities have positively impacted the village's economy, they have also been associated with adverse effects on the community, particularly concerning physical health and the environment. Studies conducted on several rivers in Gorontalo Province, including the Bone River located in the Tulabolo ASGM area, have demonstrated the presence of harmful substances such as mercury (Hg), lead (Pb), and arsenic (As). These substances are believed to originate from the amalgamation process employed during gold extraction in ASGM activities (Basir, Kimijima, Sakakibara, Pateda, & Sera, 2022; Gafur et al., 2018). Additionally, other research has revealed mercury contamination in the hair of individuals residing near ASGM sites (Abdul Gafur, Sakakibara, Sera, & Indriati Arifin, 2020).

3.2.2. Current Profit Gained from Corn Farming

This study focuses on the corn farmers residing in West Tulabolo Village. This section presents an analysis of the current corn farming practices adopted by the community. The assessment of farming costs is intricately linked to their inclination towards engaging in activities associated with the ASGM sector. Specifically, if the income derived from farming is relatively meager, there is a greater likelihood of heightened interest in motorcycle taxis or mining. A more comprehensive examination of the viability and practicality of corn farming can be observed in Table 2.

Table 2. Farming and feasibility analysis on current practice on corn farming.

Item	Total	$\bar{x}$
Total fixed cost (TFC)	IDR 667,943	IDR 25,690
Depreciation	IDR 8,943	IDR 344
Tax	IDR 659,000	IDR 25,346
Total variable cost (TVC)	IDR 29,644,000	IDR 1,140,154
Seeds	IDR 4,300,000	IDR 165,385
Fertilizer	IDR 4,090,000	IDR 157,308
Pesticides	IDR 4,749,000	IDR 182,654
Labour cost for transportation	IDR 4,800,000	IDR 184,615
Labour cost for shelling	IDR 4,750,000	IDR 182,692
Labour cost for planting and fertilizing	IDR 6,955,000	IDR 267,500
Total cost (TC)	IDR 30,311,943	IDR 1,165,844
Total revenue (TR)	IDR 114,454,350	IDR 4,402,090
Price per unit (P)	IDR 4,023	IDR 4,023
Production quantity (Q)	28,450 kg	1,094 kg
Total profit (π)	IDR 84,142,407	IDR 3,236,246
Feasibility analysis per individual		
R/C ratio		3.78
$BEP_{(p)}$		IDR 1,065.45
$BEP_{(v)}$		290 kg

The average cost incurred by corn farmers per planting season amounts to IDR 1,165,844, while the generated revenue reaches IDR 4,402,090. In comparison to corn farmers in other regions, this income is relatively low. The meager income can be attributed to the farmers' low corn kernel yield, averaging only 1.094 kg on an average land area of 0.98 hectares. Although the BEP values seem relatively low, it is primarily due to the impact of low total costs, resulting in suboptimal corn yields. The data collected reveals that, on average, farmers cultivate corn on their fields twice a year, leading to an annual revenue of IDR 8,804,180. In terms of feasibility, the value of the R/C ratio exceeding the value of 1 indicates the viability of corn farming, surpassing the break-even point and ensuring that farmers do not incur losses. However, despite its feasibility, the income generated through corn farming remains disproportionately small when compared to that from ASGM activities. Consequently, farmers become less reliant on agricultural income.

3.3. Scenarios of Alternative Income Based on the Feasibility of Improved Corn Farming

One of the inherent challenges in formulating alternative income scenarios lies in identifying appropriate benchmarks for comparison. Komatsu et al. (2020) assert that in order to diminish reliance on mining, alternative income sources that can ensure the well-being of the community are indispensable. Consequently, this study incorporates several comparative figures to facilitate a meaningful evaluation. Firstly, the income derived from ASGM activities, including motorcycle taxis and mining, is employed as a relatable benchmark, as individuals find it easier to comprehend comparisons that directly reflect their own experiences. Secondly, the current regional minimum wage (RMW) for Gorontalo Province is utilized as a reference, which stands at IDR 2,989,350 per month or IDR 35,872,200 per year. Lastly, the poverty line specific to each family within the Bone Bolango Regency is considered, with an estimated value of IDR 449,543 per capita per month, equivalent to approximately IDR 1,780,190 per family per month (amounting to IDR 21,362,283 annually), as illustrated in Figure 2. These benchmarks serve as a basis for comparing the corn farming scenarios examined in this study.

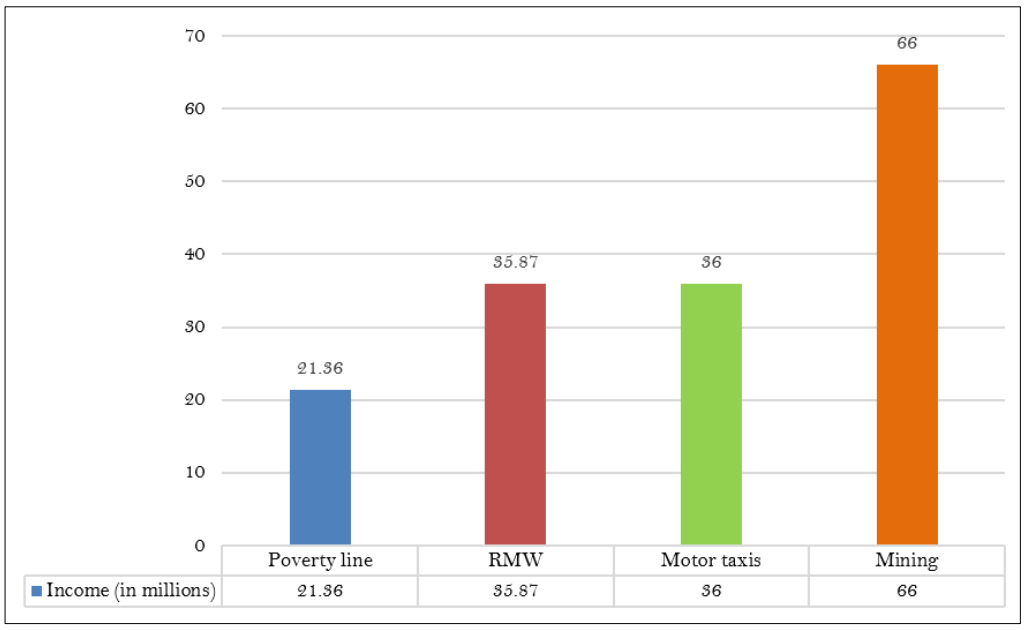

Figure 2. Benchmark for comparison in formulating alternative incomes.

3.3.1. Scenario 1: Increasing Planting Area

In scenario 1, this research presents an estimation of income per crop cycle by considering an increase in the production land area. The study takes into account assumptions regarding farming behavior, productivity, and fixed prices. A detailed analysis of this scenario is provided in Table 3.

Table 3. Analysis for scenario 1.

Items	Compared benchmarks			
	PL	RMW	MT	Mining
Annual income	IDR 21,362,283	IDR 35,872,200	IDR 36,000,000	IDR 66,000,000
Income per cycle	IDR 10,681,141	IDR 17,936,100	IDR 18,000,000	IDR 33,000,000
Kernel price	IDR 4,023	IDR 4,023	IDR 4,023	IDR 4,023
Kernel production needed	2,655 kg	4,458 kg	4,474 kg	8,203 kg
Land productivity	1,184.29 kg/Ha	1,184.29 kg/Ha	1,184.29 kg/Ha	1,184.29 kg/Ha
Required land sizes	2.2 Ha	3.76 Ha	3.78 Ha	6.93 Ha

Note: PL (Poverty lines); RMW (Regional minimum wage), MT (Motor taxis).

Table 3reveals that, in order for corn farming to serve as a viable alternative income source, a minimum land ownership of 2.2 hectares is required to reach the poverty line, while a minimum land ownership of up to 3.78 hectares is necessary for a comparison with ASGM activities. Currently, the average land ownership for maize farming stands at 0.98 hectares.

3.3.2. Scenario 2: Increasing the Price of Corn Kernels

In scenario 2, an adjustment is made to the kernel price to enable comparisons with the established benchmarks. The assumptions taken into account are farming behaviour, average land area, and constant productivity. A detailed analysis of this scenario can be found in Table 4.

Table 4. Analysis for scenario 2.

Items	Compared benchmarks			
	PL	RMW	MT	Mining
Annual income	IDR 21,362,283	IDR 35,872,200	IDR 36,000,000	IDR 66,000,000
Income per cycle	IDR 10,681,141	IDR 17,936,100	IDR 18,000,000	IDR 33,000,000
Land sizes	0.98 Ha	0.98 Ha	0.98 Ha	0.98 Ha
Land productivity	1,184.29 kg/Ha	1,184.29 kg/Ha	1,184.29 kg/Ha	1,184.29 kg/Ha
Kernel production	1,160.60 kg	1,160.60 kg	1,160.60 kg	1,160.60 kg
Required kernel prices	IDR 9,203	IDR 15,454	IDR 15,509	IDR 28,434

Table 4demonstrates that, in order for corn farming to serve as a viable alternative income source in this scenario, a minimum price of IDR 9,203 is required to be comparable to the poverty line, while a minimum price of IDR 15,509 is necessary to juxtapose it with ASGM activities. Generally, the prevailing selling price of corn in Gorontalo over the past few months has ranged from IDR 3,500 to IDR 4,200 per kilogram in shelled form. The highest price observed in West Tulabolo Village is IDR 5,000 per kilogram.

3.3.3. Scenario 3: Increasing Corn Productivity Per Hectare

Scenario 3 entails adjustments to land productivity per hectare to enable comparisons with the established benchmarks. The assumptions considered include farming behaviour, fixed average land area, and fixed kernel prices, as illustrated in Table 5.

Table 5. Analysis for scenario 3.

Items	Compared benchmarks			
	PL	RMW	MT	Mining
Annual income	IDR 21,362,283	IDR 35,872,200	IDR 36,000,000	IDR 66,000,000
Income per cycle	IDR 10,681,141	IDR 17,936,100	IDR 18,000,000	IDR 33,000,000
Kernel price	IDR 4,023	IDR 4,023	IDR 4,023	IDR 4,023
Land sizes	0.98 Ha	0.98 Ha	0.98 Ha	0.98 Ha
Kernel production needed	2,655 kg	4,458 kg	4,474 kg	8,203 kg
Required land productivity	2,709 kg/Ha	4,549 kg/Ha	4,565 kg/Ha	8,370 kg/Ha

The analysis revealed that, for corn farming to function as a viable alternative income source in this scenario, a minimum land productivity of 2.709 kilograms per hectare is required to align with the poverty line, while a land productivity of 4.565 kilograms per hectare is necessary to align it with ASGM activities. Currently, land productivity in West Tulabolo Village remains significantly low at 1,184.29 kg per hectare, although there were maize farmers among the informants in this study who were able to achieve a productivity of up to 4,200 kg per hectare. Generally, land productivity in Gorontalo Province ranges from 3,000 to 5,000 kg per hectare.

3.3.4. Selecting the Best Scenario and Recommended Activities

Three scenarios have been examined to determine the most suitable recommendation. Scenario 1 involves acquiring additional land per farmer, which poses environmental risks and is particularly challenging given the proximity of West Tulabolo to protected forests and rivers. Scenario 2 is also impractical due to the substantial increase required in corn prices, making it unfeasible. Among the three scenarios analysed, scenario 3 emerges as the most realistic and recommended option, as it holds potential for achievable productivity enhancements. One approach to realizing scenario 3 is by improving the cultivation techniques employed by corn farmers to enhance productivity. These cultivation techniques are encompassed within the framework of Good Agricultural Practices (GAP).

In this part, an assessment of the level of adoption of GAP among corn farmers in West Tulabolo Village was conducted, with the aim of identifying the extent to which practices in GAP implementation, as recommended by agricultural extension systems, were adopted by farmers. This analysis is crucial in developing strategies to optimize corn field productivity per hectare, which can be compared against the income derived from ASGM activities. The components of GAP were derived from the research conducted by Suhana et al., which compiled the recommended GAP guidelines provided by agricultural extension services and the corn industry in Gorontalo (Suhana et al., 2023). These guidelines are designed to maximize corn yields. Table 6 presents the average adoption level of GAP among the participating farmers in West Tulabolo Village

Table 6. The adoption of farming practices according to recommended GAP.

Practices	$\bar{x}$
Immediate drying after harvest	3.69
Proper pest control	3.35
The use of certified corn seeds	2.62
Timely harvesting	2.54
Sufficient spacing	2.54
Appropriate fertilization	2.04
Hilling	2.00
One corn seed per hole	1.38
Using organic fertilizers	1.38

According to Table 3, farmers in West Tulabolo Village have only implemented two out of the nine recommended treatments outlined in the Good Agricultural Practices (GAP). These treatments include timely drying and pest management. Conversely, the farmers have not adopted seven treatments from the GAP guidelines, with the lowest adoption rates observed for the use of organic fertilizer and planting one seed per hole. This lack of adherence to recommended practices is believed to have a detrimental impact on land productivity, leading to suboptimal yields per hectare. Consequently, in order to enhance land productivity and achieve a minimum yield of 5 tons per hectare, it is crucial to implement measures that encourage farmers to adopt farming techniques that align with the GAP guidelines.

Table 7. Farming analysis for improved corn farming.

Items	Prices
Total fixed cost (TFC)	IDR 25,690
Depreciation	IDR 344
Tax	IDR 25,346
Total variable cost (TVC)	IDR 6,525,347
Seeds	IDR 165,385
Fertilizer	IDR 157,308
Pesticides	IDR 182,654
Labour cost for tilling	IDR 1,750,000
Labour cost for transportation	IDR 1,000,000
Labour cost for shelling	IDR 1,000,000
Labour cost for planting	IDR 720,000
Labour cost for organic fertilizer	IDR 300,000
Labour cost for fertilizing 1	IDR 300,000
Labour cost for fertilizing 2	IDR 300,000
Labour cost for hilling	IDR 650,000
Total cost (TC)	IDR 6,551,037
Total revenue (TR)	IDR19,712,700
Price per unit (P)	IDR 4,023
Production quantity (Q)	4,900 kg
Total profit (π)	IDR13,161,663
Feasibility analysis per individual	
R/C ratio	3.01
$BEP_{(p)}$	IDR 1,065.45
$BEP_{(q)}$	290 kg

According to Table 7, the implementation of GAP practices would result in an increase in farming costs from IDR 1,165,844 (as indicated in Table 2) to IDR 6,430,637 for a land area of approximately 0.98 hectares. However, this implementation holds the potential for a significant increase in income, rising from IDR 4,402,090 (as indicated in Table 2) to IDR 19,712,700 per cropping season, equivalent to IDR 39,425,400 per year. This income projection surpasses that of motorcycle taxis (IDR 36,000,000), although it remains lower than the income from mining activities (IDR 66,000,000). Consequently, the study strongly recommends the adoption of GAP practices as a means to enhance productivity for farmers in West Tulabolo Village. By implementing GAP, farmers can potentially achieve higher income levels, thereby reducing their dependency on activities such as motorcycle taxis and mining.

4. CONCLUSION

The findings of this study underscore the significant challenge faced in West Tulabolo, namely the comparably low income generated from corn farming when compared to mining activities. This disparity can be attributed to the insufficient adoption of GAP by corn farmers. Currently, the earnings of farmers from corn farming fall short when compared to the income generated by related ASGM activities, including motorcycle taxi driving or mining work. However, this study has demonstrated that implementing improved farming, such as expanding farming areas, raising the price of corn kernels, and enhancing land productivity, offers the potential scenarios to increase farmers' income from agriculture.Consequently, this may incentivize farmers to transition away from mining activities, which

can have adverse health effects, and return to farming. Among the formulated scenarios, the third scenario, which focuses on productivity improvement through the implementation of GAP, emerges as the most favourable course of action. By encouraging farmers engaged in ASGM to transition to corn farming, this scenario aims to mitigate and reduce the impact of mercury on public health and the environment.

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