EXAMINING COMPLEXITIES OF ARTISANAL AND SMALL-SCALE GOLD MINING ON BURU ISLAND, MALUKU PROVINCE, INDONESIA

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ABSTRACT: The Artisanal and Small-scale Gold Mining (ASGM) sector is presently one of the largest global sources of anthropogenic mercury emissions. The risk of mercury pollution from ASGM in Indonesia challenges other important industries including fisheries and tourism. Environmental degradation and risks to food safety and human health are major concerns that have been realised at local scales, including on Buru Island, Indonesia. Since the discovery of gold on Buru Island in 2011 the community has undergone dramatic changes. Some of these, such as rapid wealth accumulation, have been of benefit to people involved in the industry, however, they have been marred by negative social and economic consequences including rapid inflation, reduced rice production, and changes to the social fabric. We explore the Buru Island example through over 12 years of research interest and using empirical material through a socio-legal lens. Various legislative changes and government interventions have occurred since 2011 and there are complex interactions between industry players. Currently, the mining is low key with ore being transported to 'back yard' processing operations while a permitting system is anticipated. There is a legacy of land degradation and contamination as a result of the mining and ore processing. Alternatives to mercury are being considered but are challenged by uncertainty about product effectiveness, potential toxicity, and a lack of processing knowledge.

KEYWORDS: Illegal mining, mercury, human health, community, pollution

I. Introduction

Financial and geopolitical uncertainties in global markets in recent decades have resulted in the price of gold reaching unprecedented levels with peaks between 2010-2013 and again from 2021 onwards (Goldprice®, 2023). In response, Artisanal and Small-scale Gold Mining (ASGM) activities have increased, involving up to 19 million people globally, mainly in Asia, Latin America and Africa (Sippl & Selin, 2012; Fritz, et al., 2016; UN Environment, 2017). For many people in the countries of these regions, ASGM is an attractive alternative livelihood as it provides a substantial income in comparison to subsistence fishing and farming. ASGM also contributes to both local and global economies, producing around 15-25% of the world's gold (Esdaile and Chalker, 2018; UN Environment, 2017). Since 2010 the most significant expansion of ASGM activities has arguably been in Indonesia and, due to the widespread use of mercury amalgamation techniques, the country now hosts approximately 1200 ASGM contamination hotspots across the archipelago in 30 of the 34 provinces (Drwiega, 2018). It is estimated that over 2 million people gain work opportunities from ASGM across Indonesia (Meutia et al., 2022).

ASGM is one of the largest sources of anthropogenic mercury emissions globally (Fritz et al., 2016; Sippl and Selin, 2012; Spiegel et al., 2018). The basic processing technique used in ASGM results in transport of approximately 380,000 kg of mercury to the atmosphere, surrounding soil and waterways annually (Fritz et al., 2016; Drwiega, 2018). However, such an estimate is uncertain as ASGM operations are largely illegal, as is the importation and trade of mercury, rendering official records highly questionable (UN Environment, 2017; Drwiega, 2018). Although mercury dependent ASGM activities may contribute to local economies in the short term, the resulting contamination of soil, water and biota is highly hazardous in the long term to both environmental and human health, not only locally but also regionally and globally (e.g., Veiga, et al., 2006; Reichelt-Brushett, et al.,2017a; Steckling et al., 2017).

ASGM activities have substantial effects on the society, economy, environment, and food resources in locations where they occur. Initially, gold discovery is perceived as a blessing and boon to local people, but along with the perceptions of economic advantage, the rapid migration of people from different areas to carry out the mining and processing may result in a suite of complex social and environmental issues.

II. Methodological Approach

This focuses on Buru Island, Maluku Province in Eastern Indonesia (Figure 1) drawing upon empirical material and insights gained from numerous field experiences over 12 years of various co-authors to Buru Island (e.g., Male et al., 2013; Reichelt-Brushett et al., 2017a; Reichelt-Brushett et al., 2017b; Fakaubun et al., 2020; Irsan et al., 2020; Male et al., 2021; Male et al., 2024). We draw upon other existing literature (both in Bahasa Indonesia and English), local co-author knowledge and discussions with officials, landowners, stakeholders, a local Non-Government Organisation (NGO) known as Yayasan Kedai Masyarakat -Kemas (Community Store Foundation -Kemas). Our approach is particularly focussed on bringing together disparate information and contextualising the current complexities of the gold mining situation on Buru Island. In this narrative we explore the historical development of ASGM on Buru Island through a social-legal context of competing resource consumption and human health risks and suggest potential options for the future.

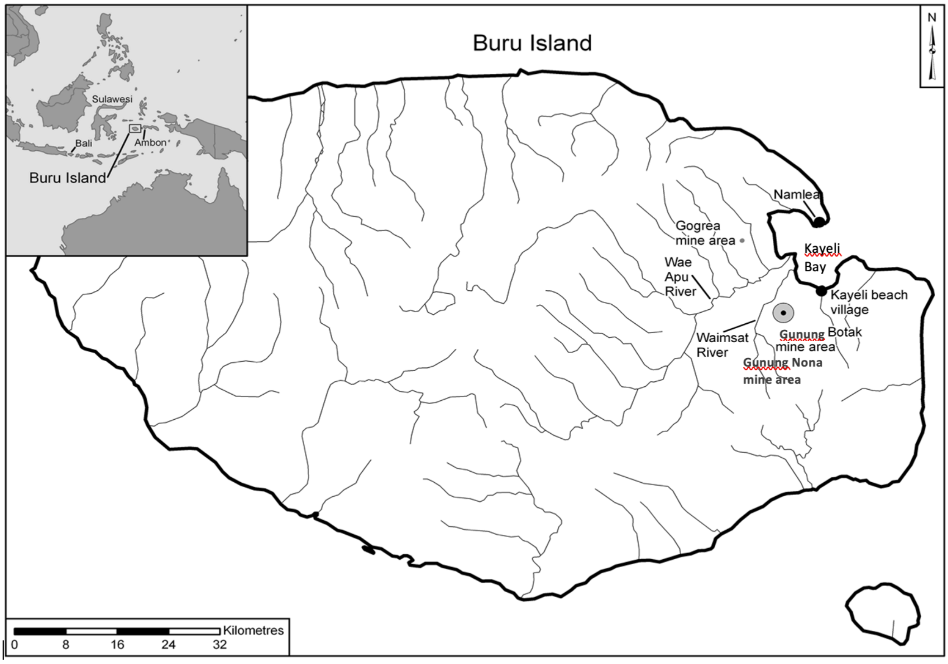

Figure 1 - Location map of Buru Island (insert) and map of associated small scale mine sites showing (clockwise from the right) the main city of Namlea, mining activities and rice growing (adapted from Male et al., 2013).

III. Fisheries and mining –competing uses of natural resources in Indonesia

Indonesia is an archipelago of over 17,000 islands (e.g., Martha, 2017), some of which host extensive mineral resources that are exploited in both small- and large- scale mining operations (e.g., Badan Pusat Statistik, 2022a). Surrounding these islands is the Coral Triangle (the global hot spot of coral reef and reef fish biodiversity and region of international tourism marine tourism) along with major fisheries that provide a substantial export market and provide food security to local communities (Allen, 2008; Ariansyach, 2018; Limmon et al., 2017; O'Neill et al., 2018). Both fishing and mining provide livelihoods for many people, particularly in regional districts of Indonesia, and coastal and marine tourism is also an important income earner in some areas (e.g., Kurniawan et al., 2019). Sustainable management of natural resources and managing competing benefits is pivotal to ensuring long term environmental health, along with social and economic stability.

IIIa. *The regulation of small-scale gold mining (ASGM) in Indonesia*

Historically local people were engaged in gold mining in Indonesia in line with customary law (i.e., rights related to gold mining sit with the rights to possess land), but in 1899 Dutch East Indies Law that denied these customary mining rights and after independence the 1967 Basic Mining Law defined underground reserves are controlled by the state (Devi and Proyogo, 2013; Meutia et al., 2022). Interestingly, with the introduction of decentralisation laws in 2001, there was a dramatic shift in the mining sector, resulting in more regional autonomy and local control over mining activities (Devi and Prayogo, 2013). The Indonesian Mineral and Coal Law 2009 gave regencies or mayors of local governments the authority to issue mining licences to individuals or cooperatives of up to ten people and, as a result, a greater proportion of the revenue generated was intended to flow back into regional communities (MacDonald et al., 2014; Saija, 2018). Significant changes were made to the law in 2020 with the amendment by Law No. 3 of 2020 on the Amendment to Law No. 4 of 2009 on Mineral and Coal Mining and Law No. 11 of 2020 on Job Creation ("Indonesian Mining Law") (Emrich, 2022). One of the changes in this amendment resulted in the responsibility for formulating and implementing policies related to development, control and supervision of mineral and coal mining activities moving back to the Central Government and specifically the Directorate General of Mineral and Coal of the Ministry of Energy and Mineral Resources of the Republic of Indonesia ("DGMC") (Emrich, 2022). This relates to all mineral mining, apart from the issuing of Rock Mining Licence and the Community Mining Licence which is still held by Provincial Governments though delegation from the Government. However, ASGM is illegal according to Article 158 and Article 160 of the Law of The Republic of Indonesia number 4 of 2009 on Mineral and Coal Mining.

The customary law idea that land holders have the right to mine their land, wholly conflicts with the national law requiring a government-issued license for mining. ASGM is illegal on Buru Island in both Regencies of Buru and South Buru. In the Buru Regency some mining participants believe that mining rights are or should be customarily granted rather than requiring a permit through legislation. Some studies suggest that using a proactive approach through exploring the drivers of artisanal mining to ascertain the responsibilities and mitigate the drivers to address the sector's health and safety, environmental degradation and conflict rather than the policing and enforcing law, which can be largely unsuccessful (Redi et al., 2016; Bester and Uys, 2023). Formalising the informal sector could also use a sustainable livelihoods framework (Delgado Jiménez et al., 2022)

IIIa. *Extracting gold from ore*

To extract gold from the ore it is commonly crushed and combined with mercury in rotary grinders (trommels) which forms an amalgam with the gold (and sometimes silver) (Male et al., 2013). This process, known as whole-ore amalgam is commonly used on Buru Island along with artisanal processing using cyanide and gold panning. Whole-ore amalgam requires a steady supply of mercury since over 50-70% is consumed in the process with much of this being lost to the atmosphere and in waste ore which is stored in outdoor retention ponds (Veiga et al., 2006; Male et al., 2013; UN Environment 2017). In 2015, the import, trade, and use of mercury were prohibited in Indonesia by the Ministry of Trade yet paradoxically, by 2016 cinnabar (HgS) mining developments had increased, particularly in Central Kalimantan, Southeast Sulawesi and Seram Island (Drwiega, 2018; Spiegel et al, 2018). Indonesian customs authorities have made efforts to reduce the export of locally produced mercury, however, local governments are comprehensibly struggling with the responsibilities of trying to regulate the illegal trade and distribution of mercury as well as the proliferation of illegal ASGM activities (Drwiega, 2018).

Despite the introduction of numerous laws and regulations pertaining to mercury use, there is a lack of compliance monitoring and law enforcement from local authorities (Saija, 2018). Nonetheless, President Joko Widodo mandated an ambitious National Action Plan to reduce mercury use, in accordance with commitments to the Minamata Convention (Spiegel et al., 2018). Yet there are caveats in the convention that allow cinnabar mines that existed before the convention to continue operating for 15 years after the agreement, which entered into force in 2017 (Article 3 of the Minamata Convention, cited by Drwiega, 2018). This caveat, coupled with the lack of regulations pertaining to selling mercury online in Indonesia and lack of enforcement of existing mercury trade regulations, means that ASGM miners can still easily access mercury (Drwiega, 2018). Illegal dealers charge prices for mercury in Indonesia in the order of US$ 111 to US$ 145 (1.7 million to 2.2 million rupiahs) per kilogram and during ore processing, approximately 10 grams of mercury is used for each kilogram of ore.

IIIb. *Regulation of fisheries in Indonesia*

Indonesia is geographically unique as its land-mass (1,913,580km^2) is dwarfed by its water area (3,257,483 km^2 and 6,159,032 km^2 when the exclusive economic zone is included) which hosts a large area of the Coral Triangle. The waters are fed by the currents of both the Pacific and Indian Oceans (Ariansyach, 2018; O'Neill et al., 2018). The fisheries sector plays a fundamental role in Indonesia's economy as it provides an income for over 6.4 million people, constitutes a primary source of protein for much of the population, and earns a significant amount from exports (US$5.72 billion dollars in 2021 (Statista, 2023)). Supply of fish from wild capture fisheries in Indonesia was estimated to be 7,066,428 MT in 2019 (Fishery Statistical Bulletin of Southeast Asia, 2019), however, research suggests that targeted fish stocks are over-exploited due to unregulated and illegal fishing practices, particularly illegal fishing from other countries such as Vietnam and Thailand fishing in Indonesian waters (Waileruny et al., 2014; Hutubessy and Mosse, 2016; Ariansyach, 2018; Tran et al., 2017).

Decentralisation of fisheries management has occurred since the introduction of the Local Autonomy Law in 1999 (Undang-Undang 22/1999, since replaced by 32/2004), which transferred authority to provincial and district governments (Satria and Matsuda, 2004). Through this law individuals and companies carrying out fishing business shall be licenced, except for small-scale fishermen and small-scale fish breeders. Unlike the mineral resources there is some recognition of traditional marine tenure and management systems (Satira and Matsuda, 2004) such as *sasi laut* (marine *sasi). Sasi* involves temporal and spatial restrictions on the harvest of certain resources or species according to customary law (Harkes and Novaczek, 2002). *Sasi laut* governs access to areas, target species, the equipment used to fish and the time of harvest and thus, increases the participation of communities in the conservation and management of their local marine resources (McLeod et al., 2009; Satira and Matsuda, 2004).

The release of substantial quantities of mercury from the ASGM sector have also impacted fisheries exports as countries including Japan, USA and the European Union have rejected and/or cautioned the import of fish from Indonesia (including tuna, a major export commodity) (Quina, 2016; Alwy, 2018). For example, in June 2006 the European Union imposed an Alert Notification related to mercury contamination for Indonesian frozen yellow fin tuna fillet (*Thunnus albacares*), and as a result severely limited market access, and according to the Ministry of Maritime Affairs and Fishery a financial loss from tuna products reached 30% of its total production (Alwy, 2018).

IV. Economic and environmental background to ASGM activities on Buru Island

IVa. *Buru Island before gold mining*

Prior to the 2011 gold rush there was no history of mining on Buru Island and inhabitants were a mix of indigenous people, transmigrants and former political prisoners (Leksana, 2019). The indigenous people have deep and interesting family customs and define themselves as (people of Buru) (Grimes, 2006a) and. Traditionally, the staple plant food of Buru Island was sago palm (*Metroxylon sagu* Rottb.) but large rice paddy fields were constructed, initially through the forced labour of political prisoners from 1969 to 1979 and subsequently through the government-sponsored transmigration program which saw the immigration of close to 20,000 people from Java between 1979 and 1981 (van der Kroef, 1976-1977; Goss, 1992; Fearnside, 1997). Under this programme, newly arrived migrants were provided with land for rice production on coastal lowland areas and given subsidies for a period of up to 2 years. In 2011, before gold was discovered, the Buru Region supported a population of approximately 50,000 people and cultivated some 11,000 hectares of rice paddy, producing 52.5 tonnes of rice which contributed to the national granary (Central Statistics Agency of Buru, 2012) (Figure 2B). While this led to the achievement of the government objective of a rise in rice production, and recognition of Buru Island as a contributor to the Indonesian 'national granary', it also corresponded with a fall in the production of traditional staple foods such as sago due to competition with rice. Both the subsidy scheme for Javanese migrants and the lack of appreciation of the value of traditional tree crops and local laws caused some tension between transmigrants and local people (e.g. Kurniati et al., 2019).

The coastal villagers of Buru Island depend on fisheries resources for daily food and within Kayeli Bay (where catchments with ore processing meet marine waters) there are permanent house fishing platforms. Fish and shellfish caught in Kayeli Bay and associated mangrove communities are sold at the local markets along with seafood from other locations. Residents of villages along the Wae Apu River depend on the river water for domestic use which, at some locations, includes drinking water (Figure 2A).

IVb. *The discovery of gold on Buru Island and the economic boom*

Gold was found by prospectors from Java who followed historic family stories of gold on Gunung Botak (Bald Mountain) in 2011 and subsequently found at Gogrea in 2013, and Gunung Nona (Lady Mountain) in 2017 (Figure 1), resulting in a large influx of unregulated miners to Buru Island (Male et al., 2013; McBeth, 2018) (Figure 2C and D). The initial influx of tens of thousands of people later slowed as a result of local government intervention. Due to its informal and largely unregulated status, estimates of the number of people involved, the amount of mercury used and the amount of gold produced are questionable but it is without a doubt that gold mining is a major contributor to the regional and national economy (e.g., Tuaputy et al., 2014; Agrawal et al., 2015).

Figure 2: A) The fishing village near the mouth of the Wae Apu River. B) Rice paddies on Buru Island. C) The mine site at Gunung Botak. D) Processing gold rick ore using mercury on Buru Island. (Photographs by the authors, 2018).

With the influx of miners and gold processors (commonly from Sulawesi where people have mining expertise) to the area and the job opportunities that small-scale mining brought, the society transformed. Job opportunities from gold mining activities included ore extraction and transportation, ore processing, and provision of the inevitable range of services associated with any mining industry. As well, gold panning and cyanide extraction methods were used by low key artisanal mining wanting to also profit. In just a few years, large changes in economic circumstances occurred for some families. Redi (2016) reported that 77% of illegal miners in Indonesia reported increased prosperity. However, such prosperity is emphasised in the migrant worker population and those people in related support services. Other residents of the local community do not profit from the mining operations but are often exposed to the adverse effects of them (Erb et al., 2021; Meutia et al., 2022) and on Buru Island it has been described as breaking down of the mutual help lifestyle and complex traditional inter-*noro* (extended family) relationships (Grimes, 2006a). This issue has been reported in other ASGM in Indonesia (e.g., Zuhdi et al., 2018).

IVc. *Ore processing on Buru Island*

We identified various roles and actors in the small-scale mining on Buru Island and traced these through the mercury supply and gold processing operations (Figure 3). The figure highlights a complex network of players/actors with specific relationships between landowners, investors, miners, trommel operators, mercury traders, and gold sellers. Landowners with gold rich ores usually lease the land to miners, who may be financially supported by third party investors. The miners employ ore transporters to take the ore to trommel sites. Trommel sites need to be close to a water source and for this reason are found close to rivers and possibly away from the mining area. In some cases, the miner owns trommels and processes their own ore. In other cases, independent trommel owners (again sometimes with a third-party investor) provide a service to miners to process their ore. Mercury, required for the gold extraction of ore was originally imported (reportedly from Spain) but the cost escalated and encouraged people to turn to local sources from cinnabar mining. Indeed, high quality cinnabar has been informally mined since 2010 on Seram Island, Maluku Province, with the ore being processed into elemental mercury mostly in Java, but also locally in Ambon and Seram (Apriando, 2017; Spiegel et al., 2018; Male et al., 2024). This further highlights the challenges in regulating the global mercury supply chain, the continued risk of increasing the bioavailability of mercury in the environment and related risk to aquatic and human health (e.g., Male et al., 2024).

The first processing of ore (stage 1) extracts much, but not all, of the gold. Trommel owners provide this gold amalgam to the miners who sell it. At this point the trommel owners become the owners of the ‘extracted’ ore, where small quantities of gold still remain (see also Spiegel et al, (2018) who highlight the value of processed ore to trommel operators/processors). At stage 2, the trommel owner then becomes the recipient of the gold amalgam after a second round of processing and sells it on. This is in contrast to some other Indonesian operations and further highlights the mining labour arrangements and asset flows are heterogenous, as previously identified in Labissi (2020, 2023). In the Buru Island experience, trust issues are raised because the stage 1 processing has no form of calibration, the miner is not certain if the processing has been optimised at stage 1 or weakened to ensure more gold is available for the stage 2 process which profits the trommel owner. The trommel owner may also complete a third extraction or the post stage 2 ore may be sold off to owners of cyanide-based extraction facilities. Importantly, each step of the process involves additional stakeholders and few operations are managed independently through the full process from the mining to the final ore extraction. Each step in the process results in mercury or cyanide waste being poorly stored in open ponds where runoff is diverted to river systems. The landowners of the mine sites, who have originally gained profit from leasing their land are left with deep shafts, dangerous conditions and enhanced risks of landslides. Landowners leasing their land to trommel operators are left with contaminated sites unsuitable for future uses such as agriculture and urban settlement. Further to this, the transboundary movement of mercury through air, water, and biota (Lambert et al., 2012) has implications for environmental and human health beyond Buru Island.

Three main mine areas on Buru Island are within the catchment area of Kayeli Bay which contains both fisheries resources and agricultural lands (Male et al., 2013). Several thousands of ore processing sites (trommels) are estimated to exist, most of which are now abandoned. The current extent of mercury contamination is of concern to environmental health and food safety. Furthermore, during the 2012-2013 drought and water scarcity, some rice farmers abandoned their farms to work in the mining industry. In 2014, 6,661 hectares of land was used for rice growing, producing 29.8 tonnes, with production less than 60% of the 2011 amount (Central Statistics Agency of Buru, 2012; Integration, Processing, and Statistical Dissemination Division, 2015).

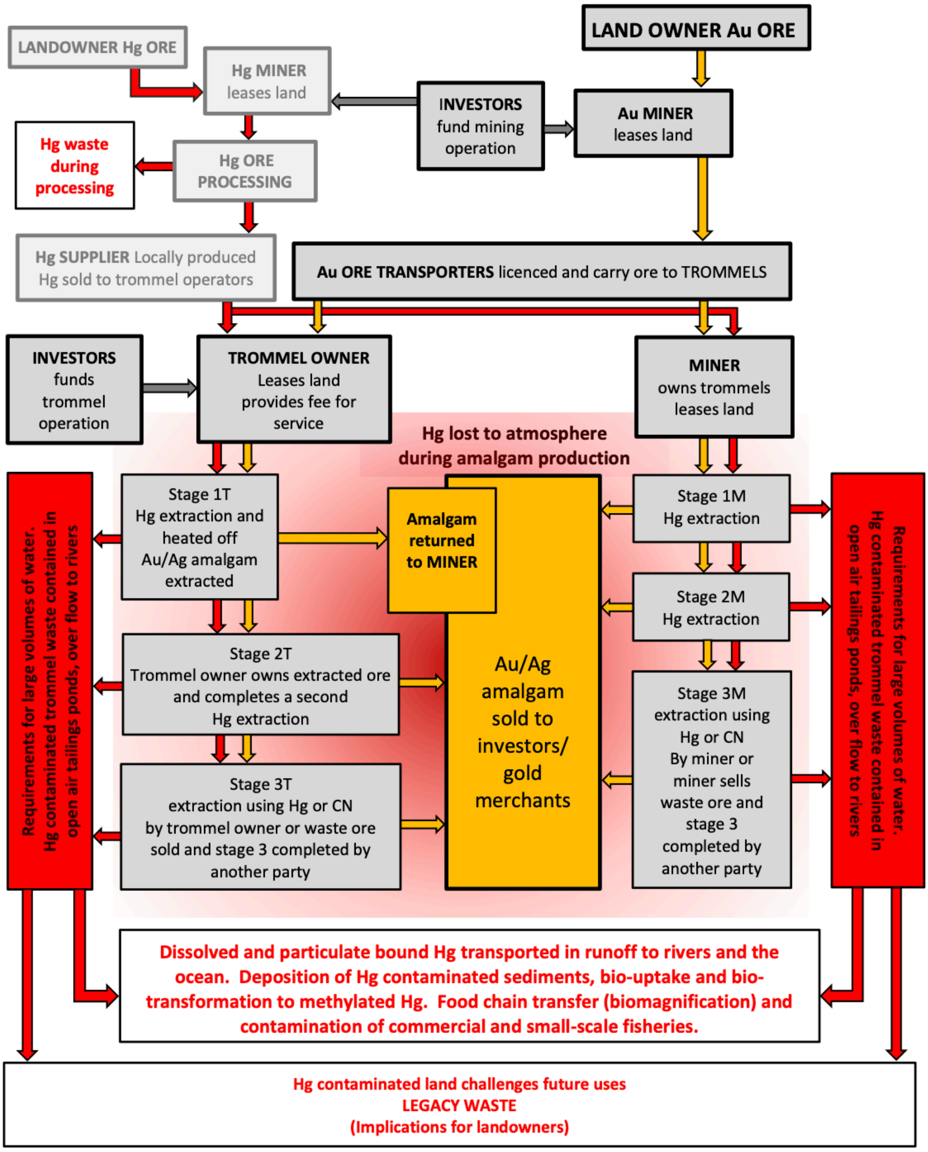

Figure 3 - Flow diagram showing relationships of landowners, investors, miners (M), trommel owners (T), mercury (Hg) investors (pale grey), and gold (Au) supply and traders (orange), highlighting the transport and fate of mercury (red) used in ASGM operations.

Mining activities at both Gunung Botak and Gogrea were officially ceased by the Government of Maluku in 2015 after President Joko Widodo visited the village of Wae Apo and instructed the closure of mining activities (Hindersah et al., 2018; Saija, 2018). It took some time for the mining and processing to wind down after the official cessation of activities. Security forces deployed to guard the mining areas were withdrawn in 2017 and visual evidence shows that illegal miners have recommenced work at nearby Gunung Nona (Saija, 2018).

IVd. Mercury contamination resulting from ASGM activities on Buru Island

Environmental monitoring, largely funded by government institutions and university researchers have quantified mercury contamination from ASGM on Buru Island. In 2013, preliminary investigations into the extent of mercury contamination of soil and sediments surrounding ASGM at Gunung Botak and Gogrea mine sites on Buru Island were conducted (Male et al. 2013). Tailings from whole ore amalgamation usually contain 50-200 mg of Hg/kg of ore and on Buru Island concentrations as high as 760 mg/Kg were reported (Male et al., 2013). Such tailings are often discharged into water streams and nearby urban and agricultural landscapes where the mercury can then be oxidized and complexed; these are the preliminary steps in the transformation of metallic mercury into a more toxic form, methylmercury (Swartzendruber and Jaffe, 2012). Mercury concentrations also peaked in sediments from the delta of the Wamsait Estuary, 20 meters offshore (Male et al., 2013). As the presence of microorganisms in receiving environments such as rivers and estuaries facilitates the methylation of mercury enhancing toxicity, this finding highlighted the risks posed by the extent of contamination (Male et al., 2013). A later study (Reichelt-Brushett et al., 2017a), showed that total mercury concentrations in marine sediments had substantially increased relative to those measured in the previous study. Most notable increases in mercury concentrations were in sediments collected from the Wamsait River Mouth, where catchment sourced sediments deposit. Between 2012 and 2013, mercury concentrations in sediments had increased dramatically from 1.8 mg/Kg in 2012 to 47.1 mg/Kg in 2013.

All mercury concentrations in sediments collected in 2013 exceeded the acceptable total mercury concentration of 1mg/kg (dry weight) recommended for aquatic sediments in both the Indonesian National Standard (SNI), raising serious concerns about the extent of contamination (Reichelt-Brushett et al., 2017a). Ecotoxicological studies shows diluted ore processing waste is toxic to marine invertebrates (Reichelt-Brushett et al., 2017a). Given the contamination and the fact that seafood is a principal component of the regional diet, serious concerns about food safety in the region were raised by this study warranting further scientific investigation, particularly into high trophic level species consumed by humans (Reichelt-Brushett et al., 2017a).

To further assess the extent of mercury contamination downstream of the ASGM operations, samples of fish, molluscs, and crustaceans were collected in 2014 from the Namlea fish market on Buru Island and subjected to total mercury analysis (Reichelt-Brushett et al., 2017a). Recent concerns associated with biomagnified mercury affecting food safety are valid with mercury concentrations as high as 2.47 mg/Kg w/w reported in edible fish (*Channa striata*) and 2.99 mg/Kg w/w in edible molluscs (*Cerethium* sp.) harvested from a river on Buru Island (Reichelt-Brushett et al., 2017a), exceeding the Indonesian National Standards (Standar Nasional Indonesia, hereafter referred to as SNI) of 0.5mg/kg for fish and fish products and 1.0 mg/kg for predatory fish (SNI 7387:2009, referenced in Quina, 2016). This is particularly important because the typical diet in the region is highly dependent on fish and other seafood for protein (FAO, 2016; Tran et al., 2017) and it is not unusual to have seafood in 2-3 meals a day. The Buru Island community are faced with serious concerns for food safety and environmental harm (Reichelt-Brushett et al., 2017a). Importantly the risk of mercury exposure differs from place to place as a result of different environments, the type of fish commonly eaten and the consumption of other locally sourced foods that may also contain mercury (FSANZ, 2011). Fish at higher trophic levels and species with longer lives (such as predatory fish) are also more likely to contain higher levels of mercury due to the effects of biomagnification (UNEP/WHO 2008 cited in Blanchemanche & Tressou, 2015). Further to this, concerning concentrations of mercury (up to 3.25 mg/Kg) have been measured in the hair of people living on Buru Island (Rumatoras et al., 2016).

Local awareness of these issues appears to be on the increase, as anecdotal information collected recently suggests that some people in the city of Namlea are aware of the potential for food contamination arising from gold mining and the use of mercury (Yayasan Kedai Masyarakat (Kemas) pers. comm. 23rd September 2019). There has been some suggestion that local people prefer to purchase imported rice rather than local and avoid fish caught in the Kayeli Bay area. The production of rice and the goal of making Buru Island a hub of productivity in Indonesia's quest for self-sufficiency (Setiawan, 2015) has been compromised by mercury contamination resulting from ASGM activities (Male et al., 2013; Mariwy et al., 2019; Hindersah et al., 2018). Research conducted by Hindersah et al. (2018) to investigate the comparison of mercury levels in plants grown in areas impacted by ASGM activities and uncontaminated sites revealed that most food crops grown on contaminated soil contained mercury concentrations above the level of 50 μg/kg suggested by the Indonesian Food and Drug Supervisory Agency (BPOM, 2008 cited in Haq, et al., 2018).

V. Social complexities and challenges on Buru Island

A search in Bahasa Indonesia using the Google search engine on September 3rd 2023 using the key phrase *gold gunung botak pulau buru'*(gold bald mountain buru island) returned over 37,000 results, which indicates it is a subject of intense interest. Past and recent discussions with a non-government organisation (Yayasan Kedai Masyarakat -Kemas) and landowners also highlight community perceptions of gold mining and activities that are being conducted to address the challenges.

Within six months of gold being discovered in 2011, many people had abandoned their farms and jobs to seek their fortunes in the ensuing gold rush, resulting in a rapid shift from cooperative communities to a more consumer-based society (Murphy, 2013). In 2013 ore transporters could earn more money than school-teachers and farmers and for that reason there was an exit of workers from these vocations who moved to mining. In 2013, the monthly income for teachers was 3 million rupiahs, while workers who carried mining materials on their backs to the base camp (a distance of 1.5 km) were paid 40,000 rupiahs per sack. On average, each person can carry 10 sacks per day. For 10 days work the wages of material transporters was 4 million rupiahs and exceeded teachers' monthly salaries. This rapid wealth generation caused rapid inflation of everyday staples such as rice, fish, and fuel, while sales of imported goods, in particular, electronic and automotive products increased significantly (Purwanto, 2012). With fuel allocations to provinces determined by Indonesia's central government, any sudden rise in demand inevitably causes increases in local prices, and during the height of the 2011/2012 gold rush, the price of petrol, diesel, and kerosene increased drastically. Existing shops selling goods and services benefited from the rapidly increasing turnover, but supply was challenging hence prices of building materials, hardware and clothing rose. During this period, the inflation rate in Buru Island reached over 100%, which was detrimental for the many local households who were not involved in mining or gold trading, and thus not benefitting from increased incomes. This had the effect of increasing social inequality, which became visually obvious in some areas, and those with low purchasing power faced serious difficulties from an inability to access basic foods and other household needs, causing local tension both within and between communities.

Newfound wealth was further observed by the purchase of new cars, which have become a symbol of family wealth, even though the owners were incapable of driving them. They were purely conspicuous consumption objects. It was also noted by landholders that reckless driving, poor road conditions, and minimal vehicle regulation have given rise to an increase in motor vehicle accidents. Changes in the type and style of dwellings are also widely evident. Originally huts with sago palm rooves were the predominant housing structure, but since 2011, there has been an increase in more costly concrete houses, with modern roofs and tiled floors which indicates increased financial resources for housing. Unfortunately, there is inadequate infrastructure to support these, with no planned sewerage or drainage, and little central electricity provision. This has been addressed by households using diesel generators, and it is not uncommon to see such houses with sophisticated electronic devices and satellite dishes, while still having a basic latrine in the garden. Wealth is more evident with those people who are more financially educated knowing how to save rather than rapid short-term spending.

At the household level, other unintended consequences of the thirst for gold mining wealth also occurred. Many young people decided to leave school to take advantage of the well paid yet unskilled jobs available in the mines. In many schools, even the teachers themselves left their jobs to join in the mining activities (Bentrokan, 2012). This left pupils without teachers in their schools. Men who decided to go to the mines left their homes and families, and it is suggested that outsiders benefiting from the mining wealth sought company with these ‘neglected’ wives. The data from the Islamic Religion Court in Buru Regency shows that the socio-economic impact of illegal gold mining has caused the divorce rate to increase by 15% after mining commenced due to domestic violence, neglect of children and infidelity.

The influx of ASGM miners from other parts of Indonesia resulted in the population almost doubling to approximately 125,000 in 2014 (Integration, Processing, and Statistical Disemination Division. 2015). A presentation to the authors from a member of Yayasan Kedai Masyarakat (Kemas) and later discussions revealed the rapid population increase further deteriorated social bonds (Leonardo pers. comm., 23 September; 2019) and triggered violent land disputes between both community members and ASGM co-operations, resulting in several deaths and injuries (Rasyid et al., 2014). A survey in 2013 reported 45% of respondents on Buru Island wanted the mining to close with 55% wanting mining to continue (Tuaputy et al.,2014). Respondents who wanted the mining to close were concerned about environmental dangers as they were reliant on natural resources for their livelihoods including fishing and farming (Tuaputy et al.,2014). In response to the disputes, the local government raised the police presence in mining and gold processing areas, and landowners developed a licencing system for access to the mine sites as a way of controlling the number of people involved in mining activities. Under this system, landowners issued a mining identity card valid for three months, so everyone entering and leaving mine sites had to report to checkpoints being run by private security guards.

In the Gunung Botak area, women’s access to mine sites was also controlled, with women being prohibited from some of the mining sites. This was purportedly in an effort to reduce/avoid personal risk to women unused to the very difficult terrain, and lack of safety provisions and in an attempt to reduce prostitution (see also Bryceson et al., 2013). Women are important players in small-scale gold mining throughout the world and are usually differently involved and their opportunities are different. Traditionally they are associated with the labour-intensive tasks of extracting remnant minerals from tailings, panning and sluicing which yield some of the lowest economic returns (Lynas, 2018; Perks et al., 2018). Additionally, women will often do ancillary work including food vendors and other services along with the household duties (Lynas, 2018). These different roles between men and women are not just due to personal choice but also relate to a series of limiting factors linked to traditional gendered division of labour along with pollution beliefs, land tenure practices, and unequal control of household resources (Moretti, 2006). Moretti (2006) further points out that in some cases the heavy male involvement in mining required women to take on tasks that traditionally fell onto men such as felling trees and clearing gardens. Furthermore, the trommel processing operations (where the highest use of mercury occurs) are often close to households and children were seen playing in the mercury contaminated tailings on Buru Island.

At Gunung Botak ruthless competition gave rise to serious criminal incidents including murder, where miners needed to vigorously defend both their equipment and the ore they extracted, for fear of theft. As a way of addressing this issue, attempts were made to make miners work as part of cooperative teams, usually of 6-8 people who live together in camps on site. On Buru Island there was a complex shifting of leadership groupings headed by *rajas* that were influenced by Dutch colonial rule (Grimes, 2006b). Around the gold mining area and for a time prior to the gold rush there was one customary leader, now there are four (Yayasan Kedai Masyarakat (Kemas), pers. comm., 23 September, 2019). One of these leaders conducted a "traditional" ceremony with the authors for the safe passage that involved collecting donations, stated "*the land is a gift from God and people can come to make money*". Yet, having witnessed the devastating socio-economic and environmental impacts of ASGM operations on Gunung Botak, this leader, whose family has lived there for generations, would like to see a transition back to more traditional methods of working to extract gold (e.g., Telapak and Gekko Studio, 2015).

The influx of ASGM miners also resulted in the increase in diseases such as malaria likely from open tailings ponds providing breeding habitat, and potentially contributed to an increase in the number of HIV and other Sexually Transmitted Infections (STI) (Table 1). Before 2015 STIs were not reported (Table 1) and said to be almost non-existent on the island (e.g., Saija, 2018). As it has been little more than a decade since mercury dependant ASGM activities started on Buru Island, the social, economic and health impacts are still evolving. Table 1 highlights some interesting trends with dermatitis and eczema being reported in the top 10 most common diseases since 2017 and previously not reported in mostly annual records until 2014. Skin reactions are a known response to mercury exposure and may develop slowly (e.g., Bates, 2003; Makek et al., 2017) but a direct link between mercury and the reported dermatitis cases on Buru Island has not been determined. Available health records before 2012 are limited so comparison between current and before gold mining are not possible. In response to health concerns from mercury exposure the local NGO, Yayasan Kedai Masyarakat was running workshops and working with the people of Buru Island (see also: Newsletter - Yayasan Kedai Masyarakat N-IDN-02019-3010). However, more recently the funding body raised concerns about the risk of staff being exposed to mercury so have not proceeded with follow up rounds of funding.

Year	Acute Respiratory Tract Infection (ISPA*)	Malaria	Dermatitis (# =order in top 10 diseases)	HIV/AIDS	STI
2021	5534	5	1123 (Non-specific) (5) 402 (contact) (6) 1555 (sum)	14	139
2020	4654	13	764 (Non-specific) (5) 569 (contact) (6) 1333 (sum)	17	295
2019	NR	NR	NR	NR	NR
2018	6606	17	835 (4)	18	149
2017	5984		1229 (5)	23	135
2016	5891 or 6805 (NRel)	123	861 (Non-specific) 652 (contact) 1513 (sum)	9	0
2015	5513	394	224 (non-specific) 226 (contact)	5	0
2014	NRel	NRel	NR (>10)	NR	NR
2013	8423	1422	NR (>10)	NR	NR
2012	11556	1049	NR (>10)	NR	NR
2011	NR	NR	NR (>10)	NR	NR

*Bahasa Indonesia acronym, STI= Sexually Transmitted Infections, NR= Not Recorded; NRel =Not Reliable; (Sources: Health Office of Buru Regency. In: Central Statistics Agency of Buru, 2012; Integration, Processing, and Statistical Disemination Division, 2013, 2014, 2015; Badan Pusat Statistik [BPS] -Statistics of Buru, 2016; 2017; 2018, 2019; 2020; 2021; 2022b.)

Table 1 - Comparative statistic for health indicators from Buru Regency.

Mining activities on Buru Island were in an apparent state of quiescence in 2018-2019. According to both government and non-government sources. ASGM activities at Gunong Botak and Gogrea mining areas had ceased, awaiting further government instructions (McBeth, 2018; Saija, 2018). Signs posted outside the mining areas attest to this warning that mining and the use of mercury and cyanide without permission can lead to substantial fines or imprisonment. Some stakeholders (pers. comm., 23 September, 2019) stated that ASGM activities continue on Gunung Nona but it is more remote with difficult access and challenging ore transport conditions. These current activities may result in downstream impacts due to Gunung Nona's location at the headwaters of several major tributaries that feed into the catchment area of Kayeli Bay (Figure 4). Furthermore, the cessation of the mining was supported by local people because they were promised a permitting system as a way forward. To date the permit system has not been developed which has created frustration and some players have subtly installed processing facilities behind closed doors and in backyards using motorbikes to transport the ore. This raises concerns about localised urban mercury contamination of soils which may well be used for growing vegetables in the future.

Siltation of the Wamsait River resulting from ASGM activities and a major landslide in 2018 (Figure 5) destroyed hundreds to thousands of hectares of sago plantations which were once the staple food of Buru Island residents (Telapak & Gekko Studio, 2015;). While information on the extent of the ore body on Buru Island is limited, the ore is high grade (Male et al., 2013) and, given the economic value of mineral resources, it is reasonably certain that exploration and mining will continue in some form on Buru Island. The silty soils deposited on the floodplain after the landslide have interrupted the flow of the Wamsait River. These soils contain both gold and mercury and it is postulated that an Indonesian company will

start large scale mining and reprocessing of these soils/sediments with a preference to use Jin Chan (see section 5.0) a gold extraction material rather than mercury.
As recently as June 2023 discussion were underway in Dava Village, at the foot of Gunung Botak with The Secretary of Buru District Ilias Hamid and the Secretary of Maluku Province Sadali Le both supporting the legalisation of the mining activities in Gunung Botak, both expressing a hope that the mining operation could be managed well for the welfare of the community (Herin, 2023).

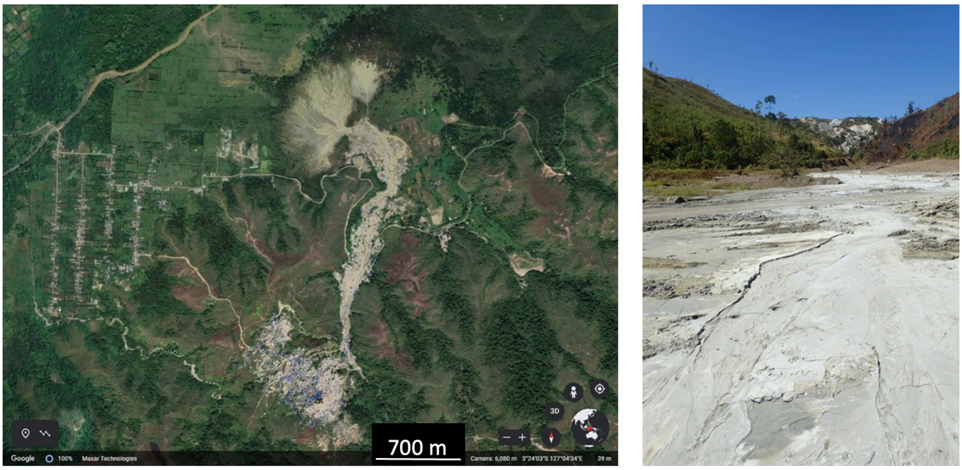

Figure 4: A) I view of the extend of the landslide that started at the mine site after heavy wet season rains filled mine shafts and enhanced already weakened hill structure (Source: Google Maxar Technologies 3°24”03’S 127°04”34’E.). B) The landslide site in 2019.

VI. Considering novel alternatives to mercury use on Buru Island

Finding alternatives to mercury use is a serious issue to address for the long-term health and safety of ore processors, their families and local communities and the environment. Spiegel et al. (2018) highlights the limitations of alternative options to mercury use for ore processing available to the miners. It is only when miners are willing to give up control of the processing that other, more sophisticated, technologies become available. The potential to form cooperatives with other miners to afford the investment in the technologies may prove to be a solution to access these technologies, albeit challenged by burdening bureaucratic complexities (Spiegel et al., 2018). Spiegel et al., (2018) also warned that campaigns to raise awareness of the ecological health risks of mercury use, unless linked to addressing socioeconomic barriers to technology transfer and other efforts to reduce mercury use (e.g. gravimetric concentration), can stigmatise miners and drive miners away from engaging in phase-out options.

There are some products on the market that profess to be alternatives to mercury us in gold extraction from ore that could be used by small scale miners. For example, Jin Chan, the name given to a leaching reagent recently patented by the Chinese company Guangxi Senhe High Technology, Ltd and is likely named after a mythical toad that is a charm of prosperity (Hyunjoo, 2022), most commonly translated to English as ‘Golden Toad’ or ‘Money Toad’. Jin

Chan is advertised as a "substitute for sodium cyanide that offers low toxicity, high environmental protection, high (gold) recovery, convenient operation, low dosage, and low cost" (Guangxi Senhe High Technology, 2011). Details on its chemical composition vary according to the limited sources of information available and their uncertain reliability. The Safety Data Sheet provided by Shenzhen Toby Technology Company Ltd states that Jin Chan is composed of the elements; carbon (22.04%), sodium (38.3%), ammonia (15.42%), oxygen (22.92%), iron (0.96%) and chlorine (0.36%).

Laboratory analysis conducted by the Department of Energy and Mineral Resources, Maluku Province, shows that a sample of the product contained 45 – 55% sodium carbonate (Na_2CO_3) and Yilmaz and Sayin (2023) show that Jin Cham performs in much the same way as sodium cyanide. A study conducted to determine the efficacy of the product (Beyuo, et al., 2016) lists the main chemical compounds as thiourea $SC(NH_2)_2$, sodium silicate ($NaSiO_3$), sodium hydroxide (NaOH), and sodium hexametaphosphate $(NaPO_3)_6$. The composition of Jin Chan seems to be relatively benign in comparison to both mercury and cyanide yet, according to the safety data sheet, wastewater resulting from processing is highly alkaline (which also poses a waste management challenge). There is no data available on its persistence in the environment or mobility in soil, issues which must be investigated and addressed before its application in mining activities. Another product/process patented as Clean Mining technology has been developed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), which is reported to be cyanide-free and mercury-free. It is based on thiosulphate, a water-soluble inorganic salt and is suitable for use in small- and large-scale mining operations (CSIRO, nd).

There are many other considerations required for successful uptake of alternatives to mercury use. They must be considered in site specific contexts including the properties of the ore, operational requirements, workflow and performance of the technologies, local technical considerations, and health, safety, and environmental aspects which are well described in Keane et al. (2023). Alternative methods could be coupled with voluntary gold certification programs, although there are challenges and shortcomings to this approach, particularly in the long term (Martinez et al., 2022). There is more extensive detail on traditional alternative methods in UNEP, (2012) and in the *Illustrated guide to mercury free ASGM practice* (UNEP, nd) (ee also EPA, 2024).

VII. Guidance for the Future

Gold rushes have existing through time in all parts of the world where gold has been found. They result in the migration of people to mineral rich sites which may have a major influence on the community cohesiveness and structure as seen in a plethora of examples including Buru Island (see Bryceson, 2018). It is likely that small-scale gold mining will continue into the future around the world whether it be legal or illegal. When the small-scale mining activities are illegal it creates a complex web of actors and politicians, government officials and law enforcement authorities add to that complexity. While the elimination of mercury use must be a priority in any step forward, Hasibuan et al. (2022) notes that there are six main determinants of persistent illegal gold mining in Indonesia including: financial, low entry barrier, regulations and policies, supporting resources availability, politics and power and psychosocial factors. These need to be addressed broadly in Indonesia and solutions must be relevant to the local circumstances of illegal mining. Importantly the process to address these involves multistakeholder dialogues involving all stakeholders, including the illegal miners. Policymakers should also be positive about increasing awareness of the citizens on their rights to a fairer share of natural resources (Hasibuan et al., 2022).

Hasibuan et al., (2022) further suggests education and vocational training to improve skills of illegal miners could open employment opportunities for them in the formal sector and help poverty alleviation. The sector certainly needs reform and a road map that includes mining license, supply chain certification and a business case for responsible small-scale gold mining (e.g., IIED, 2016) may be a vehicle to reduce the uncontrolled and fetish style business driven activities of financiers, chemical suppliers, processors and vested interest groups, including unlawful and corrupt authorities. Such an approach could include addressing gender inequality through the adoption of the Millenium Development Goal 3 (MDG 3), namely to 'promote gender equality and empower women' (Purevjav, 2011). There are advocates for applying strong sanctions to the government and law enforcement officials who support or protect illegal mining activities (e.g., Hasibuan et al., 2022).

VIII. Conclusions

The use of mercury in ASGM activities poses a significant risk to environmental and human health, not only on Buru Island but also regionally and globally. The lack of effective management of mercury pollution resulting from ASGM activities on Buru Island suggests that the current regulatory framework is ineffective. However, the rich ore body is certainly going to be mined in some way in the future. Importantly, for both local and national human wellbeing, it is vital to ensure that the mining does not result in further accumulation of mercury in agricultural areas or fishing zones. The discovery of gold is often referred to as a blessing for small communities whose livelihoods are based on farming and fishing, such as those on Buru Island. However, this risks food and water safety and security which are essential for any community and these immediate economic successes of mining must be conducted in a way that minimises longer-term environmental impacts and avoid the challenges it sets for the fabric of the traditional 'mutual help' lifestyles. Already there are indications of mercury toxicity in people of Buru Island and further investigations should be immediately funded and actioned. To ensure that the future of Buru Island is sustainable, not only will continued monitoring of mercury pollution on Buru Island and surrounds be essential; it is also recommended that urgent action be taken to map, contain and remediate areas that have already been contaminated.

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