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EFFECTIVENESS OF REHABILITATION OF FORMER LIMESTONE QUARRY LAND: A CASE OF ECOLOGICAL MARKET IN GARI VILLAGE, GUNUNG KIDUL REGENCY

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ABSTRACT

The reclamation of limestone in Gari village into the Pasar Ekologis Argo Wijil is a program of the Ministry of Environement and Forestry. The use of ex-mining limestone offers a new approach to increasing green open space and provides opportunities for the community to be environmentally responsible. The objective of the study was to evaluate the environmental, economic and social benefits of the reclamation of limestone from the quarry to pasar ekologis. Community involvement in reclamation planning is one of the government's strategies to accommodate the community's aspirations for the type of reclamation so that a sense of concern for the maintenance of Pasar Ekologis Argo Wijil can be properly carried out. The research was carried out in Gari Village, Gunung Kidul Regency. Data was collected through direct observation to measure plant height, observe the growth of vegetation in Pasar Ekologis Argo Wijil, and interview structures with traders and visitors. Pasar Ekologis Argo Wijil contains several plant species, including Terminalia mantaly, Pterocarpus indicus, Syzygium Mytifolium, and Tamarindus indica. Plant growth can be beneficial in pasar ekologis as it helps to reduce air pollution, ensuring safe activities can take place. The success of the reclamation of ex-mining limestone cannot be separated from the participation of the people of Gari Village. The community of Pasar Ekologis Argo Wijil has taken the initiative to increase green open spaces and promote vegetation growth by planting and replenishing more plants. The management of the pasar ekologis is enriched by the combination of traditional market culture and ecological concepts. Every day, traders open stalls in the Pasar Ekologis Argo Wijil. This can be an indicator of public enthusiasm for the market's activities. Pasar ekologis was originally planned for Sunday mornings only. Activities in Pasar Ekologis Argo Wijil provide an opportunity for the community to improve the local economy. The reclamation of ex-mining limestone for a traditional market with an ecological concept promotes environmentally responsible behaviour.

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INTRODUCTION

Mining activities provide opportunities for improving the local economy and creating job opportunities. On the other hand, if mining activities are not properly managed, they can have negative impacts on the environment, including causing disturbances such as damage to natural landscapes, loss of vegetation, loss of biodiversity, and loss of springs, including underground water sources drying up (Sari et al., 2019). In relation to these potential negative impacts, there are several regulations governing mining activities, including Law Number 3 of 2020 concerning Mineral and Coal Mining, Article 99 of which stipulates that mining business license holders or special mining business license holders must prepare and submit reclamation plans and/or post-mining plans, Law Number 41 of 1999 concerning Forestry, Law Number 32 of 2009 concerning Environmental Protection and Management; and their respective derivative regulations, such as Ministerial Regulation of Energy and Mineral Resources No. 1827/K/30/MEM of 2018, regarding the Implementation Guidelines for Good Mining Practices, which in Annex VI regulates Reclamation and Post-Mining.

Gunung Kidul Regency in the Special Region of Yogyakarta has karst topography. The karst area covers 53% of Gunung Kidul Regency's total area of 1,483 square kilometers. This karst landscape attracts investors to utilize it for limestone mining. The presence of investors includes mining companies as well as businesses owned by the local community. Inventory and verification data from the Provincial Energy and Mineral Resources Agency (ESDM) in 2012 identified 7 companies engaged in limestone mining, with a total exploitation area of 40,000 square meters, and there were 14 mining businesses conducted by the community with total exploitation ranging around 7,000 square meters. Limestone mining in Gari Village, Gunung Kidul Regency, has been conducted since 1975 by the local people. Formerly, this area was a limestone hill called Argo Wijil. The nature of limestone, easily dissolved and forming holes and cracks, allows water to quickly enter the underground flow system and develop into karst topography. This occurrence renders the land surface less favorable for agriculture or plantation. As an alternative means of livelihood, the community shifted to limestone mining. They utilize limestone as a building foundation material such as for making cement, road hardening, and raw material for craft industries like sculptures, ornaments, and wall reliefs. Limestone mining in Gari Village ceased in 2010 when the limestone material reserves declined, rendering the land unproductive. Abandoned mining sites can become sources of environmental disasters for both the environment and the community, hence reclamation of abandoned mining land is mandatory (Wardhana et al., 2020).

The Ministry of Environment and Forestry, through the Directorate General of Pollution Control and Environmental Damage in 2017, conducted reclamation

activities on abandoned limestone mining land in Gari Village. This activity aims to anticipate environmental, social, and economic issues. The theme of reclamation adopted was the construction of an ecological market integrating environmental management into traditional markets. Environmental function restoration was implemented by providing water infiltration areas around the market edges planted with certain plant species. The construction of this ecological market is expected to set an example of behavioral change in maintaining good and healthy environmental quality starting from the community and village components. The management of this ecological market can include the implementation of environmentally friendly materials and equipment.

The design of the traditional market creates an ecological market that provides staple foodstuffs, groceries, side dishes, and other materials, thus facilitating buying and selling processes within the ecological market. Transactions conducted by the community and traders can contribute to local economic development, but these buying and selling processes raise basic issues such as the generation of waste, necessitating environmentally friendly behavior. Integrated waste management development, including composting, is one form of concern for the environment, so the planning of limestone mining reclamation can address environmental issues and enhance the local community's economy.

Research on the evaluation of reclamation and post-mining activities has been extensively conducted, including in coal mining companies in Indonesia (Adnyano, 2016; Budiana & Jumani & Biantary, 2017), in China (Yu et al., 2020), nickel ore mining (Kamrullah et al., 2019), limestone mining at PT Semen Baturaja (MINE & TBK, 2020). Generally, reclamation forms include revegetation. Meanwhile, the restoration in former limestone mines in Gari Village involves the construction of an ecological market. Therefore, research on the effectiveness of former limestone mining land restoration activities is needed from both economic and ecological perspectives.

Literature Review

Limestone mining areas have very limited nutrient content, so reclamation efforts require soil improvement by topsoil spreading in former mining areas for planting activities. Research conducted by Nurtyahani et al. (2020) identified soil microorganisms to indicate soil quality, as the presence of microorganisms can serve as a medium for increasing nutrients. Another effort is a study by Yunanto et al. (2022) aiming to influence the chemical properties of soil in former limestone mining areas by adding organic fertilizers from animal manure and poultry. Stephan et al. (Stephan & Hubbart, 2022) showed that abandoned limestone mining land after one year, which lacks soil nutrients dominated by gravel content exceeding 60%, requires 70 years to restore plant succession in the mining area. Restoring former limestone mining land requires several efforts to maintain environmental sustainability, with community involvement being crucial in sustaining the restoration area.

RESEARCH METHOD

The research was conducted at the Argo Wijil Ecological Market, located in Gari Village, Wonosari District, Gunung Kidul Regency. The materials used in this

research consisted of literature studies from various sources such as libraries, journals, and primary data obtained directly in the field through interviews and direct observations, as well as secondary data such as reports from relevant agencies and other relevant sources, which could be used to complement primary data to support analysis in the research.

The initial stage to determine the effectiveness of the rehabilitation program is to evaluate the development of the Argo Wijil Ecological Market in terms of ecology. The ecological aspect was conducted by direct field measurements. Land quality improvement with land arrangement makes the land more productive, forming planting areas visually reflected by plant growth at the restoration site, then comparing direct observation results with planting plans data in the Detailed Engineering Design (DED) documents.

(KLHK 2020) The assessment method was conducted by giving direct scores to the site conditions based on the survey results. The score for each indicator reflects the development of the restoration results at the time of the survey with the following criteria:

1. Score 3 represents the expected good condition from the restoration results.
2. Score 2 reflects the development of restoration results.
3. Score 1 indicates that the restoration results do not show any progress.

The assessment stages were conducted directly for field survey results through interviews and indirect assessments in the form of soil quality data obtained from relevant parties. The assessment activities were conducted as follows:

Assessment of the achievement of conditions expected to develop on land arrangement variables

An assessment that describes the condition of land arrangement in the restoration area where there are indications of erosion and former mining pits that are visually visible. The data obtained were compared with the land planning data in the DED document. The assessment of land planning data can be presented in table 1.

Table 1. Land Planning Assessment

Indicator	Variable	Indicator	Condition	Value	Information
Land surface that is stable against erosion	Land Planning	Treat land arrangement in former mining pits to control disaster-prone potential	No signs of vulnerability found	3	Measurements are carried out by making direct observations of former mining pits that are detected to be prone to disasters
			Signs of vulnerability were found in a small part of the area	2	
			Signs of vulnerability were found in most areas	1	
		Treat land arrangement in	No symptoms of erosion found and	3	Measurements are carried out

	former mining pits by vegetative means and / or using technical civil to control erosion	the erosion control civil buildings are in good condition		by making direct observations on areas detected potential for erosion
		Mild erosion symptoms were found and >50% erosion control civil buildings were in good condition	2	
		Severe erosion symptoms were found - very heavy and <50% erosion control civil buildings were in good condition	1	

Assessment of soil quality in planting areas

Assessment of soil quality data can be supported based on laboratory test results and plant development in the recovery area seen visually at the time of observation. The data obtained is compared with the data in the DED document. Assessment of soil quality data can be presented in table 2.

Table 2. Assessment of Crop Quality and Land Quality

Expected conditions	Variable	Indicator	Condition	Value	Information
Productive land to support community economic activities	Improvement of soil quality in planting areas	Presentation of living plants	>80% Live plants	3	Measurements are made by comparing the living ones with the number of plants planted
			50% - 80% Live plants	2	
			< 50% Live plants	1	
		Optimal plant growth	Fertile plant growth	3	Plant growth assessment is carried out based on observations of plant physical characteristics measured based on plant height
			Medium plant growth – Fertile	2	
			Infertile plant growth	1	
		Increase crop maintenance efforts	Hard maintenance	3	1. Light maintenance includes watering, weeding, and fertilizing
			Light maintenance	2	
			No maintenance	1	

			2. Heavy maintenance includes watering, weeding, fertilizing, pest and disease control and manning
Soil quality meets requirements to support plant type growth based on laboratory test results	>80% The chemical parameters analyzed have increased towards improving soil quality and there are at least 2 characteristics of better criteria	3	Measurements are made by comparing the living ones with the number of plants planted Plants observed include plants that function to control erosion and planting areas resulting from expansion carried out by the community
	50 - 80% The chemical parameters analyzed have increased towards improving soil quality	2	
	< 50% The chemical parameters analyzed have increased towards improving soil quality	1	
Improving the quality of heavy metal contaminated soil based on laboratory test results	Soil quality meets quality standards according to its designation	3	Measurements are carried out by taking soil or water samples and laboratory testing is carried out periodically every 1 year
	Soil quality is higher than before recovery	2	
	The quality of the soil is the same compared to before recovery	1	

Improving community participation in the restoration site

Community participation in managing the restoration site was obtained from interviews with selected respondents using questionnaires. Respondent selection techniques were used to gather information quickly and accurately, and the selection was divided as follows:

1. Census technique was conducted with all market community members, where data collection was done with the help of structured questionnaire instruments.
2. Random sampling method was applied to workers, including those working as cleaners and those assisting the traders.
3. Purposive sampling method was used to determine key person respondents, namely the Village-Owned Enterprises (BUM) manager of Mardi Gemi Village and the officials of Gari Village.

Table 3 presents the assessment of expected achievements in the condition variables expected to develop community participation in managing the restoration site.

Table 3. Assessment of Community Participation in Managing Restoration Site

Expected conditions	Variable	Indicator	Condition	Value	Information
Maintained and utilized physical buildings and plants at the location of the settlement by the community	Improvement of soil quality in planting areas	There is a response of the beneficiary community to be involved in maintaining the recovery site	Initiative and self-realization	3	Measurement is carried out by interviewing selected respondents, namely beneficiary communities.
			Outside encouragement without coercion	2	
			Coercion	1	
		The functioning of community institutions mobilizes community participation to maintain recovery sites	Works well	3	Measurement is carried out by interviewing selected respondents, namely beneficiary community institutions
			Less work	2	
			Not working	1	
		There is an increase in people's income	High	3	Measurement is carried out by interviewing selected respondents, namely beneficiary communities.
			Medium	2	
			Low	1	
			Increased	3	

	The average person who visits the location every month	Fluktuative	2	Measurement is carried out by interviewing selected respondents, namely beneficiary communities.
		Decreased	1	
	Expansion of planting area around recovery site	There is a planting area	3	Measurement is carried out by interviewing selected respondents, namely beneficiary communities.
		There is a nursery area	2	
		No expansion of area	1	

Data processing and analysis methods were conducted using scoring, which is the multiplication of the total indicators and weights for each land restoration variable. The determination of weights for each variable considered: the level of importance of the variable role whose value influences the improvement of environmental function, the socio-economic benefits for the community around the restoration site, and the interventions carried out to improve the expected restoration conditions.

The weighting of assessments is grouped based on the following variables:

Land arrangement with a score of 40

The land arrangement variable considers the success in influencing the achievement of environmental function improvement through proper and safe foundation forms for planting areas along with supporting facilities to achieve economic and social benefits for the community. This condition requires interventions to maintain stable conditions and requires resources to improve damaged land conditions.

Improvement of soil quality in planting areas with a score of 35

Consideration of the success of soil quality improvement in planting areas is seen through environmental function improvement by soil fertility in planting areas with stable land conditions so that plant growth can be utilized.

Community participation in managing the restoration site with a score of 25

Community participation plays a crucial role in influencing environmental function improvement through the maintenance of arranged land and plant maintenance. Community interventions are necessary to ensure plant growth, land stability, and soil fertility remain preserved, enabling the community to receive economic and social benefits.

The recapitulation of the research results is made in the assessment format as presented in table 4 and the formula calculation is carried out as follows:

$$TS = \sum_{k=1}^{n} \left(\frac{TNk}{TNmax} \right) X\ Bobot$$

Where:

TS: Total Evaluation Score
TN: Total Evaluation values obtained for each variable
TNmax : Total maximum value of each variable
K : Evaluation variables 1,2,3

Table 4. Recapitulation of Assessment Results

No	Indicator	Score (TN)	Maximum value	Weight
	Variable 1: Land Arrangement			
1	Treat land arrangement in former mining pits to control disaster-prone potential		3	40
2	Treat land arrangement in former mining pits in a vegetative way and / or use technical civil to control erosion		3	
	Total		6	
	Score 2 (TN1/TNmax$_1$) x weight			
	Variable 2: Improvement of land quality in planting areas			
1	Percentage of living plants		3	
2	Optimal plant growth		3	
3	Increase crop maintenance efforts		3	
4	Soil quality meets requirements to support plant type growth based on laboratory test results		3	35
5	Improved quality of heavy metal contaminated water based on laboratory test results		3	
	Total		15	
	Score 2 (TN1/TNmax$_1$) x weight			
	Variable 3: Community participation to manage recovery sites			
1	There is a response of the beneficiary community to be involved in maintaining the recovery site		3	
2	The functioning of community institutions mobilizes community participation to maintain recovery sites		3	25
3	There is an increase in people's income		3	
4	The average person who visits the location every month		3	
5	Expansion of planting area around recovery site		3	
	Score 3 (TN1/TNmax$_1$) x weight		15	
	Total Score (Score 1 + Score 2 + Score 3)			

The total scoring method will provide conclusions about the condition of the recovery land. The composition of the assessment is presented in Table 5.

Table 5. Open Access Land Damage Recovery Scoring Categories

Total Score	Category	Information

77,88 – 100	Good	The condition of the land that has been restored can lead to achieving the expected target
55,55 – 77,77	Medium	The condition of the land that has been restored still requires improvement in indicators that are valued at ≤ 2 and allow for improvement
33,33 – 55,54	Bad	The condition of the land that has been restored cannot reach the expected target and needs to be coached to the community

RESULT AND DISCUSSION

The rehabilitation of former limestone mining land in Gari village adopts the concept of the Argo Wijil Ecological Market. The rehabilitation covers an area of 0.7 hectares and was constructed in 2017. The zoning for rehabilitation includes areas for the traditional market, compost houses, supporting facilities such as toilets, solar cells, management office, and green open spaces (RTH). The implementation concept of rehabilitation in Gari village is based on coordination between the Ministry of Environment and Forestry and the community, where the rehabilitation process includes (Pavloudakis et al., 2023) (KLHK 2017):

1. Adjusting planning and implementation realization considering legal obligations and applicable environmental permits. The rehabilitation plan adjusts according to the opinions of the local community.
2. Calculating safe slopes in the mining pits.
3. Land arrangement showing and constructing drainage to control surface water, sediment erosion before reaching water bodies.
4. Fertile land surfaces can be planted with agricultural crops.
5. Planting endemic plants.

The land surface on the former limestone mining land in Gari Village is relatively flat, and no mining pits are found. Erosion control at the Argo Wijil Ecological Market reveals drainage channels within the market, but during heavy rainfall, the drainage channels' capacity is insufficient, resulting in waterlogging in the middle of the market. Erosion control efforts include (KLHK 2017):

1. Soil protection from rain by increasing soil cover with plant canopy and plant residues on the soil surface.
2. Increasing infiltration to reduce surface runoff and/or creating swales, terraces, or other materials as surface and subsurface water storage.
3. Reducing land slope can decrease the speed of surface runoff.

The assessment of expected condition achievements in the land arrangement variable is presented in Table 6.

Table. 6 Assessment of Condition Achievement in Land Planning Variables

Expected conditions	Variable	Indicator	Condition	Value

Land surface that is stable against erosion	Land Arrangement	Treat land arrangement in former mining pits to control disaster-prone potential	No signs of vulnerability found	3
		Treat land arrangement in former mining pits by vegetative means and / or using technical civil to control erosion	Mild erosion symptoms were found and >50% erosion control civil buildings were in good condition	2

The rehabilitation of former limestone mining land in Gari village as an effort to increase reforestation areas is one of the indicators for expanding green open spaces (RTH). The utilization of green open spaces as a planting medium allows plants to grow naturally or intentionally planted (Pahlewi & Rahman, n.d.). Plant allocation in green open spaces is planned with plant distribution around the market area (Makmur, 2019). The distribution of plants serves to lower the temperature, making the ecological market cool and comfortable. Consequently, the growth of larger trees can enhance the function of green open spaces in that area. Referring to (PermenPU 2008), the Argo Wijil Ecological Market serves ecological, socio-cultural, and economic functions as presented in Table 7.

Table 7. RTH Functions

No	Ecological Function	Socio-Cultural Function	Economic Function
1	Shaded area	Representation of local culture	Productive results that can be sold
2	Oxygen production	Community communication facility	Part of agricultural activities
3	Rainwater absorption	Tourism/recreation site	Encouraging creativity & productivity of residents
4	Habitat for wildlife	Educational, research, and sports facilities	Enhancing aesthetic factors
5	Absorbs air, water, and soil pollutants		
6	Windbreaks		

Source: (PermenPU 2008)

The ecological concept aims to integrate environmental management into traditional markets, so the ecological concept not only involves development but also directs ecological behavior to market traders. The ecological program encourages market traders to use organic materials such as banana leaves for food packaging. Observations in the field show that some vendors of traditional snacks such as "getuk" and "pecel" use organic wrapping materials, but on the other hand, food

and beverage packaging are still made of plastic, mainly because organic materials cannot contain large-sized food or beverages.

Ecological activities include the construction of compost houses within the market area. The type of waste managed for composting is leaf litter. Compost is the residue of organic waste undergoing decomposition due to interactions among microorganisms (Syaputra et al., 2022). Waste is something not favored by society, yet it must be managed properly to avoid issues. Organic waste management can reduce environmental problems such as roadside garbage piles and serve as protection for drainage channels. Composting at the Argo Wijil Ecological Market has been conducted since 2018. This activity was interrupted in 2020 due to the Covid pandemic. During field visits, the compost houses were still neatly arranged, with remaining compost packed and leaf litter decomposing at the composting site. The management plans to resume marketing these compost products.

Criteria for the types of trees planted at the Argo Wijil Ecological Market are as follows: trees can thrive in slightly compacted soil, roots do not protrude from the surface, resistant to strong winds, branches and twigs are not easily broken, trees are not prone to falling, produce small fruits, minimal leaf shedding, capable of absorbing air pollution from motor vehicles, quick recovery from impacts, dense canopy, no allelopathic compounds, aesthetically pleasing foliage, leaf color, and flower, and pollen is non-allergenic (KLHK, 2017).

The types of trees planned for planting in the Detail Engineering Design (DED) document of the Argo Wijil Ecological Market are presented in Table 8.

Table 8. Percentage of Live Plants

Number of Trees		Growing Percentage
Planning	Live	
100 Trees	80 Trees	80%

The percentage of living plants is based on the number of plants that can survive in the revegetation area by comparing the planned number of plants that can grow or vice versa. The plant survival rate in the ecological market area is 80%. This indicates moderate success with an 80% plant survival rate (Permenhut 2009). Changes in the utilization of the ecological market location have led to the planting area being used for other purposes, such as a nursery and a bonsai plant vendor selling to both local and outside communities of Gari village. The growth rate of plants is presented in Figure 1.

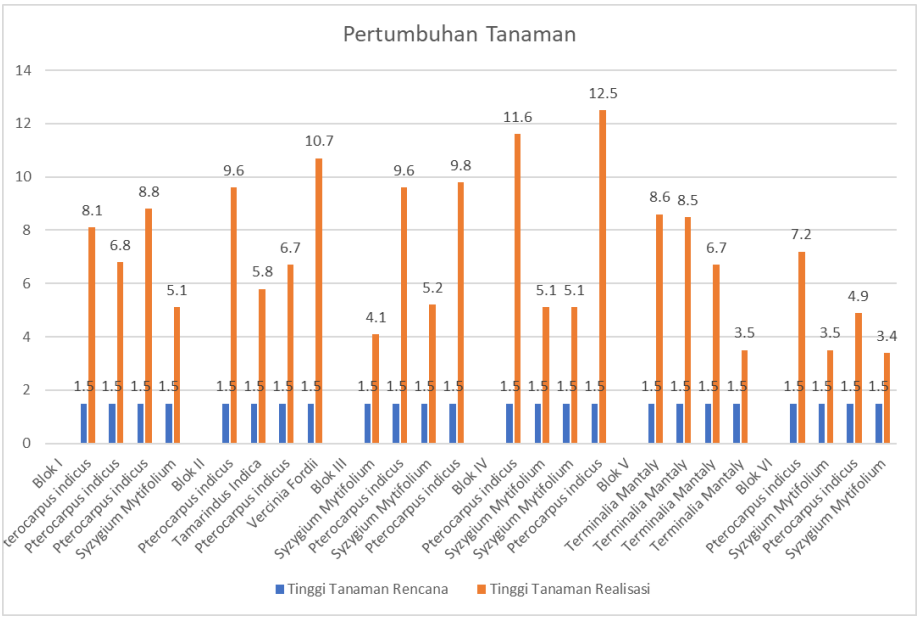

Figure 1. Plant Growth

The planting plan in the DED document for the ecological market includes 100 trees of Mimusops elengi, Filicium decipiens, Bougainvillea Sp, & Barringtonia Asiatica. Changes in the planned planting in the previous DED document were due to the unavailability of seedlings during the recovery process. Hence, the initiative was taken to replant with easily accessible plant species such as Pterocarpus indicus, Terminalia Mantaly, Syzygium Mytifolium, Mangifera Indica, and Vercinia Fordli. The replanting was done in collaboration with the local community. The soil quality of the former limestone mining land was analyzed before planting. The soil fertility in the ecological market is relatively low with a pH value of 5.5 – 7.5, indicating slightly acidic to neutral acidic soil. The organic C content is 0.017%, indicating very low soil chemical properties.

Physically observing the plant condition shows significant changes, mainly in tree height. The study of plants is adjusted based on the plant blocks surrounding the ecological market, starting from the first block at the entrance, then the left and right sides, and behind the market. Seedlings planted ± 1.5 meters apart in 2017 have experienced growth, such as the Pterocarpus indicus tree reaching 11 meters in height over 5 years. Planting is one way to improve the quality of land on former mining sites. Transforming former mining areas into green open spaces is a form of rehabilitation to create a new ecosystem. Vegetation plays a crucial role in protecting the soil surface from erosion (Sheoran, 2010). Vegetative growth can stabilize the soil with plant root spread (Widiyatmoko et al., 2017). Plants will increase soil organic matter through root systems as nutrient carriers. Plants will collect and store nutrients back into the soil as organic matter.

Plant selection considerations are made to adapt plants to the land conditions so that they can quickly adapt to the environment, with native species preferred as

they are more likely to adapt to the surrounding ecosystem. The Terminalia Mantaly species is found in the green open spaces of the Argo Wijil Ecological Market. Terminalia Mantaly is a plant known for absorbing air pollutants. Characteristics of plants that absorb air pollution include sturdy trunks, thin leaves, and abundant foliage (Febrianti & Sulistyantara, 2020). Pterocarpus indicus is suitable for planting in land lacking topsoil. Pterocarpus indicus can grow in specific areas under various soil conditions except clay soil (Rosianty et al., 2019). Visually, the plant condition shows growth improvement, but soil quality testing has not been conducted after the rehabilitation activities, so soil chemical properties and fertility levels cannot be concluded yet.

The assessment of the expected conditions for improving soil quality in the planting area is presented in Table 9.

Table 9. Assessment of Soil Quality Variables

Expected conditions	Variable	Indicator	Condition	Value
Productive land to support community economic activities	Improvement of soil quality in planting areas	Presentation of living plants	>80% Live Plants	3
		Optimal plant growth	Lush plant growth	3
		Increase crop maintenance efforts	Heavy maintenance	3
		Soil quality meets requirements to support plant type growth based on laboratory test results	No soil testing is carried out after recovery	1
		Improved quality of heavy metal contaminated water based on laboratory test results		1

The change of former limestone land used for traditional markets is an alternative for the use of economic improvement, so that there is a community initiative to open business opportunities that get additional income. Planning The Argo Wijil Ecological Market is designed to have 83 stalls, where the division of areas is presented in table 10.

Table 10. Design of Argo Wijil Ecological Market Stalls

Serial Number of Stalls	Description
1 – 10	Traditional Food
11	Recycled Fabrics
12 – 13	Agricultural Tools and Produce
15 – 17	Traditional Food
18 – 21	Agricultural Tools and Clothing

22 – 38	Crafts and Clothing
37 – 40	Kitchen Utensils and Groceries
41 – 44	Beverages
45 – 47	Snack
48 – 59	Clothing
60 – 62	Toys
63 – 82	Heavy Meals
83	Motorized Vendors

Source: (KLHK, 2017)

The role of sellers contributes significantly to attracting buyers to visit and enjoy the Argo Wijil Ecological Market. The initial planning for the market was to open every Sunday morning, but as the market activities developed, some food and beverage stalls remained open every afternoon. An economic situation analysis at the Argo Wijil Ecological Market was conducted by interviewing market vendors to observe the transformation of former mining land utilized in economic activities, as presented in Figure 2.

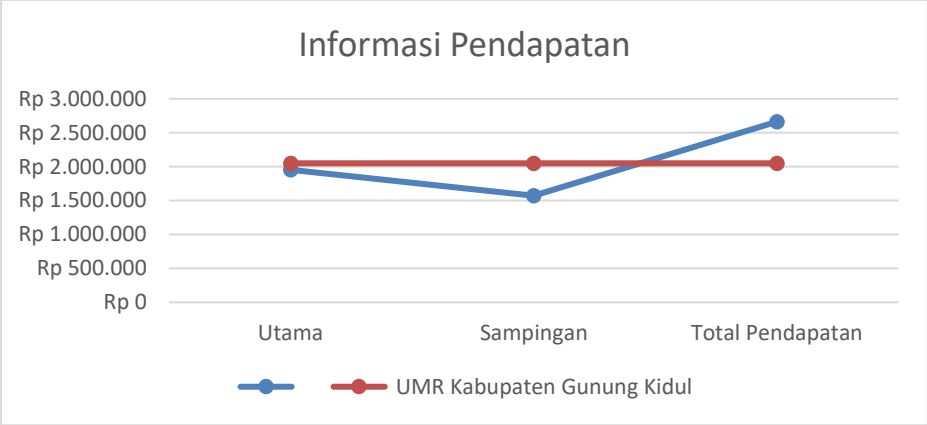

Figure 2. Revenue Information

The graph above shows the total income from community work above the minimum wage in the Gunung Kidul district area. According to data from the Central Bureau of Statistics (BPS) of the Yogyakarta Special Region Province, the minimum wage in the Gunung Kidul district in 2023 was Rp. 2,049,266. The presence of the Argo Wijil Ecological Market is considered by the local community as a side job, which, alongside their main occupation, can help improve the local economy. The average monthly income obtained at the Argo Wijil Ecological Market is Rp. 1,500,000, making it a supportive side job contributing to livelihood sustainability. For instance, traders who primarily work as farmers carry out their farming duties every Monday to Saturday and sell their produce at the Argo Wijil Ecological Market on Sunday mornings. Market activities take place from 06:00 to 10:00 AM. These activities not only involve buying and selling transactions but also include morning exercises, which attract visitors. Traditional market snacks such as

"getuk," "pecel," and "es dawet" become popular choices for the community after morning exercise sessions. Paid Wi-Fi internet facilities priced at Rp. 1000/hour are available to visitors, making the traditional market a source of information.

The sustainability of the Argo Wijil Ecological Market from 2017 until now reflects the consistent activities of the community in the market environment. Especially for traders, the presence of the Argo Wijil Ecological Market has proven to enhance the local economy, allowing ecologically-conceptualized traditional markets to endure for a long time with proper management, similar to typical traditional markets. The presence of the ecological market attracts other traders, as evidenced by the discovery of meatball and children's toy sellers outside the market building. Other efforts made by the ecological market management include organizing events on special occasions such as the ecological market construction anniversary celebrated in April with local art performances, specific competitions, and religious events.

The assessment of the expected conditions for developing community participation in managing the rehabilitation site is presented in Table 11.

Table 11. Assessment of Community Participation in Managing the Rehabilitation Site

Expected conditions	Variable	Indicator	Condition	Value
Maintained and utilized physical buildings and plants at the location of the settlement by the community	Improving Soil Quality in Planting Areas	There is a response of the beneficiary community to be involved in maintaining the recovery site	Initiative and self-realization	3
		The functioning of community institutions mobilizes community participation to maintain recovery sites	Works well	3
		There is an increase in people's income	Medium	2
		The average person who visits the location every month	Fluktuative	2
		Expansion of planting area around recovery site	No expansion of area	1

Subsequently, the assessment of each variable is weighted in each category according to predetermined formulas. The scoring results for each variable are presented in Table 12.

Table 12. Scoring Results Category for Restoration of Former Limestone Mining Land

No	Indicator	Score (TN)	Maximum value	Weight
	Variable 1: Land Arrangement			
1	Treat land arrangement in former mining pits to control disaster-prone potential	3	3	40
2	Treat land arrangement in former mining pits in a vegetative way and / or use technical civil to control erosion	2	3	
	Total	5	6	
	Score 2 (TN1/TNmax$_1$) x weight		33.33	
	Variable 2: Improvement of land quality in planting areas			
1	Percentage of living plants	3	3	35
2	Optimal plant growth	3	3	
3	Increase crop maintenance efforts	3	3	
4	Soil quality meets requirements to support plant type growth based on laboratory test results	1	3	
5	Improved quality of heavy metal contaminated water based on laboratory test results	1	3	
	Total	11	15	
	Score 2 (TN1/TNmax$_1$) x weight		25.67	
	Variable 3: Community participation to manage recovery sites			
1	There is a response of the beneficiary community to be involved in maintaining the recovery site	3	3	25
2	The functioning of community institutions mobilizes community participation to maintain recovery sites	3	3	
3	There is an increase in people's income	2	3	
4	The average person who visits the location every month	2	3	
5	Expansion of planting area around recovery site	1	3	
	Score 3 (TN1/TNmax$_1$) x weight	11	15	
	Total Score (Score 1 + Score 2 + Score 3)		18.33	
	Total Skor		77.33	

The overall total assessment on the restoration of former limestone mining land into the Argowijil Ecological Market is categorized as Medium where the condition of the completed land still requires improvement in certain indicators, such as soil quality testing indicators so that it can be proven that there is an improvement in soil quality or the need for special treatment to accelerate plant growth in the recovery area.

CONCLUSION

The rehabilitation of former limestone mining land in Gari village, transformed into the Argo Wijil Ecological Market, brings a new dimension to the local community, with the enhancement of green open spaces (RTH) serving as an alternative to reducing air pollution. Synchronizing the rehabilitation of former mining land with an ecologically-conceptualized traditional market can support environmentally friendly behavior among the community.

The development of the Argo Wijil Ecological Market still needs further improvement. While the environmental quality appears to have visually improved, its actual quality needs to be confirmed through laboratory tests to ensure scientific certainty and alignment with existing growth.

The potential for improving the community's economy has been realized fairly well. To sustain the Argo Wijil Ecological Market, there is a need to explore potential avenues, such as integrating the ecological market with local tourist attractions, which can create market opportunities to support the sustainability of ecologically-conceptualized traditional markets.

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