Economic features of the artisanal and small-scale gold mining industry in Bombana, Southeast Sulawesi, Indonesia

Basri1,2, Masayuki Sakakibara1, 3, Ratnawati4
1Graduate School of Science Engineering, Ehime University, 2-5 Bunkyo-cho, Matsuyama, Ehime Prefecture 790-8577, Japan
2 Makassar School of Health Science (Sekolah Tinggi Ilmu Kesehatan Makassar), Jl. Maccini Raya No. 197, Makassar 90231, Indonesia
3 Faculty of Collaborative Regional Innovation, Ehime University
4 Health Department of Bombana Regency, Southeast Sulawesi, Indonesia
Corresponding Author: basrikesmas@gmail.com

Abstract. There is a consensus that the artisanal small-scale gold mining (ASGM) sector contributes to trapping individuals in a cycle of poverty and financial insecurity with a low standard of living. The purpose of this study was to analyze the economic circumstances of miners in the Bombana ASGM area in Indonesia using a mixed methodology approach that involved collecting, analyzing, and mixing both quantitative and qualitative data in a single study. Results show that the average and maximum monthly incomes of 201 miner households were Rp. 4,360,000 and Rp. 9,750,000, respectively. The average income in the ASGM area in Bombana was higher than that at similar sites on Java Island (~Rp. 2,900,000) and was much higher than the average monthly income of the inhabitants of Bombana (~Rp. 2,100,000). Because of the higher revenue generated in the ASGM sector, miners and their families depend long-term on the mining work, which makes it difficult to control the mining activity and the associated environmental degradation.

Keyword: economic features, artisanal and small-scale gold mining

1. Introduction
In developing countries, the informal artisanal small-scale gold mining (ASGM) sector has rapidly expanded over the past two decades, and more than 15 million people are dependent on the gold mining sector [1,2]. Gold production from ASGM accounts for between 20% and 30% of the total world output [1].

There is a consensus that, when engaged in ASGM, individuals remain trapped in a cycle of poverty [3,4], hampered by heavy metal exposure [5] financial insecurity and a low standard of living [6]. The ASGM sector’s role in the economies of developing countries may have grown in response to the poverty caused by unemployment [3,7]. In some developing countries, this sector is designated as poverty alleviation and has been successful as a major driver of the economy where other industries have failed [8]. Social and economic benefits are obtained by simultaneously achieving maximum formalization of the artisanal and small-scale mining industry [7], promoting women’s empowerment and gender equity [9], encouraging safer livelihoods, and improving the minimal infrastructure that exists [8].

In a regional context, the ASGM sector in Bombana, Indonesia, plays a pivotal role in the economy and society. Estimates suggest that the area contains sufficient resources for about 30 years of mining and that it can bring prosperity to the whole province [10]. This activity attracts people not only from the southeast province of Sulawesi, but from other parts of Indonesia who seek to try their luck as gold
miners [11]. An estimated 800 miners and at least 6 mining companies were active at the end of 2015. Since decentralization of laws and regulations, the number of people working in this sector has doubled [12].

The higher revenue generated in Bombana means that miners and their families depend on the mining work for the long term, thereby making it difficult to control the gold exploration activity. This can produce negative environmental, and socio-economic effect. In the recent past, there have been ongoing problems of over-exploitation, poor working conditions, child labor, a lack of social security, and relationships with organized crime, and illegal mercury amalgamation process in Bombana. Previous studies have provided an overview of the negative economic, environmental, and social impacts of the mining activities, but have not compared the financial implications between the mining and non-mining communities. Equally, few studies have reviewed the economic structures that affect the income levels of the communities around mining sites. The aim of the present case study of the Bombana ASGM sites is to establish the economic features of the mining and non-mining communities. The specific objectives are to (1) identify the income levels in mining and non-mining communities, (2) determine disparities in environmental sanitation facilities, and (3) examine the various social and economic structures related to the ASGM sector [13].

2. Material and method

2.1. Description of the study area
Bombana Regency is situated on the southeast peninsula of Sulawesi, south of the equator (Figure 1). The total population of 159,718 consists of 80,616 men and 79,102 women [14]. The Moronene and Bugis native tribes dominate, and most of other residents are from Java and Bali, having migrated from other islands through a transmigration program [11]. Likewise, in the mine areas, where various ethnic groups work together, and there is a diverse community; the ethnic Bugis and Makassar still dominate, followed by the Moronene and Tolaki indigenous tribes from Southeast Sulawesi.

![Figure 1](image_url) Location of study site on Bombana Regency

This area has witnessed a rapid expansion of gold mining activities in the past eight years. We sampled two sites in this area to determine their typical household economic situations. The first site, known as the Tahi ite ASGM site, is a reference site inhabited by around 210 families, among which
are 800 active miners. The site is exploited by six mining companies. Land immediately bordering and surrounding this area comprises a forest, savannah grassland, and pastoral land. There are also geothermal hotspots nearby. The second, known as the Wumpubangka ASGM site, is inhabited by 100 households with 400 workers. This site is fully managed by three mining companies and is bordered by a residential area.

2.2. Data collection and analysis
A total of 25 households from the two sites were sampled by purposive sampling. To be included in the sample, household members had to have worked at the mine site for at least two years, and the head of the family had to be able to communicate well. A mixed methodology approach was employed, involving the collection, analysis, and mixing of both quantitative and qualitative data in a single study. Information about the economic characteristics of the miners was obtained during in-depth interviews with heads of households based on structured questionnaires.

3. Result and discussion

3.1. Demographic characteristics of the respondents
The 31–43-year-old group was the largest in the mining community, while the 44-56-year-old group was the largest in the non-mining community (Table 1). These age groups are included as the economically active [15]. There was no significant difference between the ages of the two groups (p-value < 0.05). The proportions of male and female survey respondents differed in both the mining and non-mining communities, but there was statistically no significant difference in gender within the communities (p > 0.05).

Table 1. Demographic characteristics of respondents interviewed in this survey.

| Variable               | Community status                                      |       | Total         |       |            |
|------------------------|-------------------------------------------------------|-------|-------------|-------|------------|
|                        | Mining community (n=25)                               | Non-mining community (n=18) |       |             |            |
| Age category (years)   |                                                       |       |             |       |            |
| <18                    | -                                                     | -     | -           |       | 0.26*      |
| 18 - 30                | 4 (16)                                                | 5 (27.8) | 9 (20.9)  |       |            |
| 31 - 43                | 14 (56)                                               | 5 (27.8) | 19 (44.2) |       |            |
| 44 - 56                | 7 (28)                                                | 7 (38.9) | 14 (32.6) |       |            |
| > 56                   | -                                                     | 1 (5.6)  | 1 (2.3)   |       |            |
| Gender                 |                                                       |       |             |       |            |
| Male                   | 17 (68)                                               | 16 (88.9) | 33 (76.7) | 0.1*  |
| Female                 | 8 (32)                                                | 2 (11.1)  | 10 (23.3) |       |            |
| Education              |                                                       |       |             |       |            |
| Elementary School      | 10 (40)                                               | 7 (38.9)  | 17 (39.5) | 0.615*|
| Junior High School     | 8 (32)                                                | 3 (16.7)  | 11 (25.6) |       |            |
| Senior High School     | 5 (20)                                                | 6 (33.3)  | 11 (25.6) |       |            |
| University             | 2 (8)                                                 | 2 (11.1)  | 4 (9.3)   |       |            |

Source: Field survey (2016)
Figures in parentheses are percentages and those out of parentheses are frequency.
* = non-significant at p>0.05

The fact that there were quite a few female respondents in the mining area indicates that vulnerable groups are exposed to a high level of risk. The highest level of education achieved by the miners was generally either elementary or junior high school level. Some respondents had been attending school but then dropped out so that they could help their parents extract and transport the raw material from underground.
3.2. Economic status and domestic sanitation facilities

In developing countries, the availability of sanitation facilities is an indicator of a family’s economic status [16]. A high economic level in the home generally means that there will be sanitation facilities. However, this studies have shown that even though the housing conditions of the two groups of the present study are very different, there was no significant difference in the availability of a water source or defecation facilities between the two sample groups. This result indicates that the economic level of the Bombana mining community did not fall below that of the non-mining communities.

Table 2. Disparities of environmental sanitation facilities.

| Variable                  | Community status | Mining community (n=25) | Non-mining community (n=18) | Total (n = 43) | $\chi^2$ - value |
|---------------------------|------------------|-------------------------|-----------------------------|----------------|------------------|
| **Type of water source**  |                  |                         |                             |                |                  |
| Tap water                 |                  | 1 (4)                  | 4 (2.22)                    | 5 (11.6)       | 0.154*           |
| Wells/boreholes           |                  | 11 (44)                | 5 (27.8)                    | 16 (37.2)      |                  |
| Water spring/river        |                  | 13 (52)                | 9 (50)                      | 22 (51.2)      |                  |
| **Defecation facilities** |                  |                         |                             |                |                  |
| Own facilities            |                  | 14 (56)                | 14 (77.8)                   | 28 (65.1)      | 0.313*           |
| Public facilities         |                  | 4 (16)                 | 1 (5.6)                     | 5 (11.6)       |                  |
| Others                    |                  | 7 (28)                 | 3 (16.7)                    | 10 (23.3)      |                  |
| **House materials**       |                  |                         |                             |                |                  |
| Concrete                  |                  | 0 (0)                  | 8 (44.4)                    | 8 (18.6)       | 0.000**          |
| Wood/board/plywood        |                  | 15 (60)                | 10 (55.6)                   | 25 (58.1)      |                  |
| Bamboo                    |                  | 10 (40)                | 0 (0)                       |                |                  |

Source: Field survey (2016)

Figures in parentheses are percentages and those out of parentheses are frequency.

* = non-significant at p>0.05

** = significant at p<0.05

Nearly 100% of the shelter facilities in the mine area are temporary, and so are made of wood and bamboo. Moreover, workers move to other locations on a three-monthly cycle to pursue freshly excavated land for raw material. Migrants from neighboring areas do not have permanent settlements and tend to occupy low-quality houses. There was a significant difference between the housing facilities in the two locations (p < 0.05) (see Table 2). During field observations, we noticed that spring and river water were the main sources of water for the people in the two communities. The main water network does not extend to all homes yet, and so access to tap water is limited. This resembles the situation in the Ghana’s upper east region, where as many as 70% of miners use surface water as their primary source of drinking water, and 30% use sachet water (i.e., water sold in small plastic bags) as their main drinking water source [3]. About 56% of households interviewed in the early mining community use the excavated area for recreation or as a defecation facility compared with 16% of public facility and 28% of other facilities. This proportion is lower than the percentage reported for the ASGM community in the Equador, where it is 100% [4]. Families that do not have toilet facilities use the forest, river, or beach for defecation. Human excreta contains scores of germs, some of which may cause ascariasis, hookworm infection, and trachoma [17–19]. Environmental sanitation involves raising community health by providing a clean environment and breaking the cycle of disease [19]. The criteria for this include a clean and safe water supply, clean air, efficient and safe waste disposal procedures, protection of food from chemical and biological contaminants, and suitable housing in safe and clean surroundings. On a global scale, it is estimated that 748 million women, men, and children lack access to a safe source of drinking water, and 1 billion people do not have access to safe water that is reliably and continuously delivered in sufficient quantities [20]. Lack of
sanitation facilities and sources of safe drinking water in small-scale gold mining communities may contribute to the spread of infectious diseases. Also, once infected with diseases such as cholera, typhoid, and hepatitis A, the viruses can easily be transmitted to others in these communities.

3.3. Monthly income of respondents
Gold mining has a positive impact on the economic welfare of society in Bombana. As a result, there has been extensive economic development in recent years, attributable mainly to the amount of money generated by the ASGM sector [21]. With the government’s permission, the gold mine’s management company has helped boost the economy in the area around the mining site. This approach, with the creation of new jobs, increased income, and the ability to meet daily needs, encourages new economic potential [22].

![Figure 2](image_url)

**Figure 2.** Comparison of regional minimum wage and per capita monthly income of Bombana with average monthly income of mining and non-mining community.

Table 3 shows significant differences among the monthly incomes of the general population of mine workers in Bombana (p < 0.05). The maximum income of the miners can be as much as Rp. 9,750,000 and the average income is Rp. 4,360,000, which is much greater than the maximum income of non-miners is Rp. 4,000,000. The miners’ average income is much higher than the minimum wage of the Bombana people, which is around Rp. 2,100,000 per month, and is also higher than the per capita income of the population of Southeast Sulawesi, which is around Rp. 3,700,000 per month (Figure 2). Meanwhile, non-miners who work as civil servants, fishers, farmers, and traders have income levels below both the minimum monthly income and the per capita income. The regional minimum wage and the per capita monthly income of the inhabitants of Bombana are Rp. 2,100,000, (equal to US $158.6) and Rp. 3,700,000 (equal to US $282.12), respectively. As comparison, the basic salary of mining worker determined by the Association of Artisanal Miners in Ecuador, is only US $79.20, which is equivalent to Rp. 1,029,000 per month. The ratio of the income levels between artisanal miners in Bombana and Equador is 4:1.
Table 3. Monthly income of respondent based on average, regional minimum wage, and per capita monthly income

| Variable                  | Community status |          |          |          | \(\chi^2\) - value |
|---------------------------|------------------|----------|----------|----------|-------------------|
|                           | Mining community | Non-mining community | Total (n = 43) |          |                   |
| Monthly average income (IDR) | (n=25)           | (n=18)   |          |          |                   |
|                           | 4,360,000         | 1,470,000 | 3,150,000| 0.041*   |                   |
| Regional minimum wage      | Above standard    | 11 (44)  | 16 (88.9)| 27 (62.8)| 0.004**           |
|                           | Below standard    | 14 (56)  | 2 (11.1)| 16 (37.2)|                   |
| Monthly income per capita  | Above standard    | 16 (64)  | 16 (88.9)| 32 (74.4)|                   |
|                           | Below standard    | 9 (36)   | 2 (11.1)| 11 (25.6)|                   |

Source: Field survey (2016)

Figures in parentheses are percentages and those out of parentheses are frequency.

* = non-significant at p>0.05
** = significant at p<0.05

An increase in the gold price of nearly 400% between 2000 and 2012 has led to an increase in the incomes of all the families associated with gold mining [23], such as company owners, traditional landowners, traders, business people, military, and police officers. The economic boom has impacted on both local people and outsiders. Meanwhile, the monthly income of farmers has been decreasing because of decreased production from paddy fields and horticulture. About 26,000 ha of land in Bombana area previously used for aquaculture was taken over by mining at the end of 2013. Consequently, at least 40% of the productive land (paddy fields, orchards, and fields) has been converted to mining land [21]. The situation is exacerbated by damage to agricultural infrastructure, such as rivers and irrigation channels, so that there is less clean water, and the rice is not harvested [22].

3.4. Work structure and economic benefits
Since the implementation of the decentralization of policy in 2003 and the exploration of the gold mine site in 2008 in Bombana regency [12], the interest dynamics between the main groups in the region have changed. The central and local government, traditional landowners, trommel owners, informal miners, and companies fought each other for control of the mine site [10]. Some of these stakeholders contest each other while others collaborate. The common goal of the traditional landowners, trommel owners, and informal miners is to create work structures and to establish rules for the management of the mines. So far, the key players involved in this structure have gained direct and indirect economic benefits.

In this scheme, miners extract the gold from alluvial soil [22] by excavation, crushing, milling, amalgamation, and smelting (Figure. 3). Excavation and crushing are done manually, whereas during the milling step the material is processed using ball mills (trommels). After amalgamation and smelting, the gold ore must be sold to the trommel’s owner to compensate for using the trommel. The trommel owners buy gold ore for Rp. 350,000 per gram and sell it to merchants for Rp. 400,000 per gram. In additional, the trade rates fluctuate and do not apply all the time, and is only valid in the area Bombana. In some cases, workers do not have the capital to start the process of extracting and transporting material, and so they borrow money and equipment from the land owner. When the gold ore extraction achieves maximum results, debt and equipment rent can be repaid with a surplus remaining. On the other hand, if the enterprise does not reach the breakeven point and is even negative, then the debt will accumulate for a longer period.
Figure 3. Scheme of work structure in mining communities.

There is a social change in the work structure, as the day workers gain experience and become new trommel and land owners. Several miners are saving capital and have started to buy the necessary equipment and infrastructure, which is mainly machinery and sets of trommels. Meanwhile, other miners have tried to buy new land from residents at competitive prices. Field coordinators have taken the opportunity to recruit new migrant workers and have provided them with equipment and money to undertake mining in a new location.

The property owner gives the miners authority to extract the gold under the supervision of the land coordinator, and will make an agreement to divide the profits obtained from the sale of gold. Although the structural work has defined rules, there are frequent internal conflicts. In workers’ conflicts, a verdict is decided by the landowner with assistance from a local field coordinator. In some cases, conflicts that could potentially lead to riots are handled by the local police. Under this threat of police intervention, the capital owners and mine workers continue to work together, thus creating economic interdependence [10].

4. Conclusion
We established the economic situation in mining and non-mining communities in Bombana. The mine workers’ incomes are higher than non-mining community. The exploitation of high-quality gold deposits in Indonesia has led to an economic boom in the Bombana Regency. Damage to land, agricultural infrastructure, and fisheries causes that production levels have decreased, and farmers’ incomes have dropped dramatically. The higher revenue generated in the ASGM sector means that miners and their families depend on mining work over a long term, thereby making it difficult to control both the mining activity and the resultant environmental degradation. We suggest, therefore, that the government and other stakeholders should rise to the challenge of solving the problem at the local scale.

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