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Research Article

Land conversion to cement factory and mining: Effect of environmental change to disaster and farmer livelihoods

Harifuddin Harifuddin[1*], Subhan Haris[2], Haslinda B. Anriani[3], Faidah Azuz[4], Apriningsih[5]

[1] Department of Sociology, Bosowa University, Jl. Urip Sumoharjo Km 4, Makassar 90232, South Sulawesi, Indonesia
[2] Department of Public Administration, Tadulako University, Jl. Soekaro-Hatta Km9, Palu 94118, Central Sulawesi, Indonesia
[3] Department of Sociology, Tadulako University, Palu, Jl. Soekarno-Hatta Km 9, Palu 94118, Central Sulawesi, Indonesia
[4] Department Agribusiness, Bosowa University, Jl. Urip Sumoharjo Km 4, Makassar 90232, South Sulawesi, Indonesia
[5] Faculty of Health Science, Pembangunan Nasional Veteran University, Jakarta 12450, Indonesia

[*]corresponding author: harifuddin.halim@universitasbosowa.ac.id

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Abstract

Land conversion from agricultural to cement factory and mining areas has consequences for environmental change and degradation that cause disasters and sustainability farmer livelihood. This study aimed to analyze land conversion to a cement factory and mining as determinants of environmental change, environmental change as a determinant of environmental degradation, and the effect of environmental change and environmental degradation on the sustainability of farmer livelihoods. This research used a sequential explanatory design or quantitative rather than qualitative. The research sample totaled 183 respondents. Data collection used the quantitative stage using questionnaires and the qualitative stage using in-depth interviews, observation, and literature study. The results showed that land conversion to a cement factory and mining are causes of environmental change, followed by environmental degradation, such as factory smoke pollution, dust from karst mines, factory vehicle dust, and soil pollution due to coal piles. Environmental change is a cause of environmental degradation, such as crop failure, acute respiratory illness, land clearing, and flooding. The effect of environmental change and environmental degradation on the sustainability of farmer livelihoods is that almost all farmers sell their rice fields for the factory area, then buy ponds, do business, open stalls, and open photocopy businesses. No one returned to being a farmer. The conversion of agricultural land to a cement factory and mining caused a decrease in environmental functions, namely the disruption of the ecosystem chain, which caused flooding and acute respiratory disease and caused farmers to switch to non-agricultural livelihoods.

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Introduction

Land conversion is a process of changing a function or use of land to another function. The change of function occurs based on the value that is more productive than before. In many countries, land conversion generally occurs from agricultural land to residential land (Rondhi et al., 2018; Paramasatya and Rudiarto, 2019; Aryadi et al., 2021) or become an industrial estate (Firman, 1997; Rustiadi et al., 2021), or a mining area (Zikra, 2022), etc. Any conversion of agricultural land to cement factory and mining tends to have

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consequences on the converted land (Pham et al., 2015; Salmah, 2022). The conversion gives rise to environmental change, which is understood as a change in the environment that disrupts the environmental balance caused by human and natural factors (McMichael et al., 2008). Environmental change is understood to be the result of both naturally occurring processes and human factors. Environmental systems and human activities influence environmental change by transforming and transporting energy and materials (Vitousek, 1994). Environmental changes at the research site in the form of changes in shape due to human activities from the environment of paddy rice farming to cement factory land, employee housing areas, and mining areas.

The consequence is a decline in the quality and function of the environment, which is called environmental degradation (Chu and Karr, 2017). Environmental degradation is defined as a decline in the quality of the environment in meeting its needs, including ecological, socio-economic, and health needs, so it can be said that environmental degradation is also a significant threat to human health in the world (Wei et al., 2022) or understood as a decrease in the functions of an environment over the main function it should be intended for. For example, agricultural land functions to grow rice plants but has decreased in function so that it can no longer be used for crops because it no longer provides all the substances and minerals needed by plants due to the conversion of the land including the disruption of agricultural ecosystems and land (Verhoeven and Setter, 2010; Dhanaraju et al., 2022). The main causes are natural and human (Wine, 2020; Ortega-Gil et al., 2021). The conversion of agricultural land into mining areas includes land conversion that has a large and widespread impact on the surrounding environment. Environmental change and degradation often lead to disasters that cause community vulnerability (Prasad and Francescutti, 2017), such as hazardous materials, including coal, and chemicals in cement factory fumes (Zibulewsky, 2001). There are cases around the world, such as Indonesia, Brazil, Suriname, and Ghana, where the mining industry contributes to 80 percent of all tropical forest destruction (Giljum et al., 2022). The indirect impacts of the mining industry include mining-related infrastructure, settlements, agriculture through settlements, water and soil contamination, and illegal logging **(**Rieper and Kramer, 2023**).**

The reality of mining in Indonesia shows that where mines are operating, there is bound to be environmental damage and community suffering (Briffa et al., 2020). Coal mining, for example, has many negative effects, as research has found that coal mining can have several negative impacts on the health of the surrounding environment, namely causing water pollution, changing the structure of the land, causing biodiversity scarcity, reducing soil fertility levels and causing various acute respiratory infections (Marselle et al., 2021). The results of another study also found that there was a change in land use from other land uses to unlicensed gold mining land with a high level of land damage (Putri et al., 2023). Both studies reveal the environmental degradation that occurs as a direct result of land conversion and also reveal its impact on the health of communities around the mine, especially on the sustainability of farmer livelihoods. This is important for farmers because they only depend on the land (Gai et al., 2020; Guo et al., 2023) with limited skills as capital (Serrat, 2017; Molosi-France and Dipholo, 2020).

Similarly, the construction of the Tonasa Indonesia cement factory and mining in Pangkep Regency since its establishment in 2013 has caused various problems that affect the lives of the surrounding communities, such as social, cultural, economic, health, and environmental.

Based on Central Bureau of Statistics (BPS) 2021 data, the affected area according to the research study includes three villages in Bungoro Sub-district, namely Sapanang Village with an area of 6.88 km^2, Biringere Village with an area of 3.10 km^2, Mangilu Village 18.14 km^2 and Taraweang Village in Labakang Sub-district with an area of 9.91 km^2, or a total of 38.03 km^2 ha. This degradation process is also in line with the research that examined the ambient air quality of carbon monoxide (CO) and total suspended particles (TSP) in settlements around the PT. Semen Tonasa industrial area, which took measurements in 6 locations, showed that at the Bontoa location point, the highest CO concentration at night was 2334.56 $\mu g/m^{3,}$ and the lowest in the morning was 1277.97 $\mu g/m^3$.

At the Taraweang location point, the highest CO concentration in the morning was 1116.82 $\mu g/m^{3,}$ and the lowest during the day was 987.65 $\mu g/m^3$. At the Taqwa Mosque location point, the highest CO concentration at night was 1089.4 $\mu g/m^{3,}$ and the lowest during the day was 762.48 $\mu g/m^3$. At the Biringere location point, the highest CO concentration in the morning was 1108.32 $\mu g/m^{3,}$ and the lowest during the day was 931.05 $\mu g/m^3$. At the Bontoa location, the highest TSP concentration at night was 163.89 $\mu g/m^{3,}$ and the lowest during the day was 122.6 $\mu g/m^3$. At the Taraweang location point, the highest TSP concentration during the day was 77.52 $\mu g/m^{3,}$ and the lowest in the morning was 60.3 $\mu g/m^3$. At the Taqwa Mosque location point, the highest TSP concentration at night was 147.38 $\mu g/m^{3,}$ and the lowest during the day was 90.95 $\mu g/m^{3,}$ which shows a decrease in air quality, although the air pollution standard index (ISPU) values of both CO and TSP are still within tolerance limits.

The decline in air quality can also be traced through the data of the ten biggest diseases in three health centers around the PT Semen Tonasa industry, which shows that in 2016-2017, in public health center Bungoro, as many as 922 (8.75%) acute respiratory infections (ARI) cases and 1182 (11.22%) cough cases were reported. In Taraweang public health center, as many as 446 (4.74%) cases of ARI and 1413 (15.01%)

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cases of cough, in Public health center Kalabirang as many as 939 (18.77%) cases of ARI and 2672 (21.2%) (Anwar et al., 2019). Based on these impacts, this study further investigated the impact of land conversion on environmental degradation, flood disasters, and the sustainability of farmer livelihoods whose rice fields become cement factory areas and farmers whose soil and crops were damaged by the fumes from the cement factory and the river water for rice fields contaminated by the factory fuel.

Thus, the urgency of this research is that the community around the cement plant is threatened with its life, health, and environment. Therefore, this research aimed to answer the following questions: (1) How do land conversion to a cement factory and mining as determinants of environmental change? (2) How does environmental change as a determinant of environmental degradation? (3) What are the effects of environmental change and environmental degradation on the sustainability of farmer livelihoods?

Materials and Methods

Research design

This study uses a mixed method approach, namely quantitative-qualitative with an explanatory-consequential design (Molina-Azorin and Fetters, 2022; Weyant, 2022). Data were obtained through observation, in-depth interviews, surveys, and documentation (Kakulu, 2014; Paradis et al., 2016). Quantitative data in this study were used to explain environmental degradation and disaster, while qualitative data were used to describe the sustainable livelihood of farmers. This study used triangulation to check and validate data by combining data acquisition results through observation, in-depth interviews, and documentation (Albers, 2017; Lester et al., 2020). Furthermore, the case study was chosen with consideration: (1) case characteristics are complex in the sense that data examination was carried out in-depth, detail, and detail; (2) case studies were used to explain developing situations based on facts found in the field; and (3) case studies were used to explore in-depth information related to the phenomenon of the existence of the cement plant and its impact on the environment and the community (Houghton et al., 2013).

Study area around the cement factory and mining

This research was conducted around the cement factory and mining area from July 2022 to December 2022 in Pangkep Regency, South Sulawesi Province. The research area is around the factory area, namely Biringere Village, Taraweang Village as the impacted area, Mangilu Village as the mining area, and Sapanang Village as the employee housing area. The research location is presented in Figure 1.

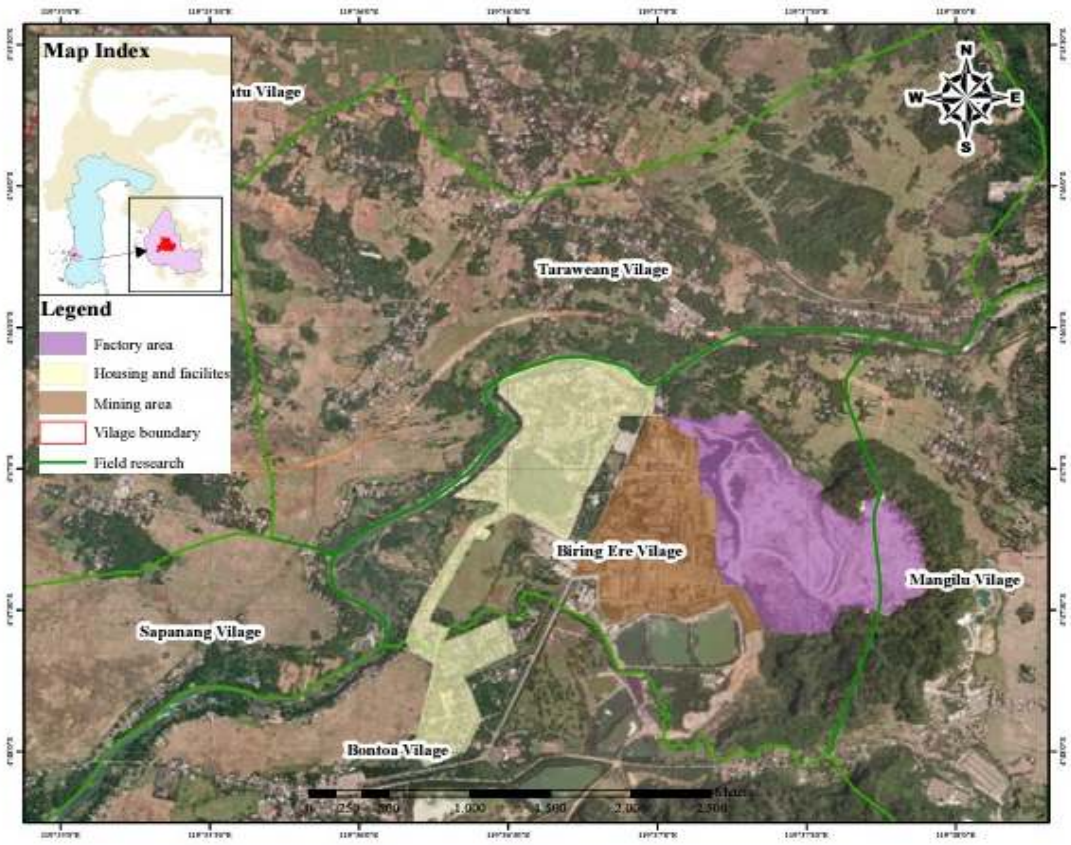

Figure 1. Map of cement factory and mining at Pangkep Regency, South Sulawesi Province, Indonesia, 2022.

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Data collection method

Observation

Observation in this study was used in data collection, namely environmental change, land conversion, air pollution, soil pollution, rice fields around the cement factory, and mining. The instruments used in collecting data through observation were (i) field notes, (ii) periodic notes, and (iii) checklists (Katz-Buonincontro and Anderson, 2020). Furthermore, the results of observations obtained were used to describe the situation or events that were taking place in relation to research variables such as environment change and environment degradation, (ii) sustainable livelihood farmers.

In-depth interview

In-depth interviews were used to collect data on sustainable livelihood farmers. Furthermore, the tools used in the in-depth interviews were tape recorders, pictures, and interview guidelines with loose notes, checklists, and rating scales. Thus, the functions of in-depth interviews in this study were (i) description, in this case, to describe the situation and conditions of the community, (ii) exploration, in this case exploring the field for the purpose of obtaining information related to environment degradation and disaster, (ii) sustainable livelihood farmers. Both of these were used to emphasize the situation and conditions of the field based on the results of the observations that have been carried out (Rutledge and Hogg, 2020).

Documentation

This study used several documents, including archives from Biringere, Taraweang, Mangilu, and Sapanang Villages.

Questionnaire

A questionnaire instrument was used for data collection, including (i) environmental degradation due to land conversion, including factory smoke pollution, demolition dust, factory vehicle dust, and soil pollution due to coal fuel piles, (ii) disasters that occur due to land conversion, including crop failure due to thin rice due to smoke and dust, the onset of ARI disease, and flooding, and (iii) consequences on the sustainability of farmer livelihoods, including the opportunity for farmers to work in the agricultural sector again.

Furthermore, the questionnaire in this study was used for two purposes, namely (i) descriptive, in this case describing the situation and condition of the object of research based on the facts found in the field, and (ii) an ordinal scale was used in measurement based on the grouping of data obtained in the field. The value scale set is distinguished by five categories, namely (i) value 5 for the category strongly agree, (ii) value 4 for the category agree, (iii) value 3 for the moderate category, (iv) value 2 for the category disagree, and (v) value 1 for the category strongly disagree (Jebb et al., 2021). Questionnaires were distributed to the community around the area of cement mining. The completion of the questionnaire was guided by the researchers and the enumerators. Enumerators were selected with the following considerations: (i) having the ability to collect data, and (ii) understanding the characteristics, social reality, and behavior of the community. Furthermore, the research sample was determined using the stratified sampling technique (Shi, 2015; Parsons, 2017). Table 1 shows that four villages around the Tonasa cement area are experiencing land conversion and are affected by the operation of cement factories and mining. The total farmers population of 4 villages is 556 farmers. There is a different quota sampling for each population taken as a sample (Putri et al., 2022), so the research respondents are 183 people. Furthermore, the general characteristics of respondents based on age, farming experience, agricultural land, and land area are presented in (Table 2).

Data analysis method

Quantitative analysis in this study used the descriptive Statistics analysis method. Descriptive statistical analysis is used to describe the indicators of each variable used. Qualitative analysis in this study refers to the results of data obtained through observation, in-depth interviews, and documentation. Data analysis was conducted through three categories, namely data reduction, data display, and conclusion.

Table 1. Population and research sample.

No	Name of Village	Tonasa Cement Area	Population of Farmers	Quota Sample
1	Biringere Village	Cement factory area	25	25
2	Mangilu Village	Mining area	78	68
3	Sapanang Village	Employee housing area	303	50
4	Taraweang Village	Impacted area	150	40
	Total		556	183

The three processes were carried out by separating information into categories based on informant views and facts found in the field. Furthermore, the stages of qualitative analysis include: (i) domain analysis, in this case, based on the social situation that takes place, including place, actor, and activity; (ii) taxonomy analysis, in this case, the domain that is determined is then described in detail. This means that environment degradation due to land conversion variables, disaster due to land conversion variables, and sustainability

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livelihood of farmers variables are described in detail, (iii) componential analysis is carried out by contrasting situations and field conditions that show differences in conditions between communities far from the factory with communities near the factory, and (iv) cultural theme analysis is carried out by integrating across domains found in the field. The aim is to explain the variables in this study concerning other variables.

Table 2. Characteristics of research respondents.

No	Demography	Farmers	%
1	Age of farmers		
	a. 36-40 years	24	13.11
	b. 41-45 years	23	12.56
	c. 46-50 years	23	12.56
	d. 51-55 years	48	26.22
	e. >55 years	65	35.51
2	Farming Experience		
	a. 1-2.5 years	16	8.74
	b. 2.6-5 years	20	10.92
	c. 5-7.5 years	66	36.06
	d. 7.5-10 years	7	3.82
	e. >10 years	74	40.43
3.	Agricultural land		
	a. Owned	59	32.24
	b. Owned by others	124	67.75
4	Land area		
	a. <100 acre	88	48.08
	b. 100-200 acre	43	23.49
	c. 200-300 acre	13	7.10
	d. 300-400 acre	24	13.11
	e. >400 acre	15	8.19

Results

This section presents research results related to environmental change due to land conversion, environmental degradation due to environmental change, and the sustainability of farmer livelihoods as follows.

Environmental change due to land conversion

The environmental changes resulting from agricultural land conversion to a cement factory and mining areas are shown in Figure 2. The consequences that arose from the land conversion could be considered a disaster for the community around the cement factory because it disrupts people's lives, including: (1) Crop failure; 15.3% of respondents answered strongly agree, 9% agree, 25.13% moderate, 23.49% disagree, and 16.9% strongly disagree. Thus, about 24.3% or a quarter stated that there was crop failure in their rice fields, almost the same amount as the moderate answer, and 35.55% disagreed. They claimed that they did not experience crop failure due to the factory. They are all far from the reach of the factory, although it still has an effect on their farmland. (2) Acute Breathing Channel Infection disease. This disease causes respiratory problems in some people, 18.6% strongly agreed, 17% agreed, 15.84% moderated, 23.49% disagreed, and 25.1% strongly disagreed. When these answers were converted to the Three Scale, 35.6% of respondents agreed, 15.84 answered moderate, and 48.50% disagreed that people experience respiratory problems. This means factory dust or smoke had no significant effect on their breathing.

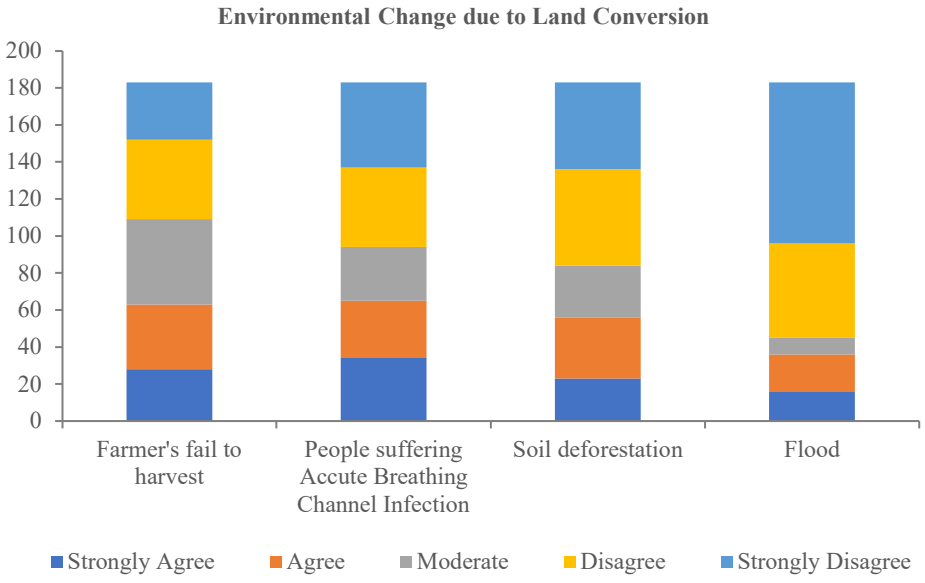

Figure 2. Environmental degradation due to environmental change, based on the questionnaire, 2022.

(3) Deforestation was a major activity of cement companies despite their reforestation efforts. In this regard, 12.6% of respondents strongly agreed, 18% agreed, 15.3% moderated, 28.41% disagreed, and 25.7% strongly disagreed. Using the Three Scale, the answers were 30.6% agree, and they know activities carried out by the company, 15.3% moderate, and 53.48% disagree. Many respondents who disagreed are

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live far from the factory and did not know anything about deforestation. (4) The community commonly experienced flooding in the employee housing area. There were 8.74% of respondents who strongly agreed, 18% agreed, 4.91% moderated, 27.86% disagreed, and 47.5% strongly disagreed. This means that 26.74% agreed that flooding is common, and this was closest to the location or area of the factory. There were 74.94% of respondents who disagreed that flooding is common. They live far from the factory and river area. Flooding is the overflow of river water that has silted up due to the soil and sand that fills the river, which comes from the destruction of karst mountains or limestone mountains.

Environmental degradation due to environmental change

The quality of the environment has decreased after the environmental change, so it no longer functions as it should. In this study, environmental degradation due to environmental change is presented in Figure 3, including: (1) Cement factory smoke pollution. The factory machinery worked continuously to process materials into cement.

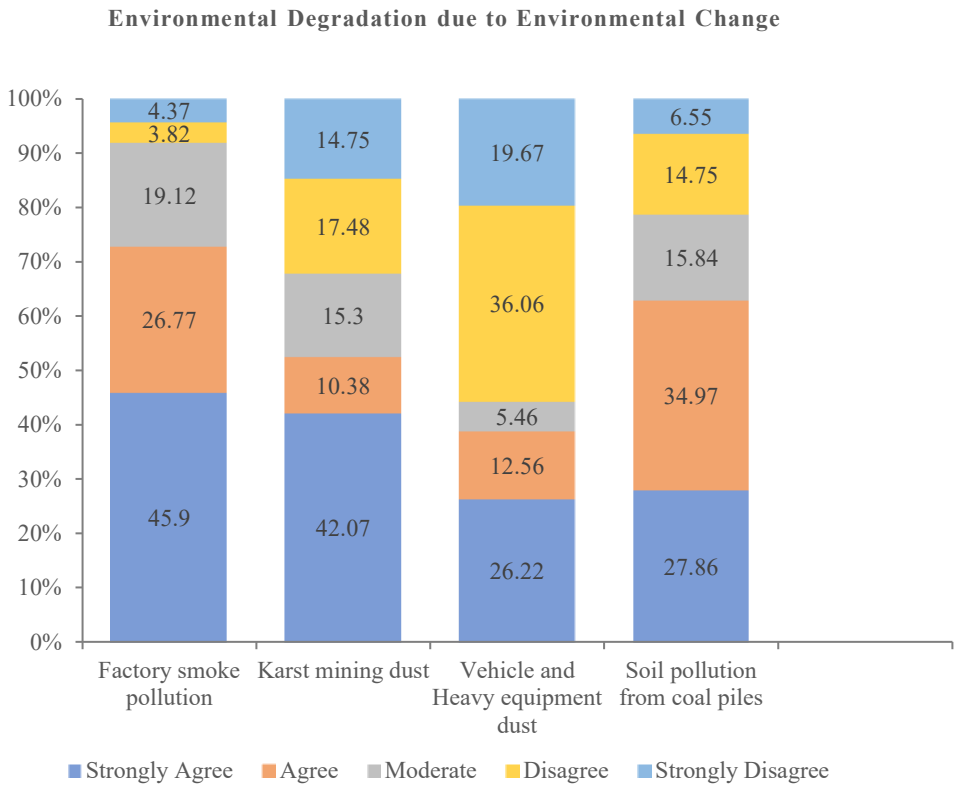

Figure 3. Environmental degradation due to environmental change based on the questionnaire, 2022.

During the processing, the machines worked continuously and did not stop for 24 hours, especially the cement kiln. So, as long as the engine was running, it would cause smoke. It was this smoke pollution that caused problems for the community. There were 183 respondents who filled out the questionnaire: 45.9% strongly agreed, 26.8% agreed, 19.1% moderately agreed, 3.82% disagreed, and 4.4% strongly disagreed. Therefore, 72.7% who answered strongly agree and agree are those who feel the smoke pollution the most, and they also live near the factory, 8.22% do not feel the smoke too much because they live some distance from the factory, and 19.1% sometimes feel it sometimes not depending on the wind blowing towards them. (2) Dust generated by the demolition of karst mountains and limestone as raw material for cement manufacturing. Karst areas are suitable areas to establish cement plants due to the availability of materials. Extracting these raw materials in the form of mountain lime requires deep excavation in the ground or mountains, which requires heavy equipment such as excavators. The activities of all these heavy equipment have the consequence of creating dust pollution nuisance. There were 42.07% who strongly agree, 10.4% who agree, 15.3% who moderate, 17.5% who disagree, and 15% who strongly disagree. Therefore, more than half of the respondents, or 52.47%, suffer from demolition dust pollution and generally live not far from the area. There are 32.8% who are not affected by the dust at all because they live some distance away from the karst soil demolition site. About 15.3% of respondents are sometimes exposed to dust, but more are not exposed depending on the wind direction. (3) Dust from cement-transporting factory vehicles travels through residential neighborhoods during the day. The trucks are very large and have up to 10

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wheels, a large number of them with high intensity and frequency. In addition, the roads on which the trucks pass are good, and some have been dismantled because they are old. The trucks that pass by every day cause damage to the roads. There were about 26.22% strongly agree, 12.6% agree, 5.46% moderate, 36.1% disagree, and 20% strongly disagree. Based on this, 38.82% of respondents are exposed to the dust of passing factory vehicles. Those who were not exposed were more numerous at 56.1%, while those who were moderately exposed were few at only 5.46%. (4) Land pollution due to piles of coal fuelled to power factory machinery. These piles of coal are collected in an open field and transported to the kiln before being used. In this regard, 27.86% strongly agree, 35% agree, 15.8% moderate, 14.8% disagree, and 6.6% strongly disagree.

Table 2. Land conversion and its impact.

No	Name of Village	Land Conversion from	Land Conversion to	Impact
1	Biringere Village	Rice fields and forest	Cement plant area	Dirty buildings and dead plants, and respiratory problems from factory dust and fumes
2	Mangilu Village	Citrus orchards	Mining area	Damaged crops and shallow rivers due to mining dust
3	Sapanang Village	Citrus orchards	Employee housing area	Flooding due to multiple blockages of water flow to large sewers and respiratory distress due to mill dust and fumes
4	Taraweang Village	Rice fields	Impacted area	Rice crops were emaciated and dead due to mill dust and fumes

Source: Tonasa Cement factory documentation (2022).

The effect of environmental change and environmental degradation on the sustainability of farmer livelihoods

The presence of the cement factory and area mining indirectly resulted in changes to the farmer livelihoods. These changes occurred because (i) their agricultural land (paddy fields and gardens) was sold to the Tonasa cement corporation, (ii) paddy fields were no longer as productive as before because the smoke and dust from the factory damaged their crops. In this context, there is little possibility for farmers to stay with their work as farmers in the location. The condition is that there is no more agricultural land in Biringere Village because all the land has been converted into a cement factory area. In Mangilu Village, there is no more land for plantations because it has been converted into mining land. In Taraweang and Sapanang Villages, agricultural land is quite extensive, and no land has been converted to an employee housing area. A small portion of the land is only less productive due to exposure to smoke and dust from vehicles and factories.

Farmers who lost their livelihoods because they sold their land mostly switched jobs to become farmers in areas far from the factory, such as Barru District and Maros District, or remained in the Pangkep area. They chose these jobs because the basic skills required are similar to farming. Some farmers choose to work as stone breakers and sand diggers. They utilize the sand and stones in the Biringere River as a new livelihood. The sand and stones are the result of mountain blasting to make cement. A small number of farmers see other livelihood opportunities and open businesses such as food stalls in the factory area, car rental businesses for employees, photocopy businesses, selling around community housing, and so on. Some farmers work as cement transport laborers for large traders in Biringere. Thus, it is unlikely that these farmers will return to farming due to the abovementioned issues, such as factory problems, environmental problems, disaster problems, etc. They can also choose many alternative jobs outside of farming and not bother to do so, such as selling, opening a stall, and so on.

Discussion

Environmental change due to land conversion

Land conversion is an action to better use land by changing its useful value. The decision to determine whether the land is converted is the authority of power tends to be capitalist and does not consider the interests of society and the environment (Jaya et al., 2021). The decision creates a policy that determines the duties of relevant government agencies to environmental risks that arise (Ustaoglu and Williams, 2022). However, such actions have many consequences for the lives of living things that are interrelated as an environmental ecosystem. In the case of land conversion, as in this study, there is a change in the environment from an agricultural to a residential environment. This has an impact on the decline in environmental quality. The damage it causes is very complex and long-term,

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especially if the land is productive agricultural land as the conversion of agricultural land in China (Yansui et al., 2004) in North Kalimantan (Harini et al., 2018) on environmental quality.

Environmental degradation due to environmental change

Environmental change will lead to environmental degradation, and damage will eventually cause problems but with long-term consequences. Because of the length of time it takes to recognize the consequences, the impacts are already catastrophic (Halim et al., 2019). The massive onset of acute respiratory illness in the study area occurred after years of breathing air containing factory smoke. Similarly, the flooding that occurred several years later occurred due to the silting and filling of the river. Other problems are also categorized as disasters, such as crop failure and loss of livelihood because they potentially threaten their lives. Incidents of land conversion that resulted in disasters for the community also occurred in several places, such as in Iran (Azadi et al., 2022), in Semarang (Saputra et al., 2021), or in the coastal villages of Central Java (Rudiarto et al., 2018).

The effect of environmental change and environmental degradation on the sustainability of farmer livelihoods

After the conversion of agricultural land into cement factory areas and mining land, farmers no longer work as farmers. They do other jobs with higher income and less work than farming (Noack and Larsen, 2019). Some have switched to working in the ponds raising fish; some sell and trade, open stalls, and other businesses. This means that their work does not require a lot of financial and labor capital, but the income is high, as is the case with most desirable jobs (Manstead, 2018). Some work as casual laborers for subsidiaries of mining companies. They utilize family networks to get in (Rubin and Bertolini, 2016). Even though the salary is insufficient, they still accept the job (Ahn et al., 2020) because it is the only type they can do and does not require specialized skills. To be involved in factory activities, you must have at least a bachelor degree. In the security section of the company, at least a high school diploma is required. Low education means that farmers cannot find work in the factory.

Conclusion

Land conversion has led to a decline in environmental quality. This condition is exacerbated by factory activities with smoke and dust pollution, land clearing, and land destruction due to mining. All of these activities eventually lead to disasters for communities around the factory, such as disease, crop failure, and flooding. The land conversion also causes farmers to lose their livelihoods and look for alternative non-agricultural jobs because they do not require skills.

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