Evaluating the impact of small-scale mining on the achievement of the Sustainable Development Goals in Guyana

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Abstract

The artisanal and small-scale mining (ASM) sector in Guyana has, over the last decade, become the main engine for economic growth, the key source of foreign exchange and a vital source of employment across the country. It has therefore served as a vital driver in alleviating poverty and helping the country to make progress on the Sustainable Development Goals (SDGs) relating to poverty and economic growth. At the same time, however, the sector has contributed to significant levels of deforestation and water pollution, threatening progress on other SDGs. In this paper we develop a framework that allows an evaluation of the impact of the sector upon progress towards a variety of the relevant SDGS and their accompanying targets and indicators. We extend this framework by presenting valuations of the environmental and social impacts from the ASM sector and compare this to the economic benefit from the sector in terms of contribution to GDP, foreign exchange, taxation and indirect employment benefits, allowing us to understand the trade-offs involved in the use of the ASM sector as a tool for achieving the SDGs. Our assessment shows prominent economic benefits crucial for the country to achieve the economic related SDG targets but at a significant social and environmental cost that will hinder the country achieving the social and ecological SDG targets. The framework presented in this paper can thus be used to identify policy areas that need prioritizing in order to address the social and ecological costs associated with ASM whilst maintaining and possibly improving the economic prosperity it provides.

Keywords: Artisanal Small Scale Mining, Environmental Valuation, Social Costs, Sustainable Development Goals

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1. Introduction

The artisanal and small-scale mining (ASM) sector has, over the last few decades, emerged as a major source of a wide range of minerals and livelihoods for millions of individuals across South America, Africa and Asia. (Hilson & McQuilken, 2014; Hilson & Maconachie, 2020).

The sector extracts minerals using generally rudimentary techniques that often lack mechanisation. It often occurs in a climate of informality, to varying degrees. There is also generally a lack of environmental management and planning occurring across different levels of formality often leading to a range of environmental problems that affects ecosystems, communities and miners. In addition, the informality of the sector often contributes to deficits in operational health and safety – causing potential health impacts to those involved. ASM often occurs in remote areas and away from the control of central government, involving cash and valuable minerals. This can attract criminal behaviour and issues such as prostitution and human trafficking.

The negative perception of ASM has tended to dominate the writing on ASM – especially in media and public forums – with focuses on child labour (Free the Slaves, 2013), mercury pollution (Human Rights Watch, 2013) and sexually transmitted diseases (Hentschel et al, 2002). However, the positive role that ASM can play in providing livelihoods, contributing foreign exchange, increasing demand for local agricultural products, and operating as a safety net has started to be acknowledged (Hilson, 2002; Aizawa, 2016).

Acknowledgment of positive benefits as well as negative consequences of ASM creates a more nuanced approach to the sector – and the formation of suitable policy to manage the sector. What is needed is a framework to first understand the positive benefits and negative impacts. This can help inform policy to maximise positive benefits whilst minimising negative impacts.

The Sustainable Development Goals (SDGs) provides a framework to help build just such an understanding. Emerging from the United Nations' 2030 Agenda for Sustainable Development the SDGs provide a set of overall goals, underlying targets and associated indicators to assess the progress countries are making towards broad-based sustainable development (United Nations, 2020). In this paper the positive and negative impacts from ASM are mapped on to these SDGs to highlight where and how the sector can contribute or not to the achievement of these goals. This mapping builds on literature such as UNDP (2016) that have conducted this exercise for the whole mining sector. This exercise helps to provide an initial insight into the complex array of impacts the sector may have across the SDGs, where there may be conflicts in achieving progress, and where there may be interactions or co-benefits from undertaking policy changes in the sector. These tasks are not the primary aim of the paper, but the work undertaken in this analysis provides a tool for future authors to continue research into this critical area.

The mapping of impacts on to SDGs allows us to take one step further and attempt to quantify some impacts to provide an overall assessment of the contribution ASM is making to achieving the goals. This task is undertaken at a country-level to provide a proof-of-concept of the technique. Guyana is chosen for this task due to the significant contribution that ASM plays in its economy, the long-term role that the sector has played in the social fabric of the country and the environmental consequences that the sector has brought (Hilson & Laing, 2017; Hook, 2019; Lowe, 2006, Pasha et al 2017; Roopnarine, 2005; Singh et al., 2013).

A valuation of the negative impacts of ASM as well as a presentation of the value of its benefits can enable an informed policy debate about the value that the sector has in contributing to sustainable development. It also helps to highlight where there may be interactions, conflict and co-benefits

from the activities of the sector as a whole, and where policy can play a role in reducing such conflicts, and maximising co-benefits. This area has been generally under-explored in the literature, and this paper provides a starting point on this path by providing a review of the quantitative and qualitative evidence of the impact of ASM in Guyana on a range of economic, social and environmental factors. The aim of this work is not to provide a comprehensive cost-benefit analysis of the industry in the country, but instead synthesises existing data on the sector, highlighting the scope of its impact across the SDGs. This task can provide an insight as to where policy may be able to positively impact SDGs together, and where policy may be targeted to reduce the negative impacts from the sector.

Section 2 provides an overview of the literature relating to the impacts of ASM. Section 3 maps these impacts on to relevant SDGs. Section 4 outlines the ASM sector in Guyana. Section 5 provides the methods used for the valuation of the impacts of the sector. Section 6 provides the results of the value-transfer analysis and Section 7 concludes, discussing the results and the policy implications.

1. Literature

Early literature on ASM tended to focus on negative aspects of the sector (Soto et al, 1975; Tarras-Wahlberg et al, 2000). In recent years however there has been a movement towards a more nuanced view of ASM – with a wider acknowledgement of the positive contribution that it can make to livelihoods and economies (e.g. Aizawa, 2016; Hirons, 2020).

This acknowledgment has led to a growing literature that aims to analyse and assess both the positive and negative impacts from mining. Hilson (2003) provides one of the first pieces of work that holistically examines the positive and negative socioeconomic impacts from ASM– from environmental and health impacts to the critical role of the sector in providing livelihoods. Further literature has delved into similar questions from a country-perspective, for example, Shen & Gunson (2006) conclude that in China the positive economic contributions outweigh the negative impacts from the sector.

In recent years, this area of research has started to incorporate SDGs to help to understand and assess these differing positive and negative contributions. Yakoleva et al (2017) focuses on large scale mining companies and the role that they can play in contributing to the achievement of the SDGs in Africa. Further work has examined similar questions for ASM in Ghana (Mensah et al, 2020). de Mesquita et al (2017) conducted a systematic literature review of mining and sustainable development, highlighting that the main focus of papers remained on the environmental dimensions of the UN goals, with further work needed on the other areas – economic and social that compose the SDGs framework.

Beyond these broad-based studies a wide range of literature has examined various specific impacts from ASM. The largest volume of work has focused on negative environmental impacts from ASM, either focusing on individual countries such as Ghana (Ayree et al, 2003) and Guyana (Roopnarine, 2002; Roopnarine, 2006), or focusing on specific environmental media such as mercury (Veiga et al, 2006; Bose-O'Reilly et al 2008), water or deforestation (Peterson & Heemskerk, 2001; Swenson et al 2011) .

A range of studies have examined environmental and health impacts from the use of mercury in the amalgamation process in ASM. A critical review of the literature conducted in Gibb & O'Leary (2014) found negative health impacts among those working or living in or near ASM communities, directly

from inhaling mercury vapour from burning the amalgam and indirectly from consuming fish contaminated with methylmercury.

Beyond the issue of mercury, studies have also examined other deleterious impacts, including deforestation, water and biodiversity. Peterson & Heemskerk (2001) examined deforestation and forest regeneration from ASM in Suriname – highlighting both the scale of deforestation and the slow process of regeneration following mining. The relationship between deforestation from ASM and driving factors such as the gold price was examined in Peru in Swensson et al (2011). The issue of deforestation from ASM in Peru has also been examined by Caballero et al (2017) and Asner & Tupayachi (2017). Similar work has examined the relationship between gold mining and deforestation across the Guiana Shield (Dezécache et al, 2017)

As well as contributing to deforestation, ASM may also impact biodiversity, with studies examining fish in French Guiana (Allard et al, 2016) and across national parks in Madagascar (Cabeza et al, 2019) and Zimbabwe (Gandiwa & Gandiwa, 2012). Recent studies have also highlighted the impact that ASM has upon rivers, causing increases in suspended sediment, with implications for fish populations (Sonter et al, 2018).

Beyond environmental impacts, ASM also brings health hazards, to those involved and those in proximity to operations. Risks from small-scale underground mining in Ghana were discussed in Bansah et al (2016) ranging from ground failures to dust and fumes from drilling and blasting. Health and safety risks were also examined in Smith et al (2016). Further work has delved into more depth on the health impacts from lead and silica dust (Gottesfeld et al, 2018) and mercury vapour (Nakazawa et al, 2016).

ASM has also been associated with a series of negative social impacts in the literature including crime (Hentschel et al, 2002; Hilson, 2002; Buxton, 2013; Zvarivadza & Nhleko, 2018), neglect of human rights (Hentschel et al, 2003), child labour (Potter & Lupilya, 2016; O'Driscoll, 2017) and gender discrimination (Armah et al, 2016; Blair et al, 2017).

Economic impacts from ASM have been subject to less study than environmental and social impacts. This is despite the fact that in a number of countries across sub-Saharan Africa, South America and Asia, ASM is a crucial source of employment, livelihoods and sources of foreign exchange. Hilson (2016) estimates that across sub-Saharan Africa more than 8 million people are directly employed in ASM activity, supporting over 45 million dependents. In an Indian context the positive contribution to both employment, and the economy in general has been examined by Ghose & Roy (2007). In East Africa Bryceson & Jonsson (2010) examines the movement of labour from smallholder agriculture to ASM, due to greater potential earnings, despite the higher risks. The contribution to foreign exchange, along with employment benefits, was highlighted in Hilson (2002) and the potential positive economic contributions of ASM to agriculture, through providing finance to purchase inputs such as fertilisers is highlighted by Hilson (2016).

3. SDGs Framework

The United Nations Sustainable Development Goals (SDGs) provide a holistic framework for assessing development across a broad set of objectives: social, economic and ecological. They can therefore serve as a useful tool in providing a realistic assessment of the costs, and crucially the benefits, of artisanal and small-scale mining across a number of dimensions. This tool can then be used to build into an economic and financial valuation of these costs and benefits to provide an overall assessment

of the contribution of ASM to sustainable development, and also identify key areas in which policies should be targeted to reduce the negative costs of the industry.

The interaction between the SDGs and the ASM sector has started to be discussed in the literature from a number of perspectives. Hilson & Maconachie (2020) focus oi the contribution ASM can make to several of the economic goals. Hirons (2020) provides a more critical perspective on the linkages – focusing on what the author perceives as a corporate and state-centric nature of the Goals – highlighting the danger of entrenching formalisation processes that fail to address issues such as poverty and inequality. This latter paper fits within a growing literature that offers a critique of the goals as offering a smokescreen for environmental destruction (Zeng et al, 2020), perpetuating paternalism in international development (Oloruntoba, 2020) and promoting anthropocentrism and neoliberalism (Adelman, 2018). These are valid critiques of the SDGs and the purpose of this paper is not to provide a value judgment on the SDGs as a whole. Instead we adopt the framework of the SDGs given its increasingly important relevance to national and international policymaking and use it to assess the varied impacts that ASM can have on the multidimensional nature of sustainable development.

A mapping exercise was undertaken regarding the impacts from ASM. This exercise extends similar literature that examines the mining industry as a whole (UNDP, 2016) and other sectors such as oceans (Le Blanc et al, 2017). The mapping exercise involved reviewing global literature on ASM, as discussed above, along with Guyana-specific literature, discussed in Sections 4 and 6 below. Both academic and grey literature were reviewed and where a specific impact that related directly and indirectly to the overall goal was identified in the literature it was mapped to the relevant goal. Such a mapping exercise could be conducted on several levels. This exercise focused predominantly on existing, direct, impacts as far as possible – although where indirect impacts have been identified such as the role of ASM in providing income for school fees and house maintenance – these were also included. An alternative approach, that is a critical area for future research, would have been to identify where policy interventions in ASM could change these impacts. For example, the effective implementation of policy that resolve land right complaints has great potential to assist the achievement of SDG 16.

Results of the mapping exercise are shown in Table 1. As can be seen, ASM has implications for all the SDGs (Goal 17 was excluded as it relates to the partnerships needed for achievement of the goals). Positive impacts arise in those SDGs related to economic activity and poverty, whilst negative impacts arise in categories relating to health and the environment. For some of the goals, such as those relating to hunger and work, impacts from ASM could occur in both directions. A key aspect that emerges from this preliminary mapping is the crucial role of interactions across SDGs and the potential for co-benefits and conflicts between the achievement of the SDGs. The role of interactions across the SDGs has been critically discussed in the literature (Pradhan et al, 2017; Nilsson et al, 2018) and the mapping exercise here can be seen a first step to understand the interactions as they relate to ASM. These interactions can be seen on two levels. On the one hand undertaking this exercise for ASM helps highlights the inherent interactions across the SDGs. The sector provides a series of economic benefits that may assist the achievement of SDGs directly, such as SDG 1 and 10, and indirectly through the investment of those benefits, such as SDG 4 and 11. The activities of the sector, if unchecked, may however hinder progress on environmental and social-related goals, such as SDGs 13, 14, 15 and 16. The sector itself therefore highlights potential trade-offs involved in the achievement of these goals. On the other hand, it can also highlight where policy interventions may have synergistic benefits across goals, - or trade-offs. For example, implementation of policy related to the emissions of mercury – if it comes at costs to ASM- may help the achievement of SDGs 3, 6, 14 and 15 – whilst hindering the achievement, in part, of SDGs 1, 4, 10 and 11.

For some goals, the picture is even more complex. For example, in SDG 2 there are two narratives emerging out of literature as it relates to ASM (Hilson, 2016). One the one hand ASM may induce greater demand for farmers, and may offer greater income for investment, whilst on the other it may result in the destruction of farming land, and the poisoning of rivers and streams that provide key sources of protein. The question for policymaking therefore becomes how interventions within the sector can be structured to encourage the former effect, whilst mitigating the latter.

Table 1: Mapping SDGs to impacts from ASM

SDG	Positive Benefit from ASM	Negative costs of ASM
1. No Poverty	Employment and wages providing livelihoods	
2. Zero Hunger	Induced demand for farmers, greater income for investment in farming assets	Destruction of farming land; poisoning of rivers and streams that provide fish
3. Good Health and Well-Being		Increased prevalence of diseases such as malaria and HIV; health-related issues relating to mercury emissions
4. Quality Education	Income from ASM can help support schooling	
5. Gender Equality	Employment opportunities	Human trafficking; exploitation of women
6. Clean Water and Sanitation		Water pollution may impact drinking water sources
7. Affordable and Clean Energy	Help to provide materials needed for low-carbon transition	
8. Decent Work and Economic Growth	Providing employment; contributing to economic growth; providing source of foreign exchange; multiplier benefits for local economies.	Human trafficking; poor occupational health and safety practices
9. Industry, Innovation and Infrastructure	Helps provide infrastructure such as roads; provide local level innovation for mineral extraction	Direct and indirect damage infrastructure due to activities
10. Reduced Inequalities	Provide employment opportunities to unskilled and rural populations	
11. Sustainable Cities and Communities	Provide income for investment in housing construction and maintenance	
12. Responsible Consumption and Production		Potential to undermine sustainable management of natural resources; mercury emissions and other chemical pollution
13. Climate Action		Emissions from deforestation and forest degradation

14. Life Below Water		Damage to water systems through mercury emissions and increasing turbidity
15. Life on Land		Damage to ecosystems through deforestation, forest degradation, soil damage, mercury pollution and damage to watercourses
16. Peace, Justice and Strong Institutions		Criminal activities linked to the sector; prostitution; human trafficking

4. Guyana Mining background

Guyana's mining sector has been the bedrock of its economy for the last two decades. It has been a key driver of economic growth and source of foreign exchange - termed as 'too big to fail' (Thomas, 2009).

The industry is segmented into a number of broad parts: mining of bauxite by large multinational companies; mining of gold by medium to large foreign-owned companies; mining of gold by small to medium locally-owned operators; and, mining of sand by locally-owned companies.

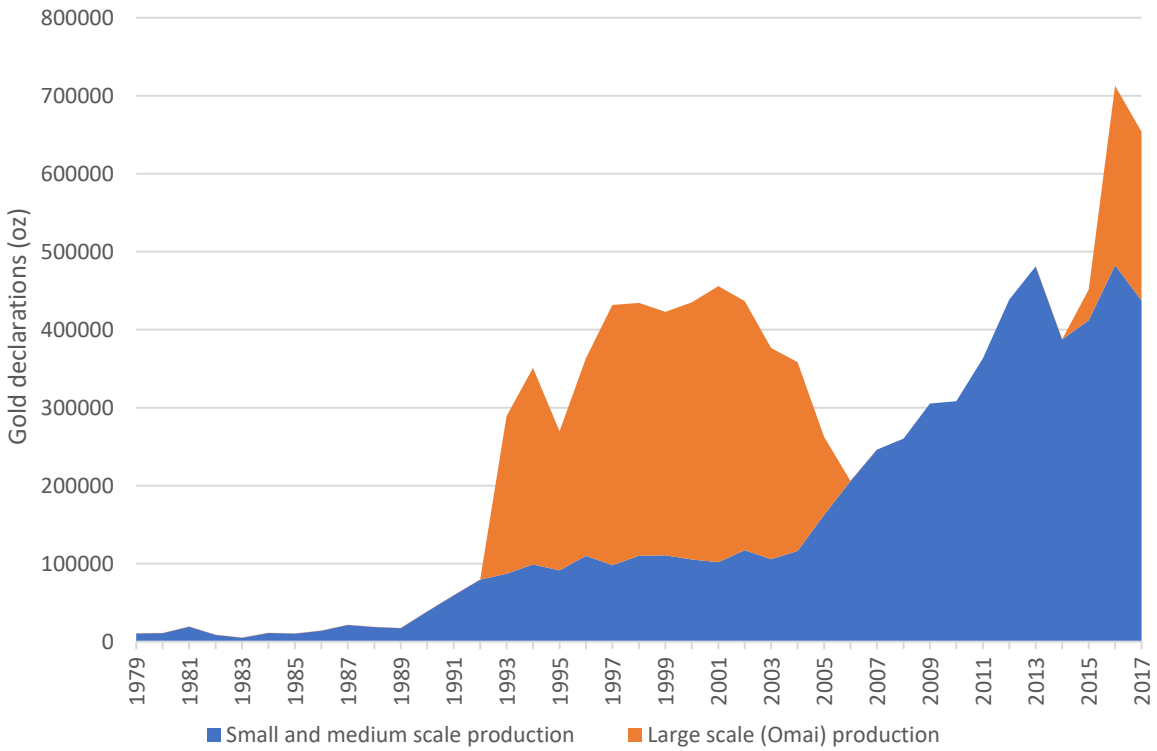
Mining has been a crucial part of the Guyanese economy since colonial times and at various times mining of minerals such as manganese and diamonds been vital to the economy (Forte, 1999; Clifford, 2011). Gold from ASM has become an important part of not just Guyana's economy but also part of its culture. Former slaves started the 'pork-knocking' culture after emancipation, following on from previous activity by the original Amerindian inhabitants (Forte, 1999). This activity has become a crucial part of many communities throughout the country, and has boomed in recent years due to changes in the legal framework, immigration of skills, people and technology from Brazil, and increases in prices (Laing, 2019).

Gold production grew from 5% of GDP in 2006 to over 10% by 2016 (Bureau of Statistics, 2020). The sector grew 246% between 2006 and 2016, accounting for on average 13% of all economic growth directly, with a much larger impact through indirect linkages to other sectors in the economy (ibid). Output grew from under 100,000 ounces annually in the early 1990s to a peak of over 700,000 ounces in 2016 [1] with most of this production from ASM.[2] A small number of medium to large-owned operations have opened in recent years, accounting for a growing share of production (Figure 1).

Figure 1: Annual Gold production in Guyana 1979 -2017: Source Author calculations from GGMC Annual reports

[1] Data for both small-scale and large-scale production was obtained from GGMC Annual Reports

[2] Production from large-scale mining occurred between 1992 and 2006 from a single, Canadian-owned gold mine at Omai, in the interior of the country.

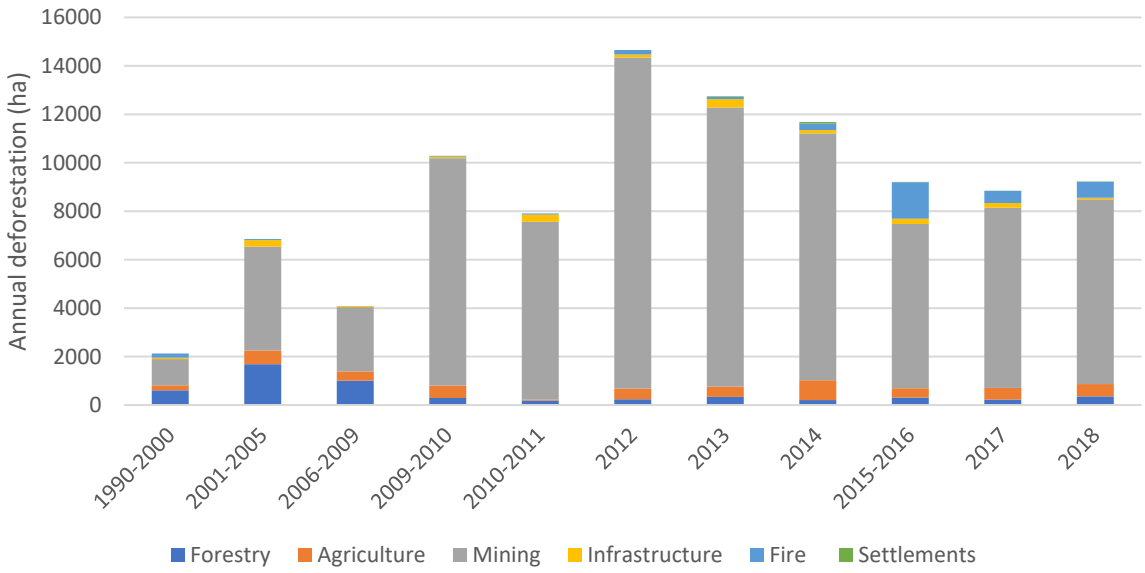


ASM has contributed to exports and economic growth, but its contribution to wider economic development and livelihoods is questionable. Hilson & Laing (2017a) examine the potential resource curse that has emerged in Guyana from the rapid increase in revenue from this mining sector, highlighting that although incomes have grown much of this wealth has been concentrated in a small number of operators, wealth has been off-shored and other sectors have been hit with the mining sector sucking out labour and capital. The capturing of the sector by the elite and the potentially negative consequences for broad-based development have also been highlighted in Bulkan & Palmer (2016) and Hook (2019a).

Mirroring the international experience, the rapid expansion of ASM in the country has led to environmental issues due to its use of mercury (with an estimated 2.39 kg of mercury used for every kg of gold extracted in 2013, McRae 2014), its pollution of water courses and the deforestation it can cause directly and indirectly (Roopnarine, 2002; Roopnarine, 2006). Mercury is a significant source of concern due to the spread of the activity across the interior of the country and the dependence of many of the indigenous communities that live in and around mining areas on fish as a key source of protein (Watson et al, 2020). The issue has been examined by a growing range of literature (Vieira, 2006; Hilson & Vieira, 2007; Howard et al, 2011; Kiefer et al, 2015).

Deforestation from mining has been of concern, especially since the start of a reducing emissions from deforestation and forest degradation (REDD+) agreement between Guyana and Norway in 2009. Mining has been identified as the main direct cause of deforestation, accounting for up to 74% and 91% of annual deforestation between 2009 and 2018 (figure 2) (GFC, 2019).

Figure 2: Annual deforestation in Guyana 1990-2018 (Source: Compiled from data in GFC, 2019)



The negative environmental impacts from the sector have been identified as being exacerbated by imperfect institutional conditions, informality and issues around enforcement (Clifford, 2011; Hook, 2019b). These issues have also contributed to social impacts such as conflict between miners and indigenous communities (Hilson & Laing, 2017b; Hook, 2019c). Further social issues, and health disparities such as crime, prostitution and trafficking have also been identified as being linked with the sector (Austin et al, 2007).

5. Valuing the Impact of ASM on SDGs

The impacts of ASMs are often complex, widespread and systemic generally resulting in social displacement, marginalization and severe ecological damages (Kitula, 2006). Such impacts can be valued either using contemporary valuation techniques or adopting a benefits transfer technique using meta-data. Contemporary valuation techniques such as stated preference and revealed preference methods require large primary data sets, are costly and can effectively value only one impact at a time (Hoehn, 1991). Benefits transfer technique is often viewed as a more cost effective means of conducting valuation studies as it uses existing data and transfers values to the relevant policy site(s) so long as the study and policy site(s) show ecological, economic and social similarities (Groothuis, 2005). With the extent and range of impacts identified (Table 1), for this study, a simple unit benefits transfer was employed by sourcing relevant literature that yielded a quantitative value for the impacts identified. Literature was explored for ASM in Guyana. Meta data were gathered from published and grey literature related to Guyana sourced from online searches and public records. The mapping of ASM impacts on the SDGs (Table 1) was used as a guide to search for the relevant literature. Scholarly research for Guyana was sourced using 'Google Scholar', 'Web of Science' and the University of Guyana library database. Grey literature was sourced from Conservation International (CI), World Wide Fund for Nature (WWF), the Guyana Geology and Mines Commission (GMC), the Guyana Forestry Commission (GFC), the Guyana Bureau of Statistics (GBSGBS), Guyana Lands and Survey Commission (GLSC), Ministry of Natural Resources, Ministry of Health and the Ministry of Indigenous Affairs for Guyana. Secondary data was also sourced from the World Bank, Food and Agriculture Organization (FAO), Inter-American Development Bank (IDB) and the Economic Commission for Latin America and the Caribbean (ECLAC).

From the literature gathered, relevant and quantifiable impacts were observed and linked to SDGs. Quantifiable impacts identified were then assigned a monetary value with the simple unit transfer technique. Values for these impacts were sourced from published reports within Guyana and from literature globally including and not limited to the global values for ecosystem services (Costanza et al., 2011), environmental damages from mercury (Hylander and Goodsite, 2006), public health costs (Alonso et al., 2019) and economic indicators (World Bank, 2020). The unit transfer technique is a relatively straight forward valuation technique accomplished by pooling data from relevant primary studies to estimate the observed changes in the policy site (Bateman et al., 2010). All values transferred were used as time and inflation adjusted approximate measures of the impacts identified for each SDG.

For a study of this nature, a review of meta-data was used to Guyana's context in order to establish a baseline value of the impacts outlined within the SDG framework Values from the literature were transferred to Guyana's context to estimate a proxy impact value. For the impacts where a measurable Meta data value was not sourced in the literature, a qualitative description from the literature of the impact was then reported.

6. Value Transfer Results and Synthesis

Our synthesis of the literature used to develop the map of ASM impacts on the SDGs (Table 1) showed that mining had distinct observable impacts on all of the SDGs. The results presented here will outline the main findings using the three dimensions of sustainability (social, economic and ecological) to arrange the information.

6.1 Social Dimension

Key SDGs related to the social dimension that were analysed against ASMs in Guyana include health and well-being (SDG 3), gender equality (SDG 5) and peace, justice and strong institutions (SDG 16). Literature shows the prevalence of infectious and sexually transmitted diseases, human trafficking, prostitution in indigenous communities and prevalence of violent crimes in mining camps along with health issues associated with infectious and vector-related disease, drug abuse and alcoholism (Austen et al., 2017; Colchester, Rose and James, 2002; Hilson and Laing, 2017; Singh et al., 2013).

According to the Pan American Health Organization (PAHO, 2017), there were 13,936 cases of Malaria recorded within mining areas which accounts for 94% of all recorded cases in the country. Medical reports from PAHO showed that the number of cases of Malaria in the country has reduced by 83% with records showing 84,017 reported cases in 1994. Malaria presents a significant public health cost. According to Alonso et al., (2019) the total public health cost including medical treatment, loss of working days and medical profession costs can estimate between US$7.90 per case up to US$107.64 for severe cases. Using these estimates, the total public health costs of malaria in mining communities can range between US$110,000 and US$1.5 million dollars annually depending on the severity of the cases. Haakenstad et al., (2019) published a global report on Malaria between 2000 – 2016 which showed that Guyana spent approximately US$1.6 million dollars on Malaria treatment and management within that time frame. The Haakenstad et al., (2019) study showed that the country spent around US$100,000 annually to deal with the Malaria problem - similar to our estimates. No reports on the severity of cases in Guyana were found in the literature.

Literature also shows the prevalence of HIV and other sexually transmitted diseases amongst miners. Palmer et al. (2002) highlighted that up to 6.5% of miners in Guyana were infected with HIV representing a significant reservoir for virus transmission within the country. Reports from the

Biologic Behavioural Surveillance Survey (2009) showed that the proportion of infections had declined to 3.9%. No data was found looking at the number of HIV cases occurring within the mining communities but evidence is showing nationally that the disease prevalence has increased by 23% since 2010 (UNAIDS, 2020). Where we cannot quantify the infection cost to society with the data available, the literature shows a negative social impact stemming from the factors causing the prevalence of the disease amongst miners. The University of Oklahoma International Human Rights Clinic (2009) stated that prostitution and sex trafficking rings developed alongside the mining sector and exploit indigenous women under the lure of employment in shops or guest houses. Colchester, Rose and James (2002) identified several reports of sexual abuse on indigenous women and prostitution rings with girls as young as 12 years old occurring in mining camps in Guyana. Miners often engage in illicit sexual activities and would return to their spouse transmitting diseases (Palmer et al. 2002).

The systematic spread of sexually transmitted diseases from miners seems to be a negative social consequence stemming from cultural norm within the mining communities of Guyana (Seguy et al., 2008). The prostitution and sexual abuse of indigenous women also inculcates several issues of gender inequality within mining communities (Mantini, 2008). According to Colchester, Rose and James (2002), Indigenous women normally assume the reproductive roles of the indigenous community and men normally assume the productive and community governance roles. Traditionally the indigenous men are the ones often employed to work in mining camps as labourers with the women affected by their absenteeism (Colchester, Rose and James, 2002). The culture and work practices in ASM are historically male dominated. Studies have shown that this is a global phenomenon in ASM operations. Hinton, Veiga and Beinhoff (2003) outlined that women are employed in ASM operations as service providers including care takers, shop keepers and cooks and are not employed directly in operational activities (Preston and Birch, 2018). This has implications in terms of the gender wage gap for mining as operational jobs pay higher wages. According to the GBSGBS (2012), there are approximately 13 male workers to 1 female worker in the mining sector in Guyana. No disaggregated data was found on gender wages and the employment activities of men and women. Despite the disparity of male and female workers, women activeness in mining is becoming more prevalent through the activities of the Guyana Women Miners Organization (GWMO), with approximately 700 members as of 2020, who are advocating for more equal rights in the sector. There is a need for more research on gender issues within the ASM sector in Guyana, including the wage gap, gender empowerment measures and current gender policies.

In the context of SDG 16 – peace, justice and strong institutions, literature shows mining areas in Guyana are hot spots for criminal activities. A study by Cummings et al., (2019) collated criminal report data for Guyana and identified the proliferation of crime hot spots especially violent crimes in and around major small mining areas. Roopnarine (2006) highlighted that mining camps are threatened by heavily–armed gangs particularly from Venezuela and Brazil, mainly because mining areas have low policing presence and miners are seen as lucrative and easy targets. In addition to gang activities and incidences of aggravated assault, there are several reports of human trafficking, illegal drug use and illegal mining activities (Singh et al., 2013). In 2018, the Ministry of Social Protection reported 156 cases of human trafficking in Guyana but no clear linkage was established to mining operations.

Despite no statistical data available to confirm the number of reports as a result of mining operations, several public sources highlight the vulnerability of women and children especially from indigenous communities in the vicinity of mining areas to human trafficking (Colchester, Rose and

James, 2002; Department of Public Information (DPI), 2018; Mantini, 2008 United States Department of State, 2018). Most victims are trafficked to neighbouring Brazil and Venezuela where they enter into domestic services or prostitution. In 2017, the government of Guyana invested approximately US$200,000 in efforts of prevention and social support for victims of human trafficking (US Department of State, 2018). Outside of government expenditure on tackling human trafficking nationally, there is an absence of empirical data to value the full impacts of human trafficking in Guyana as a symptom of the ASM culture and modus operandi. There is a wide scope for research still needed to unravel the complexity of the relationship between ASM operations and human trafficking.

When it comes to illegal drugs and narcotics, ASM camps are hubs for illegal drug activities, both as a network for drug trafficking and drug use (Clegg, 2014). Substance abuse is prominent amongst miners in Guyana. Seguy et al., (2004) reported that 92% of miners in Guyana are alcohol users, 49.6% occasionally use marijuana and 8.3% use cocaine. Statistics from the Guyana National Household Drug Prevalence Survey (2016) showed that 35.7% of mining camps sampled had prevalent drug abuse. Drug trafficking in and around mining areas is quite frequent given the isolation and low police presence of mining camps. Usually the same criminal rings that engage in human trafficking are using the same channels to move narcotics as well (Mantini, 2008). Similar to the human trafficking issue, it is difficult to value the social impact of the illicit drug activities from the mining areas because of limited data. The proliferation of health and safety issues outlined for ASM in Guyana (Colchester, Rose and James, 2002; Laing, 2019, Roopnarine, 2002) shows a significant social cost but this baseline estimate still has many elements to capture. Further work is needed looking at the statistical value of mining workers' life to fully assess the potential mortality risks and subsequent socioeconomic effects due to the health and safety risks for miners and the surrounding communities.

On the contrary, the literature also shows that a regulated mining sector, with policies inclusive of the rights of indigenous communities can see mutually beneficial development between the industry and indigenous people (Altman, 2012; Boni et al., 2014; Haalboom, 2012). As such, the social state and condition of the ASM can be seen as a positive impact to SDG 16 if within the context of a mining industry that values sustainable and participatory operations. Guyana's present ASM sector is not operating in such a manner but with the right policy, legislative and enforcement framework to change this perspective, the industry can enable the country in achieving SDG16 specifically from the indigenous people context of the country.

Our search showed that most of the social issues uncovered in the ASM sector is not caused by the presence of the industry itself but rather from a culture of predatory opportunities, lack of educational opportunities and geographical isolation restricting law enforcement (Colchester, Rose and James, 2002; Langer, 2018; Persaud et al., 1999; Roopnarine, 2002; Trotz, 2014). The lifestyle, culture and social norms of the ASM industry in Guyana are a precursor reflecting larger social issues prevalent in the country (Whitehead and Aleman, 2009). The negative social perception of ASM has more to do with the national policy agenda failing to address wider social issues that are most visible in mining areas.

In our assessments, the main behaviour that will negatively impact the country achieving SDG 16 is the lucrative lure of gold mining promoting the prevalence of illegal mining operations. The prevalence of illegal mining in Guyana occurs primarily due to a lack of public confidence in the institutional and regulatory bodies and corruption. The GGMC is the primary agency overseeing the

institutional framework for the ASM sector in Guyana but the commission has a myriad of issues and accusations of corruption in the public domain. In 2014, GGMC carried out a management and systems review which revealed a pervasive perception of corruption, perceived lack of transparency and low public image. Part of the review conducted revealed the prevalence of bribes to mining officers to ignore tailings dumping and a steady decrease in the expenditure and monitoring activity of mining officers in the field (Walrond, Heesterman and Goolsarran, 2015). According to Bulkan and Palmer (2016), miners in Guyana have expressed the absence of controls and adherence to regulations mainly because of a culture of corruption by mining officials to ignore illegal activities. According to Lowe (2006), the GGMC estimated that 17% of small and medium scale dredges are owned by Brazilians who are often accused of illegally smuggling gold to Brazil and not paying state taxes and royalties. There are no current records on the number of illegal ASM operations in Guyana. In order to value the cost of weak institutional confidence, corruption and illegal mining activities, data on undeclared and smuggled goal was sourced. In 2005, the GGMC estimates that between 30% - 80% of total gold output were undeclared and smuggled out without being taxed annually (Harvard Law School, 2007). The estimated value for this proportion of gold based on 2005 prices was approximately US$200 million dollars annually (Bulkan and Palmer, 2016). In 2015, the GGMC estimates that 15,000 ounces were being smuggled per week costing the country between US$912 million to US$1 billion that year (Pasha, Wenner and Clarke, 2017).

6.2 Ecological Dimension

ASM in Guyana has a notorious ecological footprint which impedes the country in achieving the SDG goals related to the environment (See Table 2). Predominantly, ASM has negative environmental effects on land (SDG 15) and water (SDG 14) ecosystems. Literature sourced outline two areas of concern, 1) impacts from land clearing and dredging – physical degradation and 2) the discharge of metallic mercury from the amalgamation process – chemical contaminant (Pasha, Wenner and Clarke, 2017). Physical degradation resulting from ASM include deforestation, clearing of top-soil, agitation of river beds and river bank erosion often leading to the disruption of wild life habitats and potential loss in ecosystem services (Roopnarine, 2002). ASM in Guyana is the leading cause of deforestation (see figure 2). Bholanath and Cort (2015) highlighted that 90% of deforestation in Guyana was caused by ASM. Miners clear forested areas to construct mine pits, tailing ponds, processing facilities, living quarters and access paths. Miners also use the wood for fuel and to construct their camps. Pasha, Wenner and Clarke (2017) identified that between 1990 and 2009, an estimated 45,000 hectares of forest was cleared for gold mining. Valuing the impact that ASM has on deforestation, an estimated value of US$5,382 per Ha sourced from Costanza et al. (2011) was used as the total economic value of tropical forest ecosystems. The total economic value of tropical forest includes the value of timber, climate regulation, erosion and flood control, habitat, nutrient cycling, cultural and recreational services. Using the estimated losses of forest in Guyana from ASM sector, the total average value of deforestation costs caused by ASM is approximately US$9.1 million dollars annually – using average historical deforestation rates.

The clearing of forest land is further compounded by the removal of topsoil from dredging. Singh et al., (2013) estimates that a single dredge can remove up to 130 tonnes of topsoil daily and with approximately 4000 registered dredges in Guyana according to GGMC, daily topsoil removal can be up to 520,000 tonnes. Darmody et al., (2009) approximates that the total economic value of topsoil including the ecosystem services it provides is worth US$19 per tonne. With these estimates, the daily operation of a single dredge can potentially have a negative environmental cost of US$2,470.

More information is needed on the frequency of dredge activity annually in order to fully assess the annual cost of top-soil removal.

Issues of erosion, habitat destruction and sedimentation along watercourses in proximity of the mining areas has threatened downstream mangrove ecosystems and aquatic wildlife populations, created fragmentations in animal corridors and reduced the carbon sequestration potential from the country's forested areas (Hilson and Laing, 2017a; Lowe, 2006; Pasha, Wenner and Clark, 2017; Roopnarine, 2002; Singh et al., 2013). The downstream effects do present a large social cost but limited data is available to justifiably estimate this cost.

The most well documented impact of the ASM sector in Guyana is the mercury discharge issue. In the Guyanese context, a number of studies have examined the mercury problem in more depth (Miller et al, 2003; Hilson & Vieira, 2007; Howard et al, 2011; Kiefer et al, 2015; Watson et al, 2020). The United Nations estimates that the ASM sector in Guyana imports between 7.5 – 22.5 tonnes of mercury annually (Legg, Ouboter and Wright, 2015) costing between US$240,000 – US$720,000 annually. Romero et al., (2016) in developing the Guyana Initial Minimata Assessment Report approximated that total mercury emissions for air, water and land is 28,790 kg per year. Emission concentrations of mercury in the soil and water show high concentrations consistently across all gold mines in Guyana. Howard et al., (2011) estimated total average mercury loadings in sediments across all gold mining sites in Guyana at 226 $\pm$ 171 ng/g with some mining areas recording values up to 527 $\pm$ 92 ng/g and mercury concentrations in water across Guyana ranging between 0.053 to 0.301µg/g. The proliferation of mercury use and discharge observed for Guyana from the ASM sector impacts water courses, soils and atmosphere around mining areas trickling into ecosystem food webs and impacting the health of miners and the surrounding indigenous communities. In 2001, a GGMC survey found 57% of carnivorous fishes sampled had mercury levels exceeding World Health Organization (WHO) guidelines (Legg, Ouboter and Wright, 2015). Singh et al., (2000) reported that the methyl mercury (measured as total mercury in hair) found in fish specimens sampled in water courses across Guyana had concentrations ranging between 0.24 – 1.81 µg/g with up to 39% of specimens found exceeding WHO guidelines. The majority of the fish species and water courses surveyed are vital fishing grounds and sources of water for the indigenous communities and miners. Studies have shown increasing mercury levels in the villagers of indigenous communities across Guyana. Colchester, Rose and James (2002) reported findings between 2 - 22 µg/g of mercury in the hair samples of Carib communities along the Barima River in Guyana. Singh et al., (2013) summarized surveys done on mercury contamination in indigenous communities around Guyana and found mercury concentrations up to 70.8µg/g or 5 times the WHO limit, in hair specimens of nursing and pregnant women from villages close to ASM operations. Watson et al (2020) conducted a similar study, examining mercury levels in hair in indigenous communities in Guyana – finding that levels were above World Health Organisation reference values for residents in close proximity to ASM activities. No reports were sourced looking at the concentration levels for miners.

Mercury directly contaminates miners through fumes and direct contact, water courses, soils and their respective food webs and it indirectly contaminates indigenous communities from the watercourses, fish and wildlife they depend on (Lowe, 2006; Pasha, Wenner and Clarke, 2017; Roopnarine, 2002; Singh et al., 2013). In order to value the social cost of mercury contamination two studies were reviewed for the unit transfer value. The marginal damages of mercury contamination on people proposed by Spadaro and Rabl (2008) estimates a value of US$1500 – US$3400 per kg of mercury emission. The values proposed by Spadaro and Rabl (2008) was estimated based on the neurological health impact of varying concentrations of mercury and the estimated value of losing neurological functions measured by the change in intelligence quotient (IQ). Hylander and Goodsite

(2006) estimate that mercury as a point source pollution and remediation measures globally is valued between US$2,500 to US$1.1 million per kg dependent on severity of contamination and environmental factor. Both studies derived their values after reviewing mercury emission valuation research globally. For Hylander and Goodsite (2006), the lower bound value was used as a conservative estimate measure. The estimated costs of mercury emission in Guyana potentially have an environmental damage cost of US$72 million annually and a potential damage cost to people between US$43 million – US$98 million annually.

More empirical work is needed to fully assess the social costs of the ecological damages associated with ASM. Updated research looking at changes in the ecological status quo as it relates to forest loss, water and soil contamination, indigenous livelihood impacts and biodiversity threats from the ASM sector in Guyana is needed to accurately estimate the value of the impacts on the environmental related SDGs. Such empirical work would provide the critical knowledge base needed to address larger policy issues and aid in assessing the sustainability pathway of the country based on the principles of ecological foot print and the green economy.

6.3 Economic Dimension

The wealth and economic prosperity provided by the ASM sector has been one of the main enabling factors in the country striving towards achieving the economic related SDGs. The mining sector in Guyana presently is the most prosperous sector for the country in terms of wealth generation, foreign exchange earnings and employment with gold and diamond mining accounting for 9% of total GDP (Singh et al, 2013). In the total productivity of gold, ASM accounts for 70% total production and employs approximately 17,000 – 35,000 persons (McRae, 2014; Pasha, Wenner and Clarke, 2017). In terms of total revenue generation, the ASM sector generated between US$234 million – US$548 million annually from 2010 – 2017. Estimates were calculated using annual prices for gold and the production of gold declared for the country (figure 1). As of 2019, raw gold is the highest value export for Guyana at US$411,214,600 accounting for 55% of all export values and foreign revenues from the trade in goods (GBS, 2020).

The significant revenue generation for the sector makes it possible to sustain consistent employment and investments in infrastructural development. For a country to achieve the SDGs of no poverty (SDG 1), reduced inequalities (SDG 10) and decent work and economic growth (SDG 8), then sustainable employment is necessary. ASM pays a substantially higher wage rate compared to the other employment opportunities for persons living in Hinterland mining areas. This makes working in mines an attractive prospect especially for the men in indigenous communities (Colchester, Rose and James, 2002). Singh et al., (2013) identified that a dredge operator earns up to US$60,000 a year, service workers such mechanics, cooks and delivery drivers can earn up to US$12,000 a year and a labourer earns up to US$9,600 a year in wages. Comparing GBS data of wages in the country, the wage level of service workers and labourers in ASM are equivalent to teachers and public sector staff in the country. GBS data also shows that the ASM sector is the largest employer of unskilled persons in the country. For Hinterland indigenous communities where educational opportunities and employment options are limited, mining has provided a lucrative means of earning a livelihood (Clifford, 2011). Despite the lure of employment in the ASM sector, the industries reputation for deplorable working conditions, unsafe environments and violations of national labour laws including the employment of child labour is well documented (Bulkan and Palmer, 2016; Colchester, Rose and James, 2002, GGMC, 2015).

Assessing other macroeconomic indicators for wealth and livelihood, Guyana's Gini coefficient ranges between 0.45 – 0.5 since 1998 (World Bank, 2020). This indicates the country has a

consistent measure of unequal distribution of its wealth and the productivity observed from ASM (seen in figure 1) has not significantly contributed to reducing inequality issues. In terms of public sector revenues, taxes and royalties paid to the state increased from US$1.5 million in 1998 to US$14 million in 2008 representing an 86% increase (Thomas, 2009). Over the same time line Guyana's real GDP growth averaged around 4.1% predominantly because of the increase in production from extractive industries such as the ASM (World Bank, 2020). Despite the increase in gold revenue over the last 20 years, the literature shows stagnation of the innovation, technology adoption and infrastructure (Clifford, 2011; Hilson and Laing, 2017; Hilson and Vieira, 2007; Lowe, 2014; Roopnarine, 2002). Generally, there seems to be a lack of investments being made in ASM but more empirical data is needed to verify. Consequentially, the economy of the country is dependent on the gold and mining industry and so a failure to invest in its development can open the sector to economic vulnerabilities and shocks such as a decline in real export earnings, which can have several trickle-down economic effects including fiscal deficits, declining terms of trade and inflation (Hilson and Potter, 2005).

6.4 SDG Feasibility Framework

ASM is a significant revenue source for the country but the current state of operations, management and the policy environment perpetuates a significant social and environmental cost. In our synthesis, we attempted to assign values to the benefits and social costs of the ASM sector using the SDG framework as a template to map its impacts (See Table 2). For the impacts where data was not sufficient to find values, we reported on the qualitative evidence to highlight the areas where policy intervention is needed. Table 2 also presents the research gaps identified from this assessment for the sector based on achieving the SDG targets that needs to be addressed in order to identify the appropriate policy needs for the sector. The negative social and environmental costs related to ASM may not factor in the short term outlook of the industry presently as seen in the literature (Mudd, 2007; Schueler, Kuemmerle and Schröder, 2011) but as the country strives towards a 'green economy' (Department of Environment, 2019) , then sustaining the ASM sector in the long run requires a holistic and data driven policy intervention to address the negative social and ecological impacts identified in this study.

Table 2. Estimated values and empirical evidence of the Impacts of the ASM Sector in Guyana

Sustainability Dimension	**Impacts from ASM mining**	**Value or Empirical Evidence**	**Affected Sustainable Development Goals**	**Net Outcome**	**SDG Research Gaps Identified**
Social	- Prevalence of Malaria cases in mining areas.	- A reported 13, 936 cases of malaria from mining areas (PAHO, 2017) with an estimated public health cost ranging between US$110,000 and US$1.5 million dollars annually. - Global Malaria reports show that Guyana spent US$100,000 annually from 2000 – 2016 on Malaria treatment and management (Haakenstad et al., 2019).	- The location of mines exposes miners to regular mosquito infestations thus a negative implication on achieving SDG3.	The ASM sector is impacted with a myriad of social issues in Guyana based on findings in the literature. There is the prevalence of disease, crime, exploitation, drug use, violence, corruption and gender discrimination. The most notable social cost comes from the illegal smuggling of gold. Socially, the ASM sector has a negative net outcome to society.	- Mining have negative impacts on Health and Well-being (SDG3). More work is needed on the value of a statistical life to effectively measure the loss of lives or livelihoods affected as a direct or indirect consequence of mining. - With the myriad of health and safety issues impacting mining workers and mining communities will impact achieving the targets of decent employment and economic growth (SDG8). Health and Safety issues in the ASM sector was notably absent from the literature. More work is needed looking at the health and safety practices and protocols established for the sector, and whether these protocols are being enforced.
	- Mining areas considered transmission hubs for HIV and other reported STDs.	- HIV prevalence in mining areas decreased from 6.4% to 3.9% (Biologic Behavioural Surveillance Survey, 2009).	- The issue of HIV and substance abuse may be a symptom of a larger social issue but its presence in the mining sector stills represents a negative		
	- Prevalence of substance abuse amongst miners.	- 92% of miners use alcohol, 49.6% use marijuana and 8.3% use cocaine (Seguy et al., 2004; Household Drug			

		Prevalence Survey, 2016)	impact on SDG3.		- The prevalence of crime, trafficking, smuggling and drug use in mining areas was readily identified in the literature and will impact achieving a peaceful and just society (SDG16). Reporting and monitoring of criminal activities in mining areas is sparse and lacking. More data is needed on incidences, victim effects and criminal hotspots. - The ASM sector is presently one of the main earners of foreign exchange contributing the economic growth and diversification of the country (SDG8). The sector is losing a significant value in revenue through illegal smuggling at the expense of the society. More work is needed in understanding the enabling factors that continue to promote the illegal smuggling of gold out of the country.
	- Poor worker conditions and employee health impacts from mercury emissions.	- No concrete empirical data but qualitative reports and articles documented the issue.	- The mercury emission from the sector threatens the health of the surrounding villages and workers which is a negative implication in achieving SDG 3 & 8.		
	- Health impacts in the surrounding communities from mercury mining.	- Findings showed mercury levels up to 5 times above WHO limits (Singh et al., 2013; Watson et al., 2020) found in indigenous people with a social cost approximately between US$43 million – US$98 million annually.			
	- Mining areas are hubs for gang violence, drug trafficking, human trafficking and prostitution.	- No empirical data sourced but several articles and reports showed the issue. Government spent US$200,000 for human trafficking victim support (US Department of State, 2018).	- Prevalence of crime, corruption and deviant behaviour occurring due to the isolated locations of mines, low enforcement in mining areas and low risk to reward ratio is a negative		
	- The lure of gold has seen	- Estimates showed up to US$1 billion worth in			

	a rise in gold smuggling from illegal miners.	gold is smuggled out annually (Pasha, Wenner and Clarke, 2017).	implication in achieving SDG 16.		- The gender dimensions in mining are complex and can inhibit achieving a fully gender equal society (SDG 5). More research is needed on the social and psychological effects of the sexual exploitation of indigenous women and the economic reasoning that perpetuate the sex trade industry in mining areas. Additionally, more work is needed looking at the gender wage gap for the sector.
	- Large gender disparity of workers in the mining sector.	- 13 male workers to 1 female worker employed in the sector (GBS, 2020).	- Employment in the mining sector shows a wide gender disparity gap which has a negative implication for SDG 4.		
Ecological	- Mining is the leading cause of deforestation in Guyana.	- Approximately 45,000 Ha of forest loss caused by mining (Pesha, Wenner and Clarke, 2017) with an estimated value of US$9.1 million annually.	- Deforestation caused by mining is a negative environmental impact that impacts the climate action and life on land initiatives (SDG13&15).	The ASM sector has documented evidence of the sector causing ecological degradation in the river courses and forest areas of Guyana. The sector is the leading cause of deforestation, sedimentation in river ways and pollution from mercury. Ecologically, the ASM has a negative net outcome to society.	- The deforestation, soil dredging and mercury discharge resulting from the ASM sector will have systemic ecological effects on carbon sequestration (SDG13), biodiversity in water (SDG 14) and biodiversity on land (SDG 15). More ecological research is needed to identify these systemic impacts including downstream effects, mercury contamination in the food web and the value
	- Dredges remove large quantities of top soil leading to erosion,	- One dredge can potentially remove up to 130 tonnes of top soil per day (Singh et al., 2013) which has an environmental cost of	- Loss of top soil from dredges causes erosion and turbidity and negatively impacts		

	sedimentation and habitat destruction.	US$2,470 per day of operation.	achieving SDG 13&14.		of ecosystem services lost due to mining. - All the negative environmental consequences show a lack of policies to enable sustainable production and consumption (SDG12). More research is needed on the adoption and diffusion of technology standards for the sector including mercury free technology, the implementation of ISO 14001 standards and progressive reclamation and re-vegetation.
	- The industry discharges 28,790 kg of mercury emissions per year affecting watercourses, soils, wildlife and the ambient air (Romero et al., 2016).	- Total environmental cost of mercury including impacts on water, soil and biodiversity is approximately US$72 million.	- The proliferation of mercury use in the industry shows unsustainable consumption and production (SDG 12) and negative impacts to watercourses (SDG 13), soil ecosystems (SDG14) and biodiversity which affect the food sources of indigenous communities (SDG 2).		
Economic	- National Revenue (2010 – 2017)	- US$234 million – US$548 million in revenue generated annually (Meta-data compiled from GGMC Annual Reports).	- Competitive wages will contribute to the reduction of poverty (SDG1).	The ASM is a significant revenue source and foreign exchange earner for the country. The sector employs a large portion of rural inhabitants and pays a very competitive salary compared to other industries. The ASM sector expends foreign exchange to import equipment	- The ASM sector is one of the main economic sectors for the country contributing to zero poverty (SDG 1) through employment and economic growth (SDG 8) through wealth generation. More research is needed on how policy frameworks promoting sustainable
	- Competitive wages compared to	- Skilled worker can earn up to US$60,000 annually and an			

	other industries.	unskilled worker can earn up to US$9,600 annually (Singh et al., 2013).		and mercury but this does not create an exchange deficit. Economically, the ASM sector has a positive net outcome to society.	mining will foster the economic growth and increase the marginal social welfare for all of Guyana in the long run.
	- Employment especially for unskilled and indigenous persons.	- Approximately 17,000 – 35,000 persons are presently employed in the ASM sector (McRae, 2014; Pasha, Wenner and Clarke, 2017).			
	- Largest earner of foreign exchange (1998 – 2019).	- US$411 million in foreign exchange earnings annually (GBS, 2020).	- Wealth and foreign exchange will have a positive impact on employment and economic growth (SDG9). -		
	- Royalties and taxes for public spending.	- US$ 14 million – US$ 40 million paid in taxes and royalties annually (Thomas, 2019).	- Public sector spending of resource taxes and royalties from ASMs contribute to the country's human capital needs (SDG 3 & 4) and infrastructure development (SDG 5, 6, 8 & 11).		

	- No linkages between revenue generation from the ASM sector and income equality in the country.	- Gini coefficient for Guyana range between 0.45 – 0.5 (World Bank, 2020) .	- No direct empirical link associated with the ASM sector and reducing inequality in the country (SDG 10).		
	- Importation of mercury for the amalgamation of gold.	- 7.5 – 22.5 tonnes of mercury imported at a value ranging between US$240,000 – US$720,000 annually (Legg, Ouboter and Wright, 2015)	- Guyana is one of the world's highest importers of mercury which is an unsustainable production practice in gold mining impacting SDG 12.		

7. Conclusions

ASM has been often been maligned in literature and international and national policy. The sector does contribute to a range of negative social and ecological issues, but at the same time provides a valuable source of incomes, revenue and employment to individuals, regions and countries. SDGs provide a tool to assess these two sides of the coin. ASM can assist greatly a range of countries to meet key goals relating to employment, growth and goals relating to infrastructure and energy. It may however limit the scope of achievement of a range of other SDGs related to social and ecological goals. This nuanced reflection on the benefits and costs of ASM allows a more balanced approach to policies that would allow the positive benefits to emerge whilst mitigating the negative costs.

Whilst understanding this perspective can assist policy-makers to produce balanced approaches to the sector – providing economic valuations of the benefits and costs can help focus key institutions such as the finance and natural resource ministries as to both the importance of the sector and also where policy changes need to occur to ensure that maximum societal benefits arise from the sector. Such an approach to policy would promote activity within the sector, whilst ensuring that negative aspects such as environmental degradation, social ills, health and safety gaps and gender issues are adequately addressed. This can be achieved through policies such as formalisation, fiscal incentives, technical support and institutional development within the country's context. The aim of this paper was not examine the implementation issues with these previously-identified solutions but to provide an assessment at international and country-level that can help to more readily communicate the complex issues relating to the positive benefits and negative costs of ASM to policy-makers outside the sector. The combined framing of these impacts within the SDGs along with associated economic valuations may prove to be a more useful tool for communication with policymakers outside the extractive industries. Understanding the true value of such a tool is beyond the scope of this paper but is an important avenue for future research. The combination of the SDG framework and economic values can assist policymakers to help decipher the responsible agencies that need to address individual impacts from the ASM sector and the proxy values provide justification for the need for policy intervention without any detailed cost-benefit analysis to decipher policy feasibility.

The value of such an approach can be shown in the example of the exercise in Guyana. This highlights clearly that ASM can, and has, contributed progress towards key economic goals such as SDG 1, but has caused ecological and social issues to arise, hindering progress towards SDGs 13, 14 and 15. A wide range of these benefits, and especially the costs lie beyond the scope of economic valuation, due to lack of data or merely they are conceptually nigh impossible to value. However, an approximation to the overall contribution of the sector to economic, social and ecological prosperity and the achievement of the SDGs is possible. Aside from its contribution to providing employment and tax revenue, the sector provides in the range of US$500 million per annum in revenue. Social costs from health issues related to malaria and mercury and issues such as human trafficking and drug use are likely to be in excess of US$100 million per year. Ecological issues such as deforestation, top-soil removal and mercury emissions also cause costs in a similar range. Indirect social issues also result from these ecological issues relating to the health impacts of exposure to methyl mercury. A back of the envelope calculation arising from the costs and benefits therefore highlights the overall positive contribution that the sector can make to Guyana's society and economy – but it should be noted clearly that this excludes a number of impacts to which values could not be attached. It also highlights key areas of concern for designing policy to address the social and environmental costs. Indeed, the costs from mercury far exceed other areas of environmental issues such as deforestation that have

received considerable policy attention (Kalamandeen et al, 2018; Caballero Espejo et al, 2018). It is important to note here that mercury internationally, and within Guyana, is planned to be phased out which would, if achieved, dramatically reduce some of the ecological consequences of the sector.

The mapping of mining impacts on to the SDGs and subsequent valuation in a single country case study provides a framework that can be applied to other countries in which ASM are prevalent, especially sub-Saharan Africa, and can help guide governments on determining an overall approach to ASM – and to prioritise resources to target the key costs that need to be minimised whilst ensuring that the positive economic and livelihood benefits are retained. Indeed, this exercise may prove more useful as a guide to policymakers beyond Guyana where policy is relatively more developed. It can also serve as a key tool for helping to understand what is not known about the sector, either at the level of impacts or at the level of data on the scale, scope and impact of these impacts.

The technique of mapping impacts first to the SDGs overall – and the drilling down to economic values can also be applied to other sectors such as forestry, oil production and large-scale mining, that may provide economic benefits but bear extensive social and ecological costs. There are however several limitations of adopting the SDGs as the initial framing point for the varying impacts of ASM. The multidimensionality of the SDGs is vital in important in capturing the multi-faceted nature of sustainable development – however greater analysis is needed on the interactions between the different goals on a global, sectoral and policy level. The mapping of impacts on to SDGs can help highlight some of these – but greater work is needed to understand the full scope of synergies and trade-offs as it relates to both the ASM sector as a whole and crucially around specific recommended policy interventions. The SDGs also present only one perspective of sustainable development – critiqued by some as focusing on state-centric, large-scale industrial views of development. Adoption of this framework does therefore risk a bias towards policy prescriptions that cater for this perspective. However, this comes at the risk of using a tool that is already integrated into national and international policymaking. Understanding the benefits and challenges of such an approach is a crucial area for future research.

The process of economic valuation is not perfect. As highlighted in this analysis there are many impacts, both positive and negative, that have proved impossible to place full economic values upon, especially those relating to the ecological and social impacts. This raises the potential of overestimating the benefits (that are easier to monetise) and underestimating the costs. Combining however, these values with the type of qualitative mapping of impacts to the SDGs conducted in this analysis can however reduce this effect and provide a more holistic balance of the positives and negatives from the sector. The economic values provide greater insight and illustration to this holistic balance although must by read with caution due to both issues with data and also conceptual issues around the trade-offs between economic and ecological values.

A crucial aspect for future research in relation to the sector lies in providing greater data from which such evaluations can be conducted to allow evidence-based policy to be developed. Initiatives such as DELVE[3] can greatly assist in this direction. But supplementing the data it provides with greater evidence as to the value of costs and benefits associated with the sector would allow for greater and richer assessments to supplement the analysis provided in this paper and in turn help create greater understanding of the sector across policymakers more broadly and help the implementation of more effective and efficient policy.

[3] https://delvedatabase.org/

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