Cost Benefit Analysis of Re-Developing the Panguna Copper-Gold Mine in Autonomous Region of Bougainville

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Disclaimer

Although Autonomous Bougainville Government’s visions are comprehensively represented throughout the content of this document, the authors claim any misrepresentations and opinions that may contradict other stakeholders’ views. Also, SSRN, School of Mining Engineering and Department of Mining and Petroleum, and the Autonomous Bougainville Government disclaim the methods, modeling and data analysis and interpretations, and these were the views of the authors.

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A path has begun for a new frontier of resource development
amidst challenges and myths

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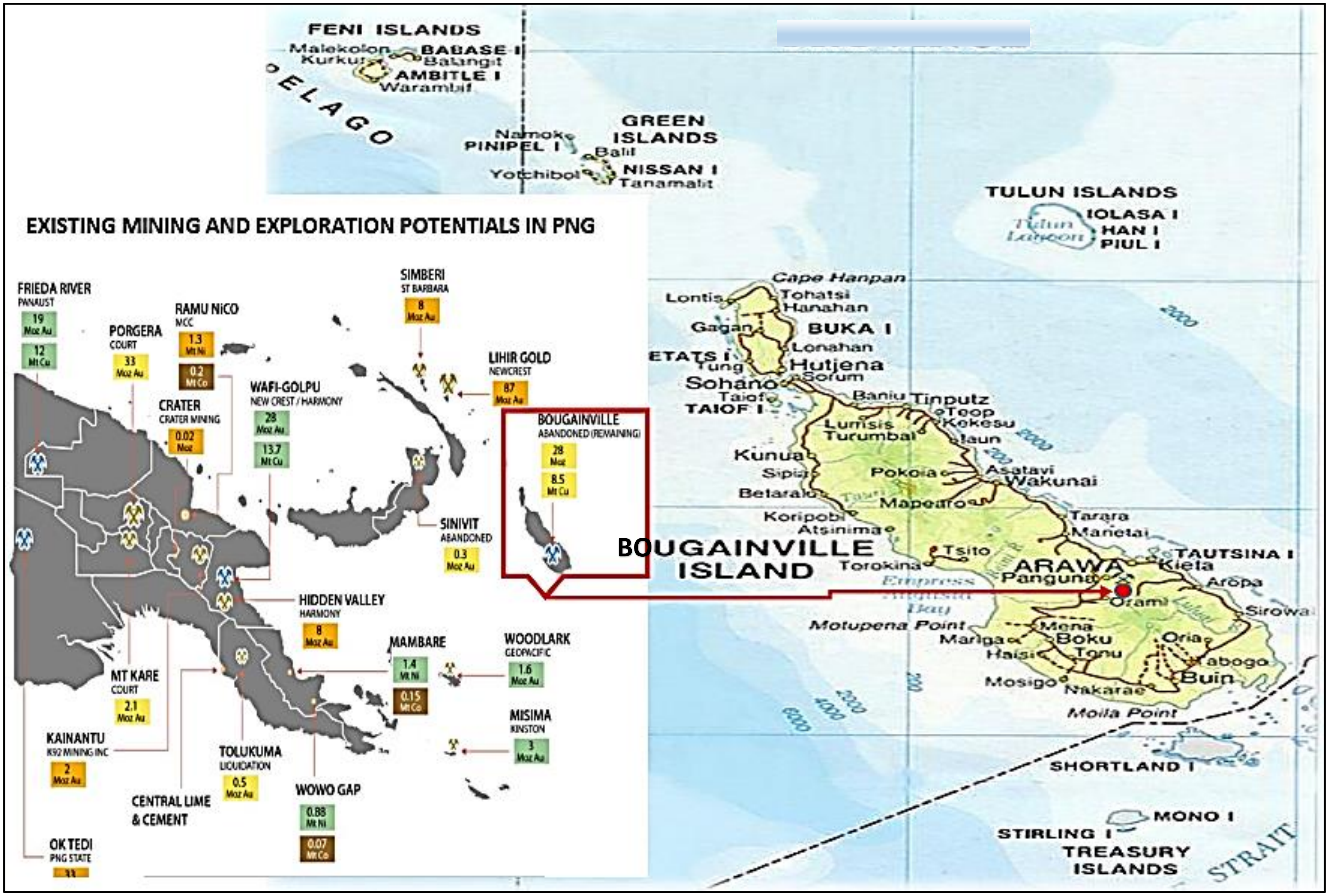
GLOSSARY OF ACRONYMS

ASM	Artisanal and small-scale mining
ABG	Autonomous Bougainville Government
AMD	Acid mine drainage
AMT	Arawa mining town
APT	Additional profit tax
ARoB	Autonomous Region of Bougainville
Au	Gold metal
BCL	Bougainville Copper Limited
CBA	Cost Benefit Analysis
CBR	Cost benefit ratio
Capex	Capital cost
CAPM	Capital Asset Pricing Method
CF	Cash flow
CIT	Corporate income tax
Cu	Copper metal
DCF	Discounted cash flow
DMP	Department of Mining & Petroluem
DSTP	Deep sea tailing displacement
DWT	Dividend withholding tax
EL	Exploration license
FCF	Free cash flow
FDI	Foreign direct investment
FIFO	Fly-in Fly-out
GDP	Gross domestic Product
GoPNG	Government of Papua New Guinea
IRR	Internal rate of return
JV	Joint Venture
LCF	Loss carry forward
MCS	Monte Carlo simulation
METR	Marginal effective tax rate
MoU	Memorandum of Understanding
NETR	Net effective tax rate
NPV	Net present value
Opex	Operation cost
Oz	Ounce of gold
PNG	Papua New Guinea
PNGK	Papua New Guinea Kina
PV	Present value
RADR	Risk Adjusted discount rate
SDR	Social discount rate
RSF	Revenue Stabilisation Fund
SSG	Special support grant
SWF	Sovereign wealth fund
TCS	Tax credit scheme
WHT	Withholding tax
USD	United States Dollar

GEOGRAPHICAL MAP OF BOUGAINVILLE ISLAND



Abstract:
In 1989, a civil conflict erupted in Bougainville, owing to, among others, political factors converging with socioeconomic and environmental grievances related to the former Panguna copper mine; which unfortunately led to political protection of the mine against local Bougainville stakeholders. It destabilised the society and adversely affected the productive sectors of the economy, such as agriculture, fisheries, and tourism. The situation created a gap in revenue needed to revive the economy and more specifically, build capacity for a political transition towards independence. Since gaining autonomy from Papua New Guinea, National Government's subsidies and donations from donors have been the primary sources of revenue. However, revenue sources have been inadequate to support the expanding needs of Bougainville. The financial constraints have enticed the Autonomous Bougainville Government to pursue constructing institutional capacities, policies, and legislation to revive the economy. The 2015 Mining Act was devised to recognize local ownership of mineral deposits found in traditionally held lands. It was devised to augment a quest for autonomy in decision-making and encourage social engagements in mining ventures. Consistent with the Bougainville Integrated Strategic Development Plan 2023-2027, a cost benefit analysis was undertaken to investigate the mining sector's role in Bougainville's economic and social developmental needs. The cost-benefit analysis used historical data from the former Panguna mine and constructed a conceptual model of Panguna's remnant deposit, which comprises of 1.8 billion tonnes of copper-gold reserves (measured). The results showed the net benefits of former Panguna mine exceeded the direct costs (excluding indirect costs). By contrast, the benefits of redeveloping the remaining Panguna resource may exceed the former, indicating a major potential for economic growth and a promising future for the region. However, ABG can diversify resource revenue into non-minerals sectors and develop physical and social infrastructure to resuscitate other sectors of the economy. Thus, the cost benefit analysis found that reopening the former Panguna mine can have positive impacts on the economy of Bougainville.

Keywords: cost-benefit analysis, inclusive mining law, resource revenue, risk and benefit sharing, direct and indirect benefits and costs, revenue gap, recommissioning of Panguna mine, copper-gold resource, equity interest, political transition

1. Introduction

The Autonomous Region of Bougainville (ARoB) has slowly recovered from a civil war that lasted approximately a decade from 1989 to 1998, which claimed the lives of over 20,000 people. Although it officially ended with the signing of the Bougainville Peace Agreement in 2001, the civil unrest caused a prolonged economic blockade that weakened Bougainville's economy (Hilson, 2006). It has been widely articulated the unrest occurred due to a lack of satisfactory mining policy and regulatory frameworks that resulted in inequitable wealth redistribution, mismanagement of socioeconomic and environmental impacts and unresolved landowner issues (Boege, 2022b). Also, PNG Government's failure to resolve community's grievances led to pervaded reactions throughout the region (including host communities). It reawakened and strengthened a passive secessionist movement that existed since the colonial era but had become more active since the 1970s (Kolotein, 2015[1]). However, Autonomous Bougainville Government (ABG) has envisioned to explore mineral resources because the region has attractive geological potentials for hosting porphyry copper-gold deposits as well as epithermal gold-silver mineralisation**.** From 1972 to 1989, Bougainville Copper Limited (BCL), an affiliate of Rio Tinto, mined a sizeable portion of the known Panguna resource before it closed prematurely. To some extent, the past experiences have augmented Bougainville's quest for independence, a movement, which gradually progressed from passive to assertive, as reflected by 98% of Bougainvilleans voted in favour of independence from Papua New Guinea (PNG) in a referendum in 2019 (Regan et al., 2022).

Bougainville's mineral sector has revolved around the past history, which served as a cautionary lesson for ABG, prompting a cautious approach to devising resource development policies (Himata et al., 2023). Mining activities have impacted Bougainville's economic and social foundations, and, thus, assert that communities should oppose mining activities on the island (Hennings, 2016). The Jubilee Report, "Growing Bougainville's Future: Choices for an Island and its people" (Hill et al., 2018), expressed some resounding sentiments. The report examined some socioeconomic challenges associated with past mining activities and provide alternatives for revitalizing social and cultural sustainability on the island. As such, the mining sector has transitioned from exclusive to inclusive policies due to an increasing appeal for direct involvement in exploration and mining activities (Regan, 2017).

Mining Act (2015) was devised to provide a regulatory framework for greater autonomy for local participation in decision-making in resource developments. These include commercial dialogues and negotiations on the allocation of benefits through redistribution of risks and rents (Boege, 2022a). Bougainville’s mining law recognizes the ownership of mineral is vested with the custodians and owners of the land. It was inevitable due to past circumstances where inclusive mineral rights are hardly granted to customary landowners and untested in most jurisdictions. On a national level, Papua New Guinea’s (PNG) mineral laws and policies were devised when the country was less aware of social and economic costs and benefits and unforeseen negative impacts and/or externalities associated with mineral sector developments (Kinna, 1978). The mining law could empower the community to participate and become integral to the growth of Bougainville's economy. Further, existing Bougainville’s mining policy strives to adhere to international practices as pillars to devise legal and policy instruments.

The policy interventions were aimed at optimizing financial and socioeconomic benefits; augment prudent management of environmental impacts; sustainable post-mine transition through land rehabilitation; and formalize artisanal and alluvial mining to ensure resource developments are integrated into societal needs. These include affirming traditional values and local contents to maximize benefits and minimize the societal costs of mining (Mosusu et al., 2023). Further, even while facing setbacks and negative perceptions within Bougainville and abroad, Bougainvilleans have moved on, to demonstrate a remarkable resilience in their efforts to use Melanesian ways of resolving conflicts that largely imparted lasting peace for Bougainvilleans. Bougainville has maintained a positive outlook by devising policies to augment the extraction of mineral resources from traditionally held lands (Regan et al., 2022).

Bougainville Island has a land area of 9, 4438 square kilometers, excluding the Atolls. It has an abundance of untapped natural resources such minerals and energy, forestry, agriculture, fishery and tourism sectors and deep waters suitable for maritime development. Bougainville’s formerly niche cocoa and copra sectors were abandoned (Thompson, 1991). In the post-conflict period, the economy relied on smallholder cocoa and copra production and artisanal and alluvial mining, pastoral and SME activities (Newsom & Scheme, 2002). These resulted in a low unemployment rate and household productivity that in, turn, led to social disintegration. ABG has been influenced by the dire situation to assess past mistakes and came up with adequate policies to resuscitate the lagging sectors of Bougainville's economy. Also, ABG's dependency on external budget supports, such as grants and donations from development partners and the National Government has been inadequate to support its development needs. The situation enticed ABG to devise policies to patch up the revenue gap, which could impede the efforts of rebuilding the post-conflict economy (Hill et al., 2018). Hence, a secured revenue source could entice ABG to shift away from depending on external budget supports, and it has placed much emphasis on rebuilding the economy from the ashes of past conflicts.

The purpose of cost-benefit analysis (CBA) study was to analyse how the mineral ownership rights could maximise benefits and minimize costs that are consistent with ABG's resource policy objectives and social and cultural endowments. The CBA study can assist the minerals sector to contribute towards rebuilding Bougainville's economy. Importantly, it was intended to identify some enabling factors necessary for strengthening the laws and policies through strategizing options that generate value (economic and social capital) and seek innovative ways that reduce societal costs through embracing sustainable mine waste management strategies. Through this study, the stakeholders can be made aware of the issues and empower them to make informed decisions and become an integral part of the sustainable development process.

The study was arranged in the following order. The article briefly covered the methodology and geological prospects, and artisanal and alluvial mining activities (*Sections 2 & 3*). Next, it analysed the benefits generated by the former Panguna mine (*Section 4*). It followed on to analyse the CBA by modeling the Panguna resource, including various options for benefit redistribution (*Section 5*). It followed on to analyse the options of joint venture partnerships as to how local stakeholders could strategize investment decision-making in light of wholly operating a mine and equity interest participation (*Section 6*). Further, *Section 7* analysed the results of a hypothetical model to forecast future revenue flows and discussed revenue management and indirect benefits and costs associated with mine waste management strategies. The final sections were devoted to conclusion and recommendations (*Sections 8 and 9*).

2 Methodology and Limitations

The CBA study was conducted using a dynamic discounted cash flow (DCF) model based on capital asset pricing method (CAPM) (Guj, 2013). The techno-financial technique is commonly applied to model resource projects using input variables (e.g., price, costs, grade and resource data) and fiscal (taxation) and financial variables. The CAPM technique was used to generate cash flows, tax and royalty proceeds and decision-making variables. To serve our purpose of the CBA study, we discounted the aggregate benefits and costs to derive the present values (PV) and then computed the efficiency ratios. The study used a social discount rate (SDR) of 5% to discount the net costs and benefits. The cost-benefit ratios (CBRs) were determined by dividing the net present value (NPV) of benefits by the NPV of costs. This was the accepted way to calculate cost-benefit ratios to derive credible efficiency ratios (Mishan & Quah, 2020). Further, Panguna's brownfield resource data, price, costs and other input variables of the model were covered in *Section 5*.

The CBA study required a cross-sector assessment that compares short and long-term benefits against other land and sea-based sectors (e.g., forestry and fisheries) (Boardman, 2008). However, conducting a CBA study across multiple sectors was challenging due to complexities associated with estimating monetary values of non-marketable benefits and costs (social and environmental impacts). Despite this, evidence of environmental impacts and social indicators of exploration and mining were practically observed and measured. Thus, the CBA study focused on the mining sector only, which made it possible to estimate the costs and benefits to compute the CBR. Moreover, due to limited data, the CBA study covered only a few footprints of mining activities and focused on ABG's efforts towards exploration, small scale mining and mine development.

3 Geological Potential and Small-Scale Mining

3.1 Geological Potentials

Geological potentials of mineral deposits in selected areas of Bougainville Island are well articulated from works done in early 1960s by Conzinc Rio-Tinto of Australia Limited (CRA). This included aero-geophysical survey data from 1986 and 1987 to 1988. These include follow-up investigations and interpretations of aero-geophysical anomalies of porphyry copper-gold mineralization over the entire island by Bering et al. (1990). Also, Blake and Miezities (1967) and Rogerson (1989) describe the geology of Bougainville and Buka Island. They expounded the knowledge of geology and mineral deposit potentials in selected exploration areas, and these have been enhanced by more recent exploration works from 2018-2021 (Rogerson, 1989).

The Melanesian Arc comprises of a chain of islands that extends from Solomon Islands to northeast of PNG (Davies, 2009), of which Bougainville is a part. This island arc covers Manus, New Britain, New Hanover, New Ireland, Bougainville, Solomon Islands and PNG and its islands. Deep sea trenches from both sides of the islands as these arcs are constructed in two stages of subduction and volcanic activity. They are built as island arc subduction related to magmatism in two main stages of subduction associated with ongoing collision of the tectonic plates. These are the Australian Plate and the Pacific Plate, with Pacific Plate currently moving towards north-west at a rate of 11 centimetres per year. Likewise, the Australian Plate moves north at seven centimeters per year (Davies, 2009). Given these geological events, copper-gold and epithermal mineralization are common geological settings since both PNG and Bougainville are linked to these tectonic events.

Historical and recent exploration work indicate that Bougainville Island is a prospective region for base metal and precious mineral mineralization styles, especially epithermal and porphyry-related high and low-sulphidation systems. Davies (2009) proposed that most probable areas lie within a 10 km radius of the Panguna region. These regions have favourable structural conditions and, thus, could hold potentials for other proximal Cu-Au porphyry apophasis adjacent to existing Panguna's porphyry and other greenfield epithermal systems.

The porphyry and epithermal mineralization in Bougainville is primarily associated with some dioritic-monzonitic intrusions whose age range from 8.2 – 1.3 Ma (late Miocene and earliest Pleistocene). However, mineralization potentials of these intrusions have been untested (Garwin et al., 2005). Notably, most mineral deposits in PNG are related to geologically young intrusions from Miocene to Pliocene ages (23.03Ma-1.806Ma).

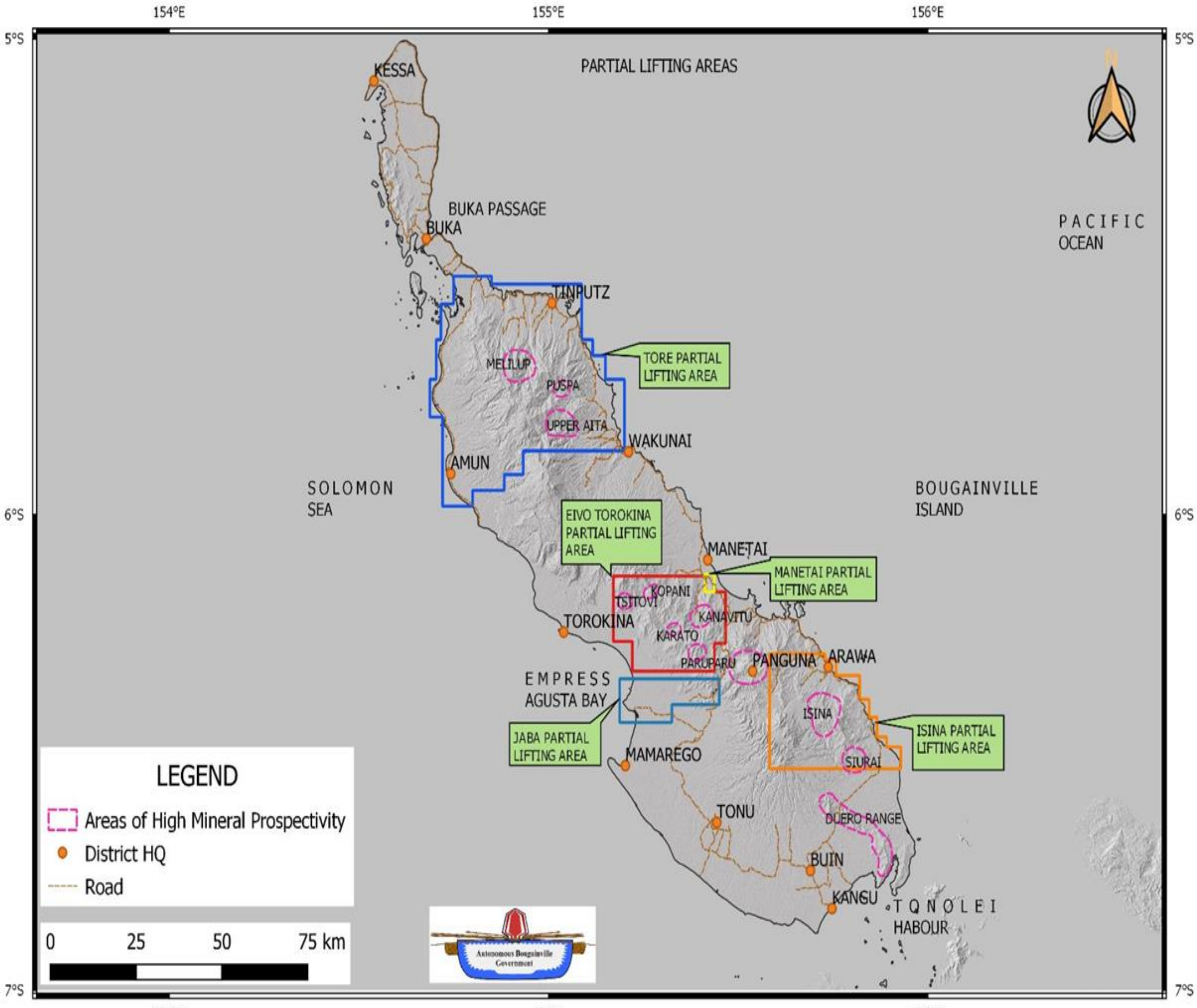


Figure 1: Map of areas where ABG has partially lifted the mining reservation.

In *Figure 1*, most of the AROB is currently reserved for mining and exploration activities. ABG has lifted a reservation, commonly known as 'moratorium', in some regions of Bougainville to permit investors to apply for exploration leases (EL). The reservations were lifted to allow active exploration. As a result, exploration activities target anomalies that could lead to delineate epithermal (polymetallic veins and Au) and Volcanogenic Massive Sulphide (VMS) type deposits. Recent mineral exploration from 2018 to 2021 identified some porphyry and epithermal targets in these areas, which affirmed the past historical exploration works.

Three areas have been prioritized and actively pursued with a partial lifting the restriction in Tore region. These potentials include the Melilup, Puspa, Rarie and Teoveane, and Upper Aita and Baiano areas were identified to host porphyry copper and epithermal gold deposits. The Eivo-Torokina area is part of the Crown Prince Range, which includes the Panguna deposit. Several sites near Panguna could be highly anomalous in terms of gold and copper mineralization. The Paruparu, Karat, Kopani, Kanavitu, and Atamo areas have experienced intensive alluvial mining (*Fig. 2*).

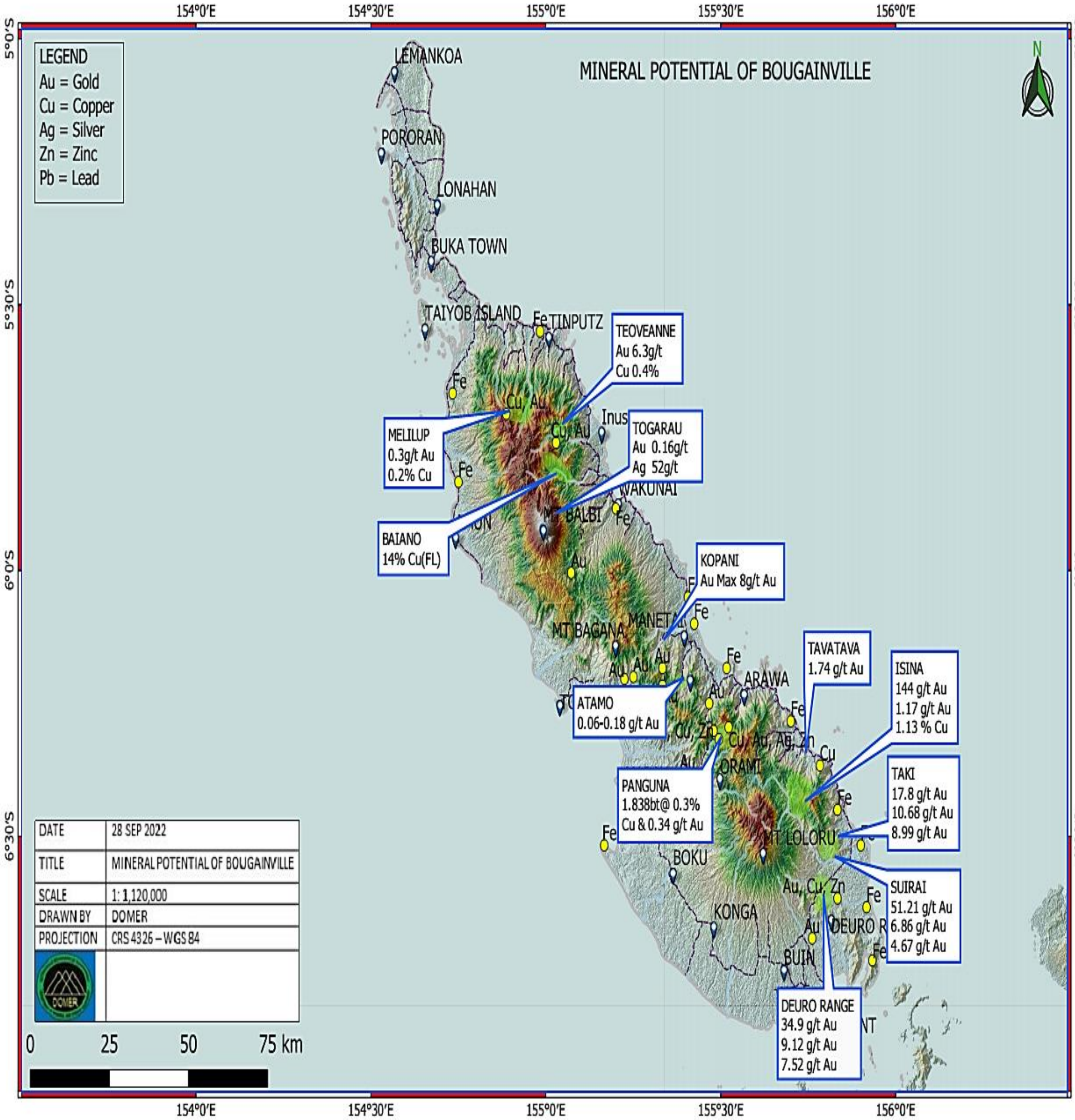


Figure 2: Distribution of gold and copper anomalies on central Bougainville Island

As shown in *Figure 2*, historical and recent exploration works indicated that mineralization potentials extend north and south of Bougainville Island and beyond the proximity of Panguna's brownfield deposit (Fisher et al., 1991). The Isina area offers fertile agricultural land and attractive geology for discovering world-class mineralization. Attractive geological anomalies such as high gold grade of 144g/t were tested in Kanabete region and elsewhere within the mainland. Recent exploration indicated that Siurai and Taki regions have huge potentials for porphyry and epithermal systems with varying gold grades, such as 6g/t, 8g/t, 21g/t, and 51g/t gold. As reflected in *Figure 2*, high gold anomalies are associated with quartz-based epithermal vein system that may have potentials for large orebodies. Thus, the Bougainville Island has the potential for greenfield exploration, besides the known brownfield deposit at Panguna.

3.2 Potentials for artisanal and small-scale mining (ASM)

A recent survey identified 19 artisanal and small scale mining (ASM) districts (sites) in South and Central Bougainville. The 2022 Baseline Survey undertaken by DMP estimated that over 10,000 miners were engaged in activities related to ASM. Over 70 artisanal mining sites were identified within the central districts. The annual production at these sites was estimated to be around 970 kg of gold in 2022. The ASM sector alone could have injected over K60 to K100 million into the regional economy (Regan et al., 2021).

Table 1: ASM mining sites, production data and active miners.

No	ASM Areas (LLG)	Mining Type	Formal/ Informal	Produced (grams)	Active miners
1	Wisai (*Wisai*)	*Artisanal*	Informal	960	35
2	Tavatava (*Kokoda*)	*Artisanal*	Informal	2,880	228
3	Kopani (*Eivo*)	*Artisanal*	Informal	3,600	125
4	Atamo (*Eivo*)	*Artisanal*	Informal	3,744	210
5	Mid Tailing (*Loro 2*)	*Artisanal*	Informal	3,840	1500
6	Upper Tailing (*Loro 2*)	*Artisanal*	Informal	3,840	800
7	Lower Tailing (*L2 Bolave*)	*Artisanal*	Informal	4,800	1200
8	Tsitovi (*Torokina*)	*Artisanal*	Informal	4,800	277
9	Paruparu (*Eivo*)	*Artisanal*	Informal	7,104	290
10	Kupe (*North Nasioi*)	*Artisanal*	Informal	9,840	250
11	Uruto (*Eivo*)	*Artisanal*	Informal	11,136	472
12	Karato (*Torokina*)	*Artisanal*	Informal	28,800	280
13	Simini (*Wisai*)	*Artisanal*	Informal	43,200	275
14	Bagana (*Torokina*)	*Artisanal*	Informal	79,200	530
15	Rotokas (*Torokina*)	*Artisanal*	Informal	120,000	600
16	Kanavitu (*Eivo*)	*Artisanal*	Informal	120,480	1517
17	Isina (*Ami-Aming*)	*Artisanal*	Informal	126,960	535
18	Kongara (*Kongara*)	*Artisanal*	Informal	144,000	510
19	Panguna (*Ioro 2*)	*Semi-Mech*	Informal	254,400	1020
			Total	**973, 584**	**10,654**

Source: DPM Survey Report, 2022

In *Table 1*, majority of the ASM gold production comes from Isina, Kongara, and around the abandoned pit and tailing areas of the former Panguna mine, which accounted for over 68% of gold production. The ASM activities involve artisanal mining, using conventional and semi-mechanised grinding and sluicing operations. These include traditional sluicing and panning techniques and apply mercury to retort and recover gold from sluice box concentrates. The recent increase in gold price has experienced a surge in gold production amongst artisanal miners in districts that have high anomaly of near surface gold deposits (see *Fig. 2*).

The ASM sector has been prioritised because it has the potential to generate revenue and augment income-earning opportunities, including employment (Nema, 2019). However, according to DMP reports in 2022, economic benefits dissipate along the supply chain due to inapt practices in artisanal mining, processing, and marketing the gold mined. Thus, if not managed properly, the ASM sector could affect the health and safety of miners of surrounding communities and cause environmental impacts. As such, the ASM development trajectory has remained as an informal and unregulated sector despite the surge in alluvial mining activities. In 2022, DMP reported that 97% of miners used over 8kg of mercury per week, which has presented a discerning concern to the regulator. This requires proper regulatory backing to address safe handling of mercury and control other environmental and social impacts.

Because the ASM sector existed as an informal sector, ABG has not collected revenue from the small scale mining sector (Boege, 2023). In view of ABG's visions, it needed an effective policy, and a mineral taxation regime to collect taxes and levies from the ASM sector. In some aspects, ABG has devised policy guidelines to effectively regulate it into formalising the sector (Boege, 2023). Through the DMP, policy guidelines have been progressively developed to address these issues and formalise the ASM into a sustainable sector. The ASM sector requires regulatory supports on regular basis, such as integrated trainings on mine safety and control environmental pollution to attain environmental and safety standards.

4 Benefits and Costs of Former Panguna Copper Mine

The former Panguna copper mine contributed immensely to PNG's economy being an infant nation at that time. The Panguna mine was responsible for 25.5% growth in PNG's GDP, which increased the income per capita and reinvigorated productivity growth (Auty, 1998). The Panguna mine was operated by Bougainville Copper Limited (BCL) from 1972 to 1989, which became a pillar of Bougainville and PNG's economy before the mine closed in 1989 (Basu et al., 2013). The mine closure interrupted PNG's copper and gold production, which caused the economy to decline, including employment and direct and indirect benefits. In the post-conflict period, Bougainville's formerly niche agriculture and other economic sectors deteriorated and declined and remained stagnant in the present condition. Further, the region experienced the highest human development index compared with rest of PNG due to targeted skill development. The Panguna mine had a successful training program through in-house apprentice training. Many PNG and Bougainvilleans were trained and dispersed to develop PNG's infant education and social sectors during the pre and post-independence periods (Imbun, 1997) (*Fig. 3*).

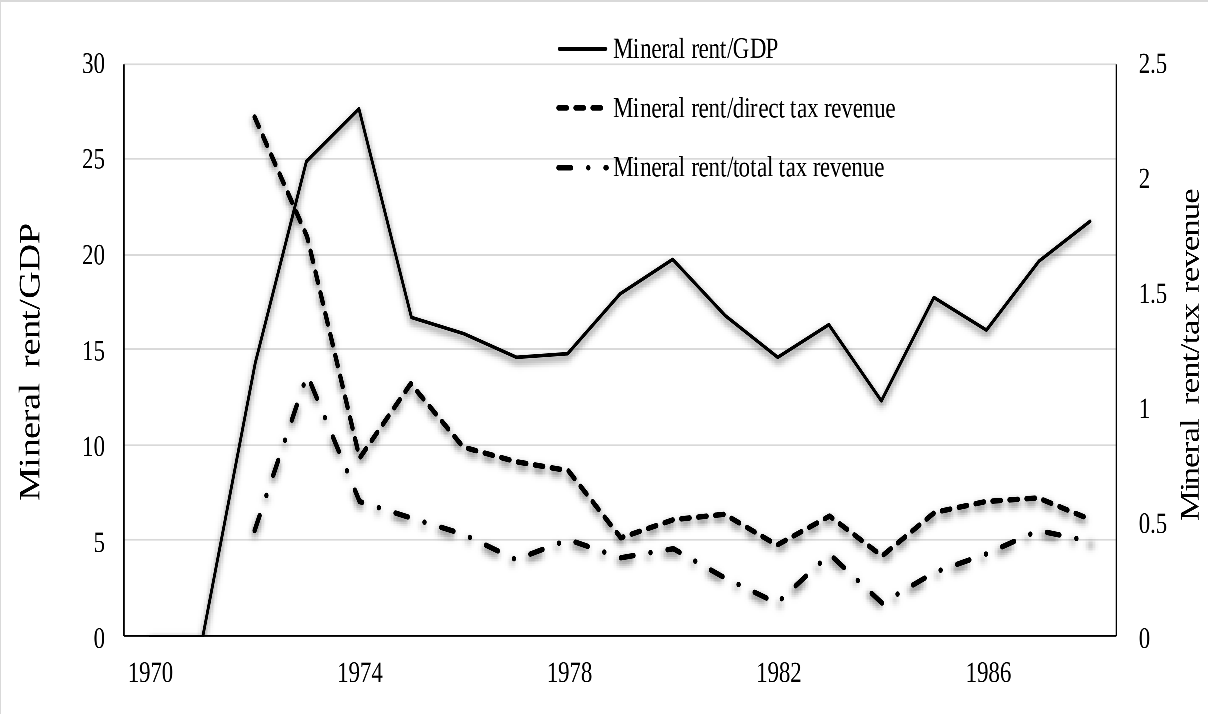


Figure 3: Mineral rents per GDP and per tax revenue

The curves in *Figure 3* were generated by dividing mineral rent (profit) by respective gross domestic product (GDP) against direct revenue and total benefits. During early stages of mine's life, mineral rent per GDP peaked at 30% and remained relatively stable at around 16% before it closed. The mineral rent remained constant at around 0.5 percentage points. Between 1970 and 1974, the total tax revenue per mineral rent was around eight percentage points due to high copper prices. Similarly, mineral rent as a portion of GDP remained around three percentage points during low copper prices from 1975 to 1989. These results show that mining industry can support an emerging economy when revenue is prudently managed. Moreover, redistribution of benefits was considerable, which saw PNG benefited more from the former Panguna mine than other mines that were developed later in the post-Panguna era (*Appendix I, Table 1-AI*).

The Panguna mine produced 2.989 million metric tonnes of copper metal, 9.5 million ounces of gold, and 24.4 million ounces of silver over the 18 years of operation (Skrzypek, 2022). Initially, Panguna had 900 million tonnes of copper and gold reserves with a grade of 0.3% copper and 0.30 grams per tonne of gold. It had a projected mine life, which ranged between 25 and 30 years. It operated profitably for 18 years with a real NPV of 215 million PNGK and had a ground value of 5.228 billion PNGK (i.e., US Dollar equivalent). The 11% IRR (real) was consistent with an IRR range between 11% and 13% for most copper mines (Otto, 2000) and it took 7 years for BCL to recover the initial capital cost of 535.7 million USD (Ail, 2024). Furthermore, the financial performance was attractive due to low operating costs (i.e., 8 USD per metric tonne of copper) and its proximity to a copper concentrate loading facility near Arawa town. Although real financial values (cash flows) may seem small compared to present terms, the buying power was substantial due to a fixed currency regime (i.e., against the US Dollar) between 1972 and 1993. The aggregate wealth transfer comprises of direct revenue and indirect benefits (*Table 2*).

Table 2: Distributions of revenue (benefits)

Stakeholder/Tax	**Amount (PNGK Million):**
• Dividends	167.4
• Dividend withholding tax (DWT	97.6
• Miscellaneous	10.1
Total	**1088.2**
North Solomon Provincial Government	
• Royalty (95%)	61.4
• Non-renewable resource fund	1.8
• Others	12
Total	**75.2**
Landowners	
• Royalty (5%)	3.2
• Compensation	35
Total	**38.2**
Non-Government Shareholders	
• Dividend (Net of DWT)	582.1
Employee Wages	
• Wages (Less Payee)	575.6
Total benefits	**2359.3**

Source: BCL Annual Report 2014 (equivalent to US Dollar)

The former Panguna mine generated a net revenue of 1.88 billion PNGK from basic tax instruments, which excluded dividends paid to non-government shareholders (*Table 2*). The basic tax instruments comprised of corporate income tax (CIT) and dividend withholding tax (DWT), including a substantial amount of revenue were collected from employee payroll tax. The basic tax instruments collected over 70% of aggregate revenue, which included GoPNG's equity interest of 19.06% (Ail, 2018). Additionally, equity interest generated substantial dividends compared with other mines developed in the post-Panguna era. Likewise, BCL paid additional profit tax (APT) only four times. Despite the expectation of raising sizeable revenue using the APT, it did not perform to expectation. Further, the former mine's marginal effective tax rate (METR) was 40%, which was substantially higher than other mines that were commissioned in the post-Panguna period. This reflected the economic benefits were high despite the discrepancies in redistribution of benefits to local communities.

A 40% of gross revenue was allocated to suppliers of inputs to production, demonstrating a commitment to supporting local businesses (if any), with increased incentives to capture a larger portion of quasi-rents. From the total real gross revenue (i.e., 5.228 billion USD), 8% was allocated to financial capital providers (*Fig. 4*) and 36% of export value were transferred to the community, which was a substantial portion that was retained in the local economy. Unlike other mines in PNG, the direct tax payments exceeded the profits BCL was receiving, which demonstrated its commitment to a high level of transparency in tax compliance. Although, it was difficult to speculate, it seemed that there were premature payments of APT when the IRR did not exceed the 15% threshold rate. Also, BCL paid abnormal dividends on state equity participation. It perhaps used incorrect techniques to compute the APT and state equity interest as to when these payments became accessible (Ail et al., 2024). We suspect that free equity option could have been practiced, which consistently earned dividends for the then colonial government. Two important points were identified. Firstly, BCL diligently paid the CIT and DWT, which accounted for over 70% of direct revenue due to BCL's transparency and efficiency in tax administration and compliance. Secondly, non-tax benefits were relatively low, since PNG needed more entrepreneurial skills and financial capital to secure high-value contracts that could be secured by a local content policy.

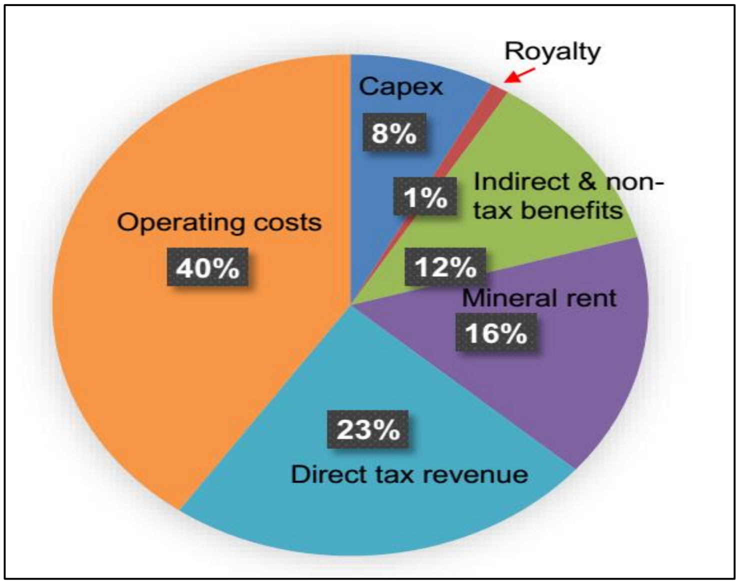


Figure 4: Value-chain redistribution from the former Panguna mine (1972-1989)

Indirect taxes comprised of wage payee tax, excise and duties, and goods and services tax imposed on contracts and logistic services. Revenue collected from customs and group payee tax was marginally higher in real terms (*Fig. 4*). However, Allen (2017) reported that landowners in Panguna received few incentives. For instance, BCL applied at a suboptimal royalty rate of 1.25%, which was below the average royalty rate in most jurisdictions (Ail, 2018). Royalty should be calculated based on net smelter return (NSR) revenue and directly redistributed to landholders for extracting minerals found on their traditional lands. Additionally, it ignored the land tenure system and Bougainville's predominantly maternal social structure. The North Solomon Provincial Government received 95% of royalty proceeds, while landowners received only 5% of royalty proceeds (*Table 2*).

In response to the low royalty payments, the ABG, through the Bougainville Mining Act (2015), sought to increase the royalty rate to 3.75% (Regan, 2017). ABG has indicated to raise the royalty rate to 5%, which could exceed PNG's 2% royalty rate. These intentions can be socially fair to allow royalty proceeds flow to landowners unabated and reserve some portions for developing physical infrastructure and health and education institutions (Boege, 2022b). Additionally, a 0.5% production tax could be imposed to cover the cost of tenement administration, mine coordination and regulatory functions. The lessons suggest that an efficient redistribution mechanism could have ensured the communities to receive a full measure of uninterrupted flows of royalty proceeds, regardless of royalty types and rates applied.

The former Panguna mine could have induced vertical linkages to occur amongst other sectors of the economy. However, there were no records of local contractors and procurement of goods and services (*Table 2*) (Jackson, 2015). For instance, if inputs from the agriculture sector were valued at K10 million in 1988, the former Panguna mine could have injected 2% of every PNGK1 export earnings into the agriculture sector. Before the Bougainville crisis, the agriculture sector was vibrant due to mine-induced multiplier effects. Further, former Panguna mine employed over 2500 local personnel, which contributed to PNG's infant mining industry. The then Panguna mine's workforce comprised mostly of unskilled and semi-skilled personnel. As such, the personnel who worked at the mine attained tradesman skill-levels through in-house apprenticeship programs (skill-based training). At that time, labour mobility was high, which enhanced the skilled workforce to find employment in other mines in PNG and abroad (Filer & Imbun, 2009). The non-mineral sector experienced positive results from diversification of income and replication of technical skills.

Mining employment represented less than 1% of formal employment compared to non-mineral sector (Allen, 2017; Newsom & Scheme, 2002). The low formal employment rate relates to mining sector's high mechanization, which requires a limited number of highly skilled personnel. By contrast, the high income of mine employees could offset the low employment rate in agriculture sector. Put differently, despite mining's low employment rate, the highly paid mining jobs could exceed the value of agriculture sector's high employment rate (low salary rate). Additionally, mining sector's employment and its multiplier effects could be discretely higher than that of the agriculture sector. Although these scenarios could hold, the lessons learned suggest that ABG may need to devise better benefit packages by engaging stakeholder dialogues for more equitable redistribution of benefits than former arrangements.

5 Benefits and Costs of Recommissioning the Panguna Copper Deposit

At the time of undertaking the CBA study, the copper and gold resources of Panguna have been the main target for ABG to focus on reviving the ailing economy. Also, ABG has not only focused on Panguna, but also discovering other deposits, mostly porphyry copper-gold and epithermal mineralization within the island's porphyry belt (*Section 3*). The ABG has pursued its interest to recommission the Panguna mine as an economic agenda to support its independence aspirations. To achieve this objective, there has been ongoing dialogues with landowners to establish social consensus to hasten community's ambition to benefit from future resource developments (Boege, 2022a).

Rio Tinto, the former parent company of BCL, has divested its 53.8% stake in BCL. The change of ownership motivated ABG to have a 36.45% shareholding in BCL and initiated dialogues to further acquire National Government's 36.45% shareholding in BCL (Skrzypek, 2022). This could have made ABG a major shareholder in BCL, with 72.9% shares, which could be an impetus to fast-track mine's redevelopment. These transitions placed Bougainvilleans in an advantageous position to have major shareholding in the BCL. The restructure occurred progressively during the transition periods, which increased the representation to five out of seven BCL Board members are Bougainvilleans. Hence, Bougainville's fight for justice and equality has gradually moved closer to reality to fulfill the aspirations of those who stood united to benefit from fully commercializing the remnant reserves at Panguna. Thus, adoption of legislation and policy frameworks, recent restructure of shareholding in BCL, and ongoing stakeholder consultations have enhanced fast-tracking the redevelopment of Panguna resource.

Given the progresses made so far, the CBA study used data from the former BCL, ABG, and other publicly available data sources to model the known Panguna's reserve. The preceding sub-sections describe the data inputs, costs and price, and tax and fiscal instruments, and procedures required to model the deposit (*Fig. 5*).

Figure 5: The status of the abandoned Panguna copper mine (*Source*: DMP, 2023)

Table 3: The upgraded ore reserve estimation of the former Panguna mine.

	As at December 31 2011				As at December 31 2021		
Resource	Measured	Indicated	Inferred	Total	Indicated	Inferred	Total
Tonnes (Mt)	*0*	*1,000*	*64*	*1,064*	*1,538*	*300*	*1,838*
Grade % Cu	*0*	*0.33*	*0.28*	*0.33*	*0.30*	*0.30*	*0.30*
Grade g/t Au	*0*	*0.37*	*0.41*	*0.37*	*0.33*	*0.40*	*0.34*
Copper (Mt)	*0*	*3.3*	*0.2*	*3.5*	*4.6*	*0.7*	*5.3*
Gold (MOz)	*0*	*11.9*	*0.8*	*12.7*	*16.1*	*3.2*	*19.3*

Source: http://bcl.com.pg

The BCL conducted a scoping study to develop a conceptual development plan based on preliminary data provided in *Table 3*. The same data was used in this study. The proposed mine reconstruction comprises of production layout (pit redesign), options for waste rock and tailing disposal and placements, power generation facilities, and accommodation facilities for over 2500 employees. Also, infrastructure such as roads, ports, airports, and reconstruct the Arawa mining town may be upgraded and refurbished in preparation for recommissioning the Panguna mine. The ailing infrastructure needed major reconstruction, including electricity and water supply. The hypothetical modelling of the Panguna resource required some input variables as given in *Table 4*. These variables were carefully selected to achieve a minimum confidence interval to derive decision variables in the hypothetical model (*Table 4*).

Table 4: Summary of input variables (see *Table 1-B, Appendix B*)

Input variables	**Values**	**Input variables**	**Values**
Capital Cost ($B)	6.8	Copper Production/Yr. (t)	180000
Operating Cost ($/t)[2]	10.9	Gold Production/Yr. (Oz)	643000
Reserve (Mt)	1838	Revenue from Copper ($M/Yr.)	1060
Mine Life (Years)[3]	30	Revenue from Gold ($M/Yr.)	933
Annual Throughput (Mt)	61	Total Revenue ($M cu + $M Au)	1784
Mill Recovery Rate	88%	Royalty Rate	5%
Refinery Recovery Rate	95%	Corporate Income Tax	35%
Copper Grade	0.30%	Discount rate (RADR)	8.5%
Gold Grade (g/t)	0.34	Real discount rate	4.9%
Copper Content (Mt Cu)	5.3	Inflation rate	3%
Gold Content (MOz Au)	19.3	Salvage value ((2% Capex) ($M)	116
Copper Price ($/t)	6000	Depreciation (Declining balance)	
Gold Price ($/Oz)	1250	SDR	5%

1. Capital and operating costs were adjusted using US CPI inflator and used a 3% real escalator
2. Annual operating costs equal mining + milling + refining costs
3. The mine life was derived using Taylor's formula [6* (diluted reserve) $^{0.25}$* recovery rate]
4. The DB depreciation method was used to compute the initial and sustaining capital costs

Revenue and financial outlays, economic decision variables, and costs and benefits were estimated using the input variables given in *Table 4*. The financial and tax variables are outlined as follows:

- The DCF model was constructed based on two assumptions. First, a 100% equity model assumed that a single owner (ABG, landowner or an external investor) would redevelop the Panguna mine. The second option assumed a joint venture (JV) partnership in which ABG and external investors could own 50% interest each (i.e., 50/50% JV partnership). In this arrangement, ABG and landowners could jointly own 50% interest (i.e., ABG (30%) and landowners (20%)).

- A 35% CIT rate was imposed on pre-tax base accounting for PNG's unlimited loss carry forward (LCF) provision. A 15% DWT rate was imposed on post-tax profit, specifically on each stakeholder's profit redistributions. Also, an APT rate of 30% was imposed with a 15% threshold trigger rate on the pre-tax base cash flows. The model applied a 5% royalty rate and a 0.5% development levy (royalty rate included), and a 10% import duty was imposed on each stakeholder's share of capital cost contributions. Further, a 12% withholding tax (WHT) was imposed on both foreign and local contractors. The model assumed that foreign and local contractors could occupy 80% and 20% of the contract value. At the time of undertaking the CBA study, ABG did not have a mineral taxation regime but proposed to adopt these taxes, royalties, and levies given in *Table 4*.

- A 8.5% risk-adjusted discount rate (RADR) was applied to remodel the Panguna mine, while a 5% social discount rate (SDR) was applied to discount benefits and costs to compute the CBR.

The CBA study relied on BCL's estimated capital cost of 5.2 billion USD (i.e., *2012 EST*.). The capital and unit operating costs were inflated using the *US CPI* for January 2012 to 2023 (i.e., 10 years) and a 3% real escalation rate. The indexed inflation was 24% and the average inflation was 67.2%. The historical inflation rates were used to adjust the capital cost to 6.8 billion USD (December Quarter 2023). Similarly, the historical operating cost was inflated to 10.9 USD per tonne of ore using a 3% real escalation rate. Also, Monte Carlo simulation (MCS) technique was used to triangulate the operating cost to cater for a 10% variation over entire life of the mine.

The CBA study used a base gold price of 1250 USD/Oz Au and 6000 USD/t Cu copper price. The prices were set at a conservatively low percentile since optimistic forecasts could lead to miscalculate the decision-making variables. Furthermore, the MCS technique was used to adjust the gross revenue to mimic randomness of copper and gold prices. It iteratively sampled the frequency and uncertainty of spot prices, especially the average volatility over time. A mine operator may secure a market through forward sales of copper concentrate. A contract price between a producer and a buyer could determine the price of copper and gold in this arrangement. For instance, the former Panguna mine operated with a Japanese smelter under a fixed sale contract price. Thus, recommissioning the Panguna mine could have a similar contract pricing arrangement.

5.1 Conceptual results of redeveloping the Panguna resource

The nominal DCF model for Panguna deposit was constructed using the methodology described in *Section 2* and configured cash flows and performed some whole-of-life simulations. The hypothetical DCF model estimated that it could take 3 to 4 years to redevelop the Panguna mine. Further, the MCS technique was applied to sample stochastic distribution of gross revenue and operation costs by simulating 20,000 times using RiskSim software in Microsoft Excel^{TM}. This made the model more dynamic than a standard DCF model would perform to derive reliable results. It mimicked a 10% variation amongst the input variables, which resulted in sporadic behaviours of the cash flows (*Fig. 6*). Although it would be complex to forecast the future performance, the MCS ensured the benefits conform to controlled risk paths (costs and price) to configure realistic cash flows at different phases of the mine life (*Fig. 6*).

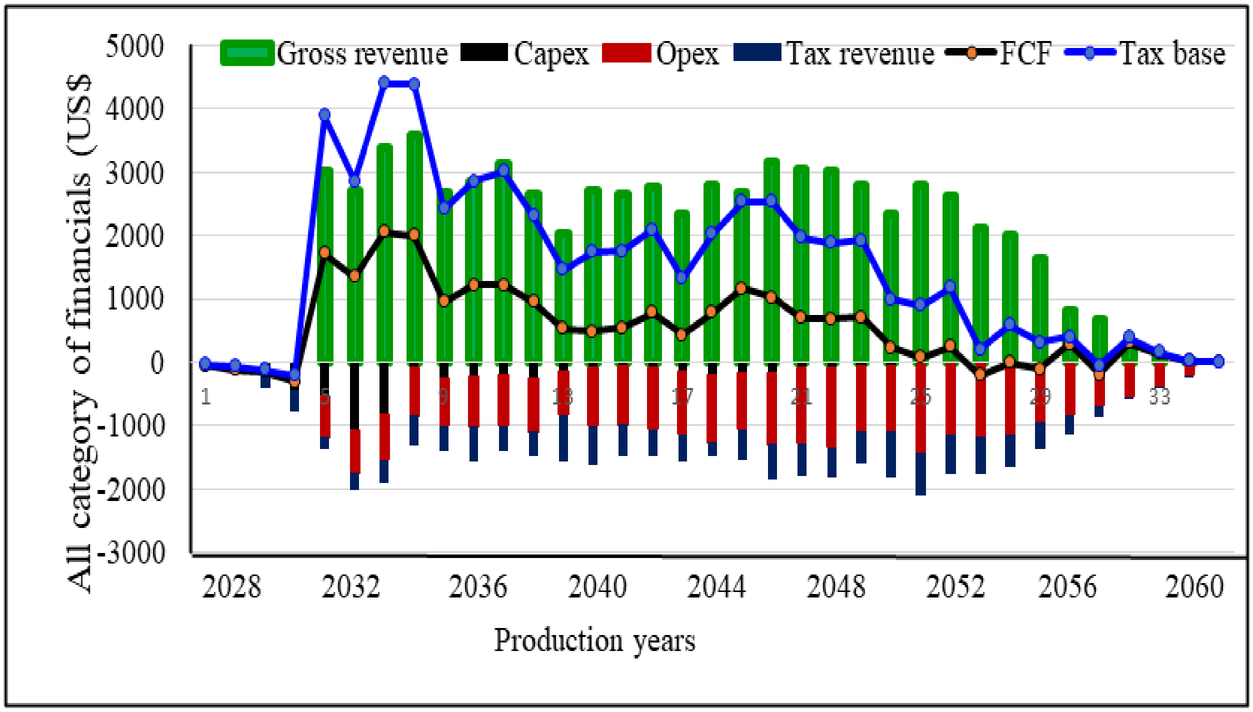


Figure 6: Cash flow streams over the proposed 30-year life of the Panguna project

The Panguna mine would be subject to high risks during early and low risks during mature production stages. In *Figure 6*, risk levels tend to increase at initial stages and likewise, cash inflows diminish towards the mine closure stages. As expected, this model generated ideal cash flow patterns for a typical copper mining project. The adjustment of price volatility and production risks using MCS technique influenced positive correlation between NPV and other financial derivatives. The results showed that NPV could fall within a 75% confidence interval of reaching a 6.0 billion USD (NPV) (see *Table 2-B, Appendix B*). The simulated mean of upper and lower percentiles of NPVs increases the confidence in achieving the project's financial viability under uncertainty. It enhanced the credibility of attaining economic profits, direct and indirect tax revenue, and non-tax benefits estimated over mine's life. The dynamic model ensured that revenue would be available when tax base becomes positive during mature production stages. Also, under different JV partnership arrangements, the efficiency of value chain distribution should reflect how each stakeholder could benefit from a typical mining venture (*Fig. 7*).

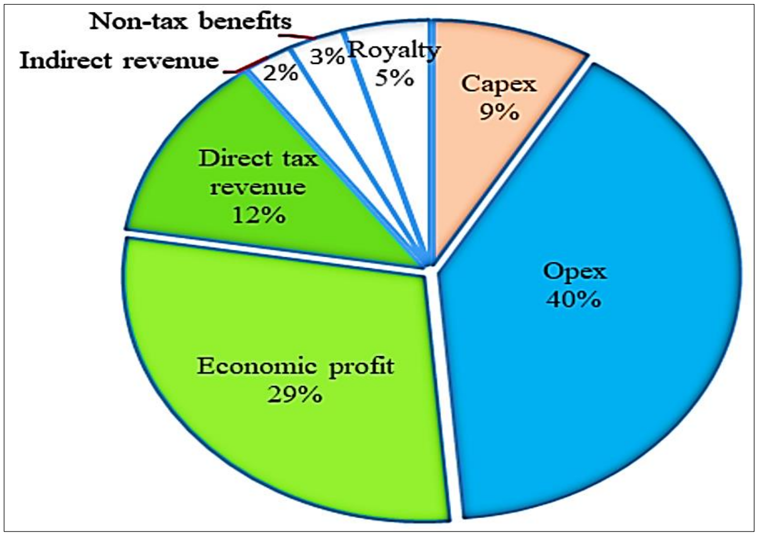


Figure 7: Conceptual value chain distribution of cost and benefits based on 100% ownership

In *Figure 7*, about 9% of export value could be allocated to capitalize the fixed costs, while 40% could be allocated to production costs under the 100% equity model assumption. Similarly, direct taxes could generate around 12% of revenue and the total fiscal benefits would be 22% when added with royalty, indirect (i.e., payroll taxes) and non-tax benefits. Non-tax benefits could be small (3%), since ABG did not have a local content policy. Under the 100% local ownership structure, about 29% of economic profit, when added to fiscal benefits could increase the aggregate benefit to 51%. This inferred that a localised mining venture could be attractive in terms of retaining the accessible value. However, local stakeholders could face capacity limitations in securing financial capital to develop a mining project. Further, a lack of prudent management, especially political influences may alter the value chain redistribution over time. In some cases, government-controlled production could lead to mismanagement and decline in exploration, resulting in elimination of benefits and erode the industry's tax base. To avoid such a decline in productivity, a 50/50 % JV partnership between an external investor and local stakeholders could be a suitable option that could effectively augment sharing the risks and benefits equitably (*Fig. 8*).

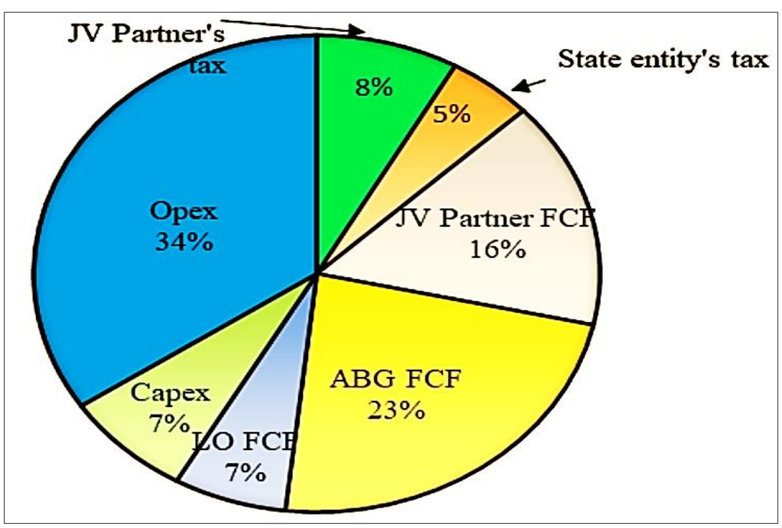


Figure 8: Value redistribution of cost and benefits based 50/50% JV partnership

In *Figure 8,* the 50/50% JV partnership could contribute 15% revenue from direct tax payments, levies, and royalties. The aggregate direct revenue would be 43% compared with a 16% economic rent (i.e., JV partner's profit). These results reflected that a 50/50% JV partnership would be a better option than the 100% ownership where about 10% of the value would be an efficiency trade-off (e.g., capacity constraint). However, the likelihood of raising revenue through a combination of basic tax and profit-sharing options could be doubtful due to dynamics of risks and opportunities over time. Furthermore, legislation and policies can endorse a government and community to own a mining venture, but it would be practically difficult to develop a large scale mine because of limited financial, technology and managerial capacities. For instance, the 100% local ownership option has to be supported by equity capital or have the credibility to secure debt capital at a market value. Thus, the 50/50% JV partnership could place local stakeholders in a better position to maximise the benefits of redeveloping the brownfield deposit than the former Panguna mine (*Fig. 9*).

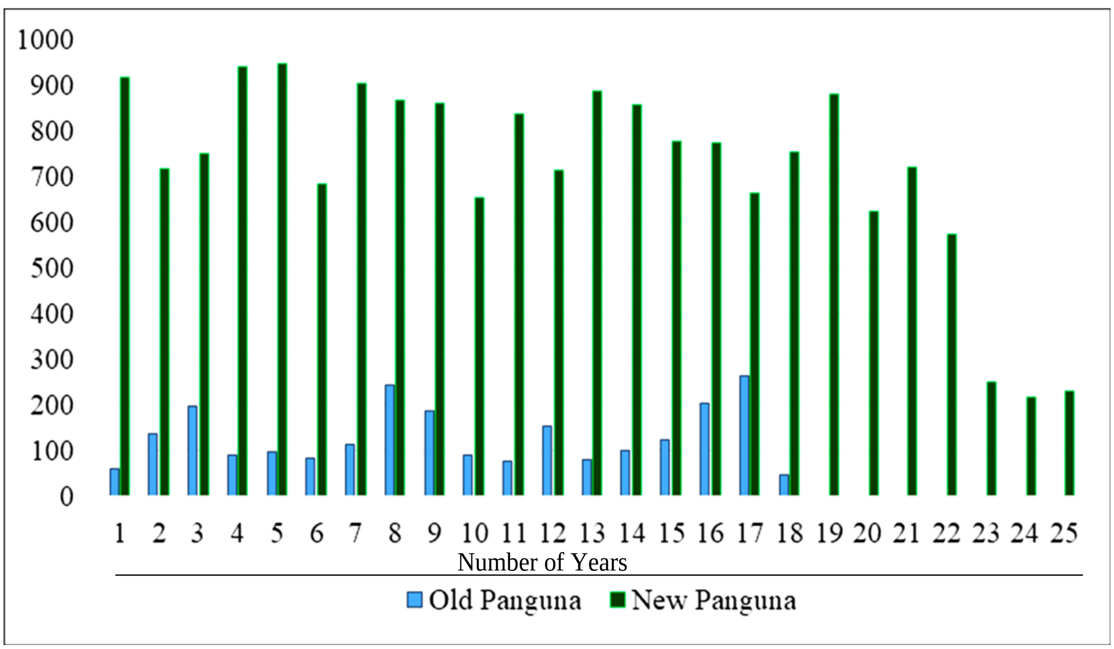


Figure 9: Comparison of revenue from former versus redeveloping the Panguna mine

In *Figure 9*, comparing the benefits of the proposed mine recommissioning with those of the former Panguna mine was important to assess the future benefits of redeveloping the Panguna resource. As such, the latter could generate direct and indirect revenue than the former. The new Panguna mine could generate over 720 million USD per year compared to the former operation. The difference could relate to real prices of copper and gold being 70% lower than those used in the hypothetical models. As a result, former Panguna mine operation's value chain distribution was low. However, it supported PNG's economic and social needs due to transparency in tax compliance and prudent public expenditure planning. Furthermore, the results of Panguna model were compared with pre-feasibility study results of Wafi (Morobe Province) and Frieda (West Sepik Province) (*Table 5*).

Table 5: Comparison of Panguna model result with Wafi and Frieda copper deposits.

Economic variables	**Panguna (2022)**	**Wafi[1] (2020 updated)**	**Frieda[2] (2018 updated)**
Mine Life (years)	30	28	33
Construction period	3–4 years	5 years	6 years
Capital cost (US$ Billion)	6.8 (2022 est.)	5.382 (2017 est.)	6 (2018 est.)
Operation cost US$/t	10.9	17.2 (2017 est.)	10.31
Copper price (US$/t or lb)	3.00/lb ($6000/t)	3.40/lb (	3.3/lb
Gold price (US$/Oz)	1250	1200	1390
NPV (US$ Billion)	6.034 ($i = 8.5\%$)	2.823 ($i = 8.5\%$)	1.8 ($i = 8\%$)
IRR (%)	11.4	18.2	11.0
DPBP (years)	4 (8 years*)	5 (or 9.54 years*)	5 (11 years*
Capital Efficiency	0.87	0.53	0.30

1. *Revised Wafi Technical Report, Newcrest Mining Limited (2020)*
2. *Updated Frieda River Feasibility Report (2018)*
   ** Payback years include proposed construction periods after granting of mining leases*

In *Table 5,* Panguna's NPV was higher than the Wafi and Frieda copper deposits. The variations arose from cost structures unrelated to discount rates used. The Panguna and Wafi projects applied similar discount rates (i.e., 8.5%), while the Frieda project applied an 8% discount rate (Duhe, 2023). The undeveloped Wafi-Golfu deposit could be a high-cost underground mine whose operating costs could be much higher than surface mines. Also, Frieda project could face high environmental management costs, especially concerns related to waste and tailing management (Plan, 2018). Frieda's high cost of treating impurities could be a reason for the low NPV. Despite the variations, the undeveloped copper projects could be commissioned at capital costs ranging from 6 to 7 billion USD or even higher than anticipated. From a conceptual standpoint, copper and gold mines have 5 to 10 years of payback periods, excluding construction periods after granting the mining leases. In addition, Panguna and Frieda projects may share similar IRRs (e.g., 11%), while Wafi project's IRR of 18.2% was a higher rate for any copper porphyry mine in PNG and, perhaps abroad. Since copper has become a critical mineral for adaptation to climate change (Tabelin et al., 2021), the undeveloped copper mines could be world-class operations that could generate substantial benefits for investors, state, landowners, and host communities (Ail, 2023; Skrzypek, 2022).

5.2 Historical and conceptual Cost-Benefit Analysis

The primary objective of the CBR study was to assess the efficiency of mining. The CBR, a pivotal metric in this study, was determined by dividing mining project's total benefits by total costs (i.e., NPVs of each component). A CBR of less than *1* could suggest a mining venture may not benefit a society since costs associated with environment and communities' livelihoods could exceed the benefits. Conversely, a high CBR could arise from benefits that exceed the costs, which would present a promising outlook of a viable mining venture and benefit a community. However, some critical analytical considerations may be necessary to make decisions to select a resource project. In this respect, identifying the category of costs and benefits was crucial for generating credible CBRs. The costs were classified to follow some correct procedures.

The historical benefits and costs of former Panguna mine were not discounted since real values incurred from past transactions. However, it was necessary to distinguish the costs and benefits to avoid bias when computing the CBR. The CBR calculation could be skewed if benefits (direct and indirect benefits) become part of the operating cost. However, our analysis ensured fairness by deducting royalty proceeds, direct taxes (CIT, DWT, equity dividends, and APT), and indirect taxes (employee income tax, excise, and duties) from net operating costs. Also, initial capital costs were excluded because these would have been recovered through capitalisation (depreciation and amortization). Likewise, costs of public facilities (electricity, water supply, and medical supplies), contract procurements, and administrative fees were included in operating costs because these items could benefit both mine operator and community. Thus, isolating the discrete costs from the quasi-rents ensured a balanced and fair approach to compute the CBRs in this CBA study.

Table 6: Historical Cost-Benefit Ratio of former Panguna mine (*Tables 2-A & 3-A, Appendix A*).

FCF	**Pre-tax CF**	**Post-tax CF (*A*)**	**Capex***	**Opex (*B*)**	**Royalty (*C*)**	**Direct Tax (*D*)**	**Direct + Indirect (*E*)**	**Total Rev**
5228.2	1411.9	975.3	536	3053.5	64.6	1494.17	801.5	2360.3
		(F) Benefits (E – non-gov't dividend)				= 1,777.2		
		(G) Costs (*B*– *C*+ *D*+ *E*)				= 693.23		
		(H) Cost Benefit Ratio (*F/G*)				= 2.56 (2.56: 1)		
		(I) Investor's Cost Benefit Ratio (*A/G*)				= 1.41 (1.41: 1)		

*Capital cost was excluded from the CBR calculation as it is a riskless asset.

In *Table 6*, the historical CBR (used cost and benefit data given in *Table 1*) was 2.56:1. For every cost unit, the former Panguna mine generated 2.56 units of benefits, which reflected that social benefits accounted for every PNGK1 spent on a mining operation. This result was expected since BCL consistently paid tax revenue before the mine attained normal ROR in 1977. Similarly, investor's CBR (i.e., 1.41) was related to profits earned from spending PNGK1 on the minerals extracted. The CBR greater than 1 inferred the benefits exceeded the costs, which was a positive indicator of the former Panguna mine, which generated more benefits than it costed to operate the mine. However, some limitations were identified with the CBR. Firstly, the CBR did not reflect the magnitude of benefits that flowed to specific groups (e.g., landowners). Due to a lack of local content policy, Panguna communities could have received one *toea* per total mine-related expenditures. This inferred that non-tax benefits were lower than direct and indirect tax revenue. Secondly, historical CBR may be biased as it did not include intangible social and environmental costs, especially the long-term impacts of mine-induced civil unrest. Third, the CBA study did not assess some control options, which could have ensured a balanced analysis of the targeted project. Similarly, the CBR of redeveloping the Panguna copper mine was computed to weigh the benefits against the costs by applying these considerations (*Table 7*).

Table 7: Conceptual CBRs (*Tables 3-B to 6-B, Appendix B*).

CBR @5% social discount rate (n=30 years		**NPV(US$M)**	
Panguna's CBR (5% SDR):	NPV Net Benefits	9,199	**CBR**
	NPV of Net Costs	7,394	**1.24**
Scenario test @3% SDR:	NPV Benefits	16,380	
	NPV Costs	13,165	**1.24**
Scenario test @10% SDR:	NPV Benefits	2,279	
	NPV Costs	1,831	**1.24**
CBR @5% social discount rate (SDR)			
External investor (NPV computed from 50% interest)		3,372	
NPV Costs* (50%)		3,697	**0.91**
ABG (NPV computed from 30% interest)		2,732	
NPV Costs* (30%)		2,218	**1.23**
LO (NPV computed from 20% interest)		1,379	
NPV Costs* (20%)		1,479	**0.93**

The conceptual NPV of benefits could exceed the NPV of net costs, as indicated by a CBR of 1.24:1 (*Table 7*). This suggested the proposed Panguna mine redevelopment could generate a social benefit of 1.24 USD for every 1 USD spend over the 30-year life of the mine. The high CBR implied that it could generate revenue when copper and gold prices trend in the upper percentile of conservative price paths used in the model. For the scenario with 50% interest bracket with an external investor, ABG's CBR was greater than 1 (CBR>1) compared to that of landowners and investors' interests (CBR<1). Similarly, variations in cost-effectiveness of each stakeholder's CBR depicted that wealth transfers may depend on stakeholder's capacity and ability to manage risks and secure capital. For instance, an external investor's low CBR indicated that its risk trade-off could be higher than that of local stakeholders' exposure to risk. Furthermore, a mining venture's financial viability and cost-benefit efficiency could diminish to favour the society if the costs exceed the benefits.

Intangible costs could become externalities only if the impacts exceed the society and environment's bearing limits. For instance, if a mining company honestly invests in developing innovative technology in mine waste management and reduce societal impacts, then, community could realize tangible benefits from improved mine closure and environmental stewardship. These may include monetary benefits of imposing levies on mine waste discharge, waste treatment costs, technical studies, medical charges and compensation. A CBA study that excludes these intangible benefits may underestimate the aggregate benefits of extraction activities. In contrast, inequitable benefit redistributions and ineffective waste management strategies could induce social and environmental impacts to exceed the economic and financial benefits. This could make host community's living conditions worse-off than conditions before the extraction activity takes place. Besides these, the high CBR presented a promising perspective for local stakeholders to redevelop the Panguna copper-gold mine.

6 Options for Sharing Benefits and Costs

6.1 Equity Interest Options

Owning and operating a mine may be financially appealing, but more could be required to enhance a favourable value chain redistribution that would work well for all stakeholders. A government's quest for benefit sharing through equity interest participation has become problematic as cost of rent-seeking increases while struggling to meet the social development goals (Ail et al., 2024). In addition, state-owned firms could give up exploration, especially when dividends and mineral rents become more volatile in the long run. Given these risks, local stakeholders could consider choosing a suitable ownership structure that assures risk and benefit sharing. Equity interest may resemble 'symbolic partners' to ensure local stakeholders' voices are heard and considered, fostering a sense of inclusivity when involving in decision-making processes, while dividends may be uncertain. At a project's development phase, local stakeholders are often invited to negotiate for a suitable equity interest rate and thus, it is important to select a suitable equity interest rate (*Fig. 10*).

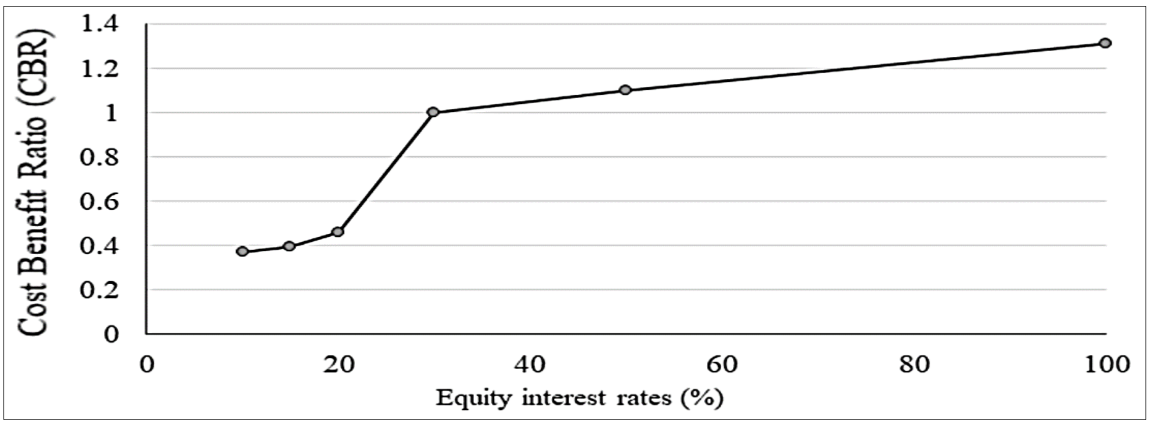


Figure 10: CBRs of different equity interest rates.

The CBR curve correlated positively to a scenario with an increased equity interest rate (*Fig. 10*). The opposite was true when CBR decreased, which correlated with decreasing equity interest rates. The CBRs responded slowly (i.e., CBR<0.5) with low equity interest rates between 10% and 20%. This inferred that rates within this range could not be financially viable, especially when adopting the fully-paid equity arrangement. Hence, equity interest rates lower than 15% could not offset the cost of equity interest in a mining venture. By contrast, linear segment of the curve in *Figure 10* correlated with high CBRs that responded favourably to equity interest rates exceeding 30%, which could yield a reasonable amount of dividends. Intuitively, using proper equity financing techniques and rates exceeding the 10% benchmark could enable accessing the dividends. The intuition provided in *Figure 10* could guide local stakeholders to collectively bargain for equity apt interest rates during bargaining phases of developing a mining project. Thus, there were merits in assessing various interest options in a JV partnership as described by three *Cases (Table 8*).

- *Case 1* assumed an 80% and 20% interest-sharing bracket between the ABG and landowners;
- *Case 2* assumed 60% and 40% interest JV between ABG and an investor;
- *Case 3* simulated the option of ABG and landowners owning a 51/49% interest JV operation.

Table 8: Various JV structures between the ABG, landowners, and potential investors.

JV structure		FCF (US$B)	Costs (US$B)	Direct Tax	Indirect Tax	CBR
Base case:	100% ownership	22.84	31.632	10.998	2.11	1.14
JV Case 1:	80% ABG	14.282	25.306	11.435	0.58	1.04
	20% LO	5.96	3.865	0	0	1.54
JV Case 2:	40% Investor	11.125	7,73	4.89	0.689	2.16
	40% ABG	11.125	7,73	4.89	0.689	2.16
	20% LO	5.96	3.865	0	0	1.54
JV Case 3:	51% Locals	21.477	9.856	3..771	0.845	2.65
	49% Investor	14.229	9.469	4.63	0.828	2.08

As depicted in *Table 8*, *Case 1* yielded a 1.04 CBR, which indicated that this *Case* could yield high net benefits. However, this *Case* may not be financially viable because local stakeholders may not secure the capital cost of developing a standalone mine. They may invite an external JV partner, as in *Case 2*, which featured a 50/50% interest bracket whose CBRs were relatively high (CBR>1). The high CBR suggested that local stakeholders' net free cash flows could be substantially higher than expected. The results of *Case 2* reflected that local stakeholders could gain substantial benefits by sharing the risks of equity capital by outsourcing to external partners. Thus, it could be more appealing than the 100% local ownership option. In addition, despite the differences between *Case 2* and *Case 3*, both could generate substantial revenue to fulfil locals' expectations. These *Cases* reflected that local stakeholders may need viable partnerships in securing financial capital and technology to develop a standalone mine. Besides these, landowners could be interested in other types of equity interest as discussed below.

Option 1: Royalty pre-financing

Royalty pre-financing involves subsidizing equity cost by utilizing a share of future royalty benefits. A JV structure may take 10-15 years to fully offset the cost of taking an equity interest using royalty proceeds. This technique could assist in avoiding the risks of securing market-based equity capital. For example, a 150 million USD revenue could be raised annually using a 5% royalty rate to finance a community's share of equity interests. However, landowners would not be willing to give up royalty revenue in exchange for receiving dividends in the future, which makes this option socially unviable. The delayed access to dividends and, at the same time forfeiture of royalty proceeds when price becomes volatile, could make this technique unviable. That said, landowners would decisively rethink direct equity participation if financial assessments may, otherwise, indicate a delayed dividend payment or may not exist as expected. It could eventually become a disappointing venture as the costs may exceed the dividends.

Option 2: Free-carried interest

Landowners can secure their share of equity interests with a *free-carried interest* financing technique, which involves cumulatively expensing their share of future cash inflows against an equity capital cost. This arrangement could resemble a loan settlement, where landowners would receive dividends after fully expensing the cost of equity (including interest) using their share of future cash flows from a viable venture (Ail, 2018). The *free-carried interest* could reduce exposure to credit risks of securing a market-based equity capital. It could suit both ABG and landowners compared to obtaining a market-based debt capital. However, the *free-carried interest* may place a burden on an external partner, especially in cases where local stakeholders need to contribute their share of upfront capital cost of constructing a mining project (Ail et al., 2024).

Option 3: State-subsidised free equity

Alternatively, ABG may establish policies to acquire equity interests on behalf of landowners. In this arrangement, the state would secure landowner’s equity interests, which may resemble *free-carried equity interest*. In this arrangement, the state may then guarantee to repay the equity debt (bank loan) using landowner's share of future cash inflows from a mining project. In doing so, the state accepts to bear the equity liability (financial risk) of securing financial capital on behalf of landowners. However, landowners’ opportunity to receive the risk-free dividends may be delayed if the state chooses to settle the equity debt first before permitting landowners to access dividends. This mimics a *free carried-interest* equity arrangement. Moreover, the subsidized equity could increase state's external (foreign) debt rating if a mine's profitability declines. It may create a free-rider problem as the equity subsidy is executed at a community's expense. Put differently, while a few privileged landowner groups benefit from state’s equity subsidy scheme, the cost of the subsidy could be transferred to a wider society. As such, ABG could need more credibility to secure financial capital for subsidizing community’s equity interests in a resource project.

Option 4: Free equity interest

The *free-equity interest* arrangement, unlike *option 3*, could pose a problem for landowners who seek to earn dividends without committing upfront capital cost of constructing a mine. As it requires efforts and costs to produce minerals, an in-situ deposit has value only if someone has to pay for shortfalls in securing the upfront capital costs (Tilton, 2004). The community could revert to *option 2*, and *fully-paid debt financing* technique if policy does not permit the *free equity interest*. By contrast, equity interest holding could yield dividends in scenarios where high prices rapidly offset the cost of securing the equity interest. Likewise, equity interest may not be suitable for low-grade and high-cost mining projects, including small and medium scale mines (Ail, 2024). These risks may emerge since Panguna has a slightly low-grade deposit (*Table 6*). The equity interest arrangements in options 2 and 3 seemed to be low-risk arrangements for local stakeholders.

A partnership between ABG and landowners, that is, 100% local ownership could capture the entire value chain of the mining venture. However, viability of this option could be unlikely since local stakeholders could have low credibility to raise market-based equity capital. Thus, the 50/50% or 51/49% interest bracket could form viable partnerships with external investors create a strategic alliance. Likewise, landowners may secure equity ownership through a *free-carried interest* option. This arrangement may delay access to dividends as it requires time for future cash flows to fully offset the cost of equity participation. Thus, low interest equity capital (e.g., concessional loans) could reduce the risks compared with market-based financing techniques. Alternatively, landowners can forge equity interest and negotiate to increase for and equitable royalty rate to access royalty proceeds at early stages of a mine’s life compared with high risk of waiting for equity dividends (Ail et al., 2024).

6.2 Contract mining

Capacity constraints of local stakeholders could be resolved through a contract mining option. This option involves a financing technique in which a contractor (both local and foreign) would be invited to develop and operate a mine on behalf of local owners over an assigned contract period. Under this arrangement, capital cost (interests included) would be refunded to a contractor, including a management fee imposed on net profits (Chuluundorj et al., 2022). This financing technique can secure funds needed for constructing a mine by starting small and gradually ramping it up into a large-scale operation within 7 to 10 years (*Table 9*). Contract mining could be advantageous for obtaining specialised technology and innovative mining methods to reduce initial capital cost (Distadio & Ferguson, 2022). Under this arrangement, at an early stage of a mine's life, local stakeholders could outsource the risks of wholly developing a mine to an external partner. Also, contract mining could free up time for all layers of governments and host communities to concentrate on social service delivery, benefit redistribution, and manage social issues. Thus, ABG and landowners could invite potential contractors (both local and foreign) through competitive bidding for contract mining (*Table 9* and model structure in *Fig. 11).*

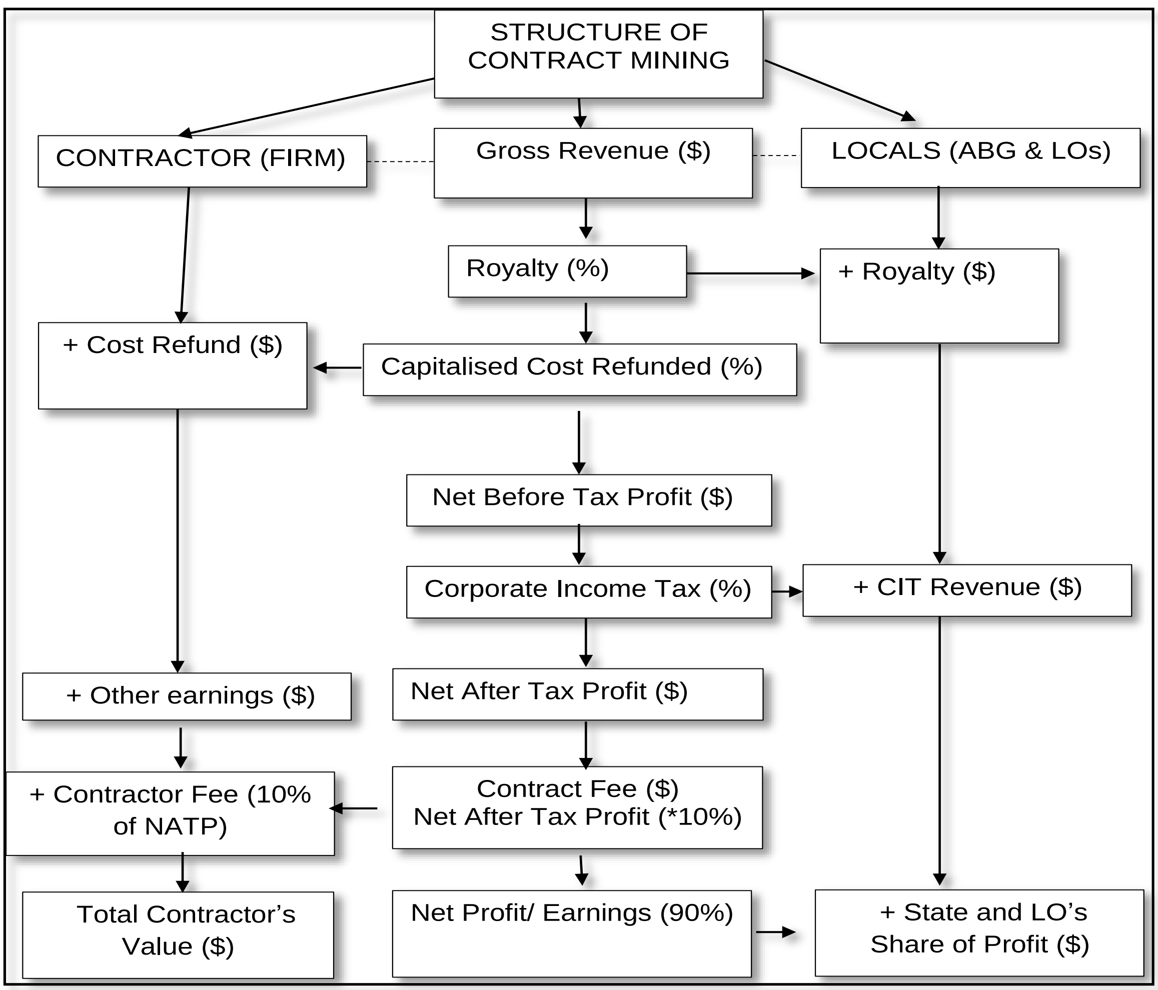


Figure 11: Flow chart of contract mining.

The flow chart in *Figure 11* describes operational structure of contract mining, where arrows designate costs and benefits flow over an entire project's life. The middle part features project's cash flow configuration. The left side of the flow chart displays a contractor's benefits, including refunding the capital invested. A contract management fee could be imposed on after-tax net profit. The right side of the chart designates benefits flow to local stakeholders. The magnitude of royalty, tax revenue, and share of net profits could depend on cost and market price differentials. Furthermore, operational attributes of contract mining could work efficiently if a local entity shares management roles with a contractor. This could gradually enhance local stakeholders' ability to localise a mining venture over a contract period. However, isolating the local stakeholders in decision-making may provoke disagreements, especially over financial disclosure issues. Thus, by outsourcing risks at early stages of a mine’s life, the contract mining could fulfil locals' quests to maximise benefits through direct ownership at latter stages of a mining project.

Table 9: Results of contract mining model of Panguna deposit over a 10-year mine life.

Summary of contract CF model	**US$B)**	**Tax, royalty & levies**	**US$B)**
Gross revenue	28.343*	Royalties	1.513
Less Royalty	(1.513)	Mining levy	0.166
Less mining levy	(0.229)	Corporate Income tax	1.821
Less Opex	(7.541)	Additional profit tax	-
Contractor cost refund	**(1.695)**	Dividend withholding tax	0.228
Less Tax	(1.814)	Import duties	0.448
Less Import Duty	(0.448)	Foreign Contractor WT	0.575
Less Withholding Tax	-	Landowner	2.189
Less Foreign Contractor Withholding Tax	(0.662)	State Net value	8.925
Undiscounted Free Cash flow	**14.529**	**Total ABG & LO**	**20.569**
Contractor Management Fee (-)	**1.453**		
DWT	(0.228)	**Contractor benefits**	
Net Cash flow	14.301	Cost refund (+interest)	1.525
NPV	9.162	Management Fee	1.647
IRR	31.3%	Other fees & benefits	0.500
DPP	3 years	**Total contractor benefits**	**3.673**

* Values estimated for a 10-year mine life under the contract mining option.

The numerical contract mining model over a 10-year mine life could deliver a low-cost option at an estimated capital cost of 1.5 to 2 billion USD (*Table 9*). It could be a medium-scale operation, which once commissioned could gradually expand into a large-scale operation at production mature stage. The results showed the project economics (NPV and IRR) improve with contract mining compared to local stakeholders' financing and operating a standalone mine. This technique can raise revenue of over 4.7 billion USD within a 10-year period. Local stakeholders can obtain approximately 90% of gross FCF (economic profit) if a contractor consents to receiving a 10% contract fee. The benefits accruing to contractors and local stakeholders may depend on the terms and conditions of initial contract agreements. Contract mining may be appealing as it would resolve the capacity constraint compared to the three *Cases* assessed in *Table 8*. Additionally, it may create opportunities for local stakeholders to wholly own a mine at mature stages of a mine's life after a contract term expires. Thus, contract mining could resolve the capacity constraint problem associated with equity interest participation.

7 Discussion

7.1 ABG's revenue forecast

ABG has aspired to raise revenue to develop Bougainville's economic and social sectors (Chand, 2017). However, the reliance on external budget supports exposed ABG to a dependency attitude and become vulnerable to unpredictable budget shortfalls. This could entice the transitional government to seek financial aid from predatory nations and investors. The frustration over lack of support and revenue shortages could entice ABG to seek support from predatory donors and investors to develop its natural resources, but could entangle itself into serious political instability in the region (Kolova, 2024). To avoid such pitfalls, the ABG ought to be financially independent to exist as an autonomous entity by empowering the people to become self-reliant in generating revenue. Such a vision could motivate ABG to secure policy and administrative capacity building programs to develop megaprojects both in minerals and non-minerals sectors. Hence, financial independence could foster self-determination to trigger the emergence of locally grown enterprises and social institutions that may increase revenue and sustain the tax base of the economy.

ABG's budget relies heavily on grants from National Government, which accounts for 90% of annual budget appropriations (Nema, 2019). The remaining 10% come from internal sources such as goods and services tax (GST), personal income tax (PIT), and CIT collected mostly from retailing and a thin merchandise sector. Hence, it would be crucial for ABG to focus on attaining financial stability and secure sustainable sources of revenue while maintaining the external donors. The situation may require a strong determination to develop natural resources that are accessible within its boundaries to sustain the autonomous status.

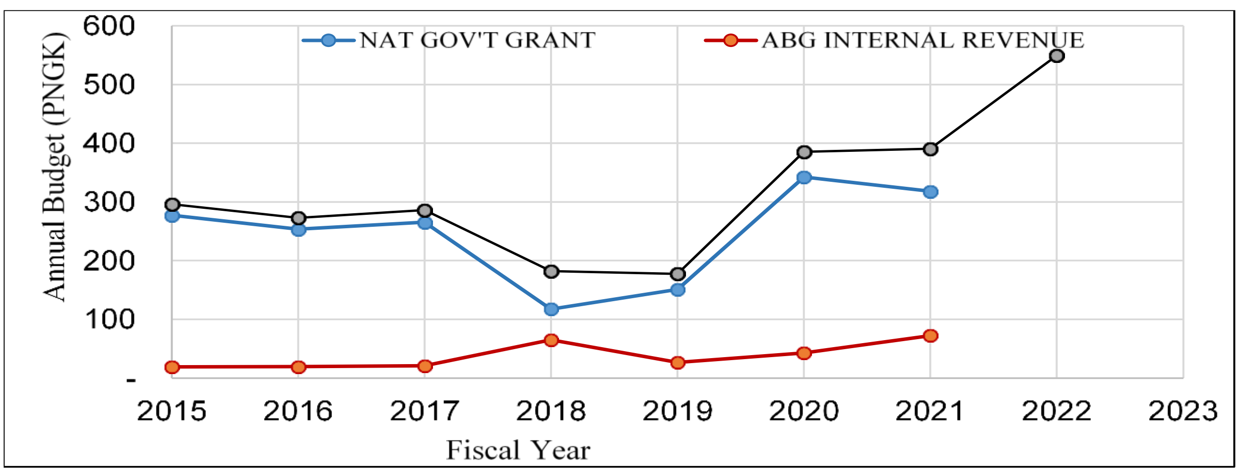


Figure 12: Historical sources of revenue for ABG's annual budgets.

ABG's internal revenue comprises of mainly National Government grants and few other revenue sources (*Fig. 12*). Since 2015, ABG's average annual budget has been around 250 million PNGK per year and has increased to 594 million PNGK in 2022 and onwards. These budget allocations have been primarily earmarked to meet social and administrative services. However, with the inclusion of development budgets, ABG's annual budget requirement has exceeded 1.2 billion PNGK, which could increase to 3 billion PNGK in the next five years. Since its inception, ABG's internal revenue has remained low due to subdued economic activities, high unemployment rate and exportable sectors have declined over time. This reflected that developing a megaproject would be crucial to repel against an impending dilemma that could become critical if ABG succeeds its agenda for independence in the 2025-2030 periods (*Fig. 13*).

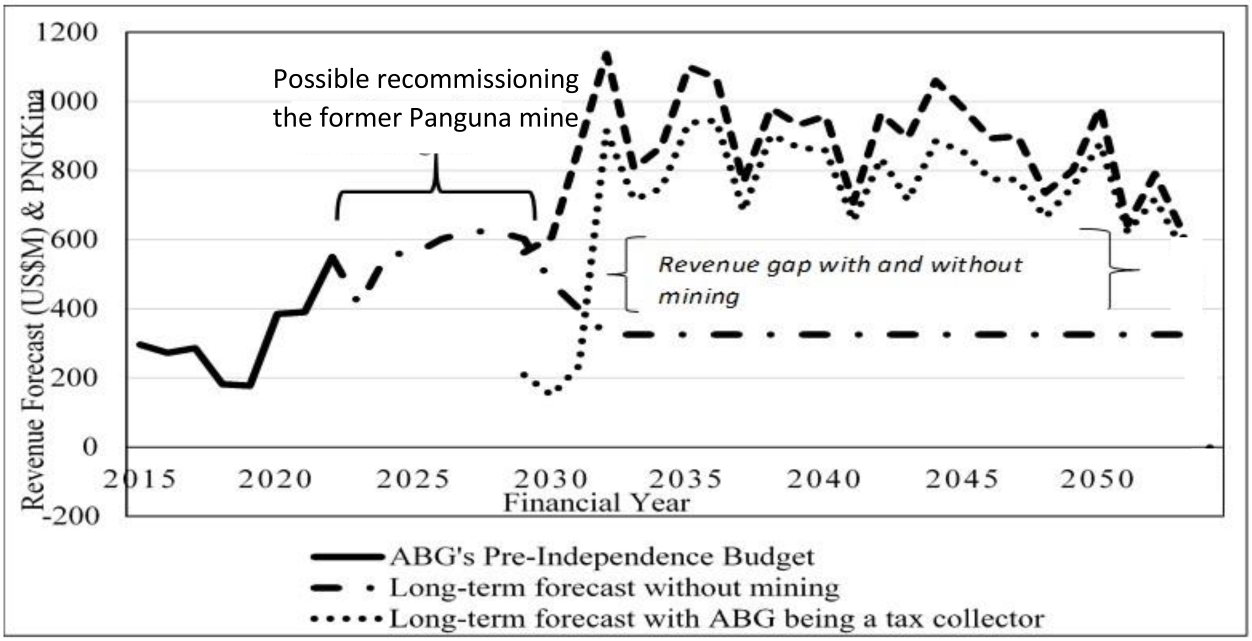


Figure 13: Revenue forecast from different sources and options.

In *Figure 13*, revenue forecasts were based on timely redeveloping the Panguna deposit and compared with a revenue forecast in the pre-independence period. The long-term revenue forecast with and without mining in which the scenarios of wholly owning a mining project were compared with state being a tax collector only and owning an equity interest in the Panguna project. It presented three assumptions. First, revenue could increase during high-price periods if ABG becomes both a regulator and a partner. Second, revenue differences between scenarios with and without direct equity participation could be small since over 70% of revenue comprise of revenue from basic taxes compared with equity participation. For both scenarios, the cumulative difference could be substantial during high prices, compared with revenue raised during low price levels. This behaviour can be seen in the revenue curves, which tend to merge (low points in *Fig. 13*). Hence, the difference can be small, irrespective of options with or without direct participation.

As depicted *Figure 13*, Bougainville's economy without mining could decline with a widened revenue gap, thus, could become critical over time. It could jeopardize ABG's ambitions to expand the economy and expose to severe financial shortages when successive budget shortfalls intensify into an impending cycle of fiscal imbalance. This condition could be critical when the GoPNG ceases its annual budget appropriation as Bougainville progresses towards its political transition.

Thus, redeveloping the Panguna mine can narrow the revenue gap, providing a glimmer of hope for ABG to become financially independent to meet its development aspirations.

7.2 Strategies for Revenue Management

Governments and investors need to envision robust frameworks ensure equitable redistributions of benefits, information transparency, and support sustainable enterprises when developing finite mineral resources. Inflows of windfall revenue often necessitate prudent management strategies to control public expenditure and diversify surplus revenue. A mineral-dependent economy is often fragile and susceptible to commodity supply cycles that may influence revenue fluctuate (Gould, 2010). During non-boom periods, a government can have access to budget surpluses saved in a Sovereign Wealth Fund (SWF). Such strategies are crucial to avoid the likelihood of external price shocks that may adversely affect an economy (Alhashel, 2015). Intuitively, it could be imperative for ABG and local stakeholders to use resources to generate revenue. Sustaining economic and social growths would be critically important for resource endowed nations.

The GoPNG previously created a Mineral Resources Stabilization Fund (MRSF) to safeguard additional profits from the former Panguna mine (Auty, 1998). This was intended to create a reserve fund, which could have accumulated over time to ascertain and provide a budget relief during low mineral prices. However, 'windfall thinking' caused PNG to depart from MRSF's initial purpose, which resulted in a misuse of resource revenue saved in the MRSF (Megginson & Fotak, 2016). To some extent, a state could be complacent with funds parked away in a SWF as it could be tempted to spend irresponsibly (Alhashel, 2015). Further, SWF may help fill a small budget gap and may not entirely cover budget shortfalls. To avoid such traps, it might be advantageous to diversify the windfall revenue into non-mineral sectors. There are success stories of well-structured SWFs for storing wealth for future generations (*Fig. 14*).

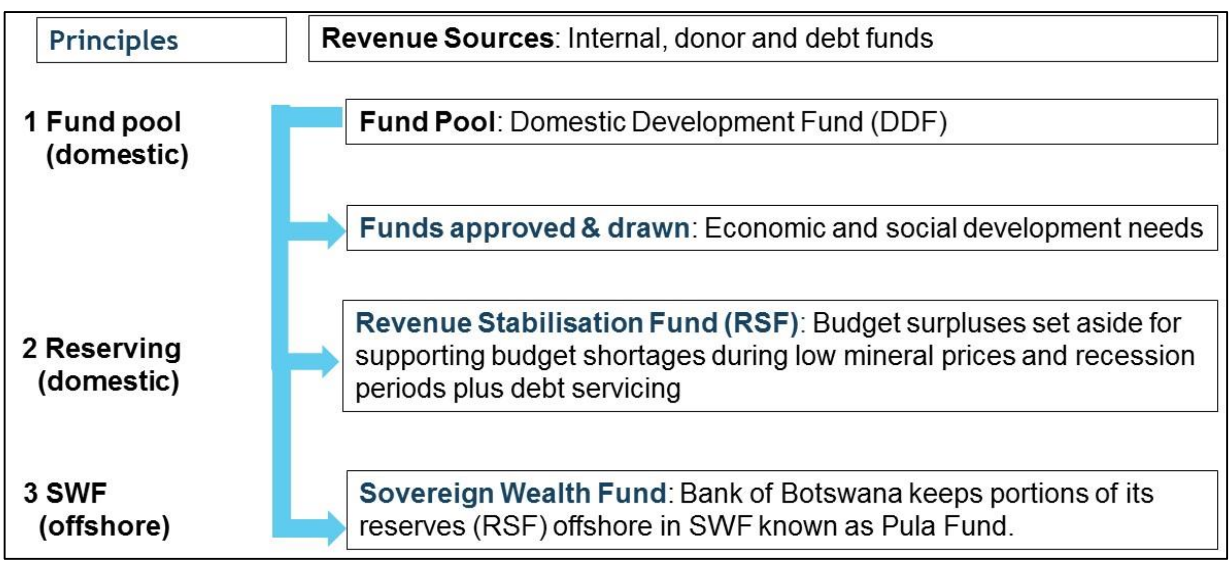


Figure 14: The Botswana model of SWF structure.

In *Figure 14*, Botswana's revenue management structure consists of three streamlined development objectives (Sebudubudu, 2021). These are annual development needs; short-term public debt servicing; and long-term budget stabilisation. The first objective entails a Domestic Development Fund (DDF) in which revenue generated internally and donor funds are diverted into the DDF for domestic use. The funds are transparently approved for social and economic project programs through transparent public procurement procedures. The second objective involves creating a Reserve Stabilization Fund (RSF) (or domestic savings) to reserve budget surpluses to fulfil development needs and cover external debts during low commodity prices and recession periods. The third aim is to attain ascertain intergenerational equity in reinvesting abnormal profits (budget surpluses) in a SWF (Wills et al., 2016). An immature economy may devise such a simplified SWF structure that could assist in attaining a high level of transparency in financial decision-making and ease of detecting public corruption (Adomako-Kwakye, 2021).

At length, establishing the core functions of SWF is important, including physical gold and budget surpluses from other resource sectors to exist within a regulatory framework and broaden the scope to reinvest in impartial institutions that are not subject to political influences. The risk of SWF being delayed or ignored is often high suppose a government neglects to allocate abnormal rents into an SWF and resort to irresponsible spending (Gilberthorpe, 2016). The ABG as a transitional government could face a mammoth challenge of transitioning to financial autonomy, which could test its capability to manage resource revenue when developing a megaproject. To an extent, discouraging the windfall mentality in expenditure planning, diversify into physical and social infrastructure and replicable capitals and budget surpluses saved in a SWF, can shield a venerable economy against fluctuation in revenue. In some ways, ABG can adopt a framework similar to Botswana's SWF structure that can suit local conditions to enhance revenue diversification and transition towards financial and political autonomy.

7.3 Indirect benefits

Indirect benefits arising from intermediate sectors may create value-added multipliers to expand and broaden an economy's tax base. Mining sector requires high mechanization both at construction and production stages, and thus, may require few local inputs. However, due to lack of capacity, a sizeable share of capital input during a mine commissioning stage could be spent abroad on specialised equipment, technology, and skills (Bainton & Jackson, 2020). Foreign constructors would be financially well prepared to secure high-value contracts in specialised production activities such as supply of explosives, equipment and spare parts, drilling and blasting and hauling, and consultation services in all phases of mining. In contrast, local contractors could take a small portion of capital expenditures due to a lack of capacity such as financial capital to start businesses and knowledge and access to supply chains. Also, local contractors may capture a small value from subcontracts (minor road and bridges, and earthworks), logistics supplies and transportation business. Also, local entities may be tempted to form JV partnership with external contractors with financial capital and skill capacity to secure high-value contracts (Bainton & Banks, 2018; Jackson, 2015). Thus, a local content policy can empower community’s participation to capture quasi-rents (Ail et al. 2024).

Value retention and supporting multiplier effects at the micro level could be important for mining-induced enterprises to emerge in the region. The size of residential workforce can have multiple effects and influence the retention of disposable incomes in host regions. Residential employees' income spending could trigger the economy to grow (Storey, 2001). At one time, Arawa mining town was a thriving and vibrant residential township in Bougainville. There was no fly-in, fly-out (FIFO) policy, which saw BCL's foreign and national employees resided peacefully in Arawa mining town. Thus, expanding and redeveloping the existing Arawa town could encourage the workforce to reside in the mining town to boost economic growth in the region. Furthermore, a mining activity can facilitate labour mobility and household productivity, and provide access to education and health services to improve the living standards of the people.

In contrast, local entrepreneurs may choose to spend their earnings in other regions that are safe in terms of leisure and social well-being. When a larger segment of mine employees (residents) spends their incomes outside of the region, effects of income leakages could be similar to those caused by the FIFO mode of mine operation (Storey, 2018). The FIFO arrangement could raise social concerns about regional multiplier leakages when incomes are repatriated out of a region (Ail & Arpa, 2023)**.** Indirect benefits can be captured using a suitable local content policy with a flexible FIFO arrangement. This may not be limited to other incentives that could help retain quasi-rents and indirect benefits that maximise the value of mineral wealth.

7.4 Indirect costs

The CBA study did not examine the environmental impacts of former Panguna mine and compare with the costs and benefits of redeveloping the remnant deposit. The CBRs computed in *Table 9* were only based on production costs and net values of minerals exported. In an ideal setting, intangible costs may include loss of income from depletion of fish stocks and forest products. This may include limiting the access to water sources, resource scarcity causing tribal conflicts, and pollution-induced regional migration (Murray et al., 2022). However, the conceptual model made some assumptions of mine waste treatment costs and fees charged per unit of waste material. In practice, identifying risks and strategies for mine waste containment are important prerequisites for environmental and social permits.

The risks associated with chemical composition of mine waste could necessitate a thorough understanding of physical and chemical composition of a mineral deposit. Having a clear knowledge of environmental impacts can enhance strategizing practical solutions and design risk-based management practices (Velásquez et al., 2022). The social and ecological costs could be reduced by employing cost-effective and technically feasible waste management strategies. PNG's mining industry applies riverine and deep-sea tailings placement (DSTP) practices under a Water Use Permit (WUP) policy (Rodríguez et al., 2021; Vogt, 2012). This policy allows mining companies to dispose of tailings into rivers and seas within the vicinities of mining operations (*Fig. 15*). Given the past legacy issues, Bougainville's mining policy may restrict riverine and DSTP tailings disposal practices and devise policies to convert mine waste into commercial value that would change society’s perception of mine waste as toxic material when disposed into an environment (Velásquez et al., 2022).

Figure 15: Satellite image of Panguna Mine's environmental footprints

In *Figure 15*, a recent satellite image of Panguna mine shows graphic view of footprints associated with past tailing disposal into the Java River, which flows into the Solomon Sea. The rich soil, temperate climate, and high rainfall conditions may have restored and supported the regrowth of vegetation within the enclave mining region (*Fig. 15*). However, there were noticeable traces of acidity loads exposed over time. The greenish-blue colour of drainage water comprises of dissolved copper and other trace metals in solution, forming acid mine drainage (AMD) (Lowen, 2021). The chemical effects on an entire ecological system could be permanent if restoration strategies are ineffective and may require extensive and costly restoration efforts. The chemical impacts on water sources and seas may be irreversible compared with physical impacts. The scoping study conducted by BCL proposed some options for mine waste management (*Fig. 16*).

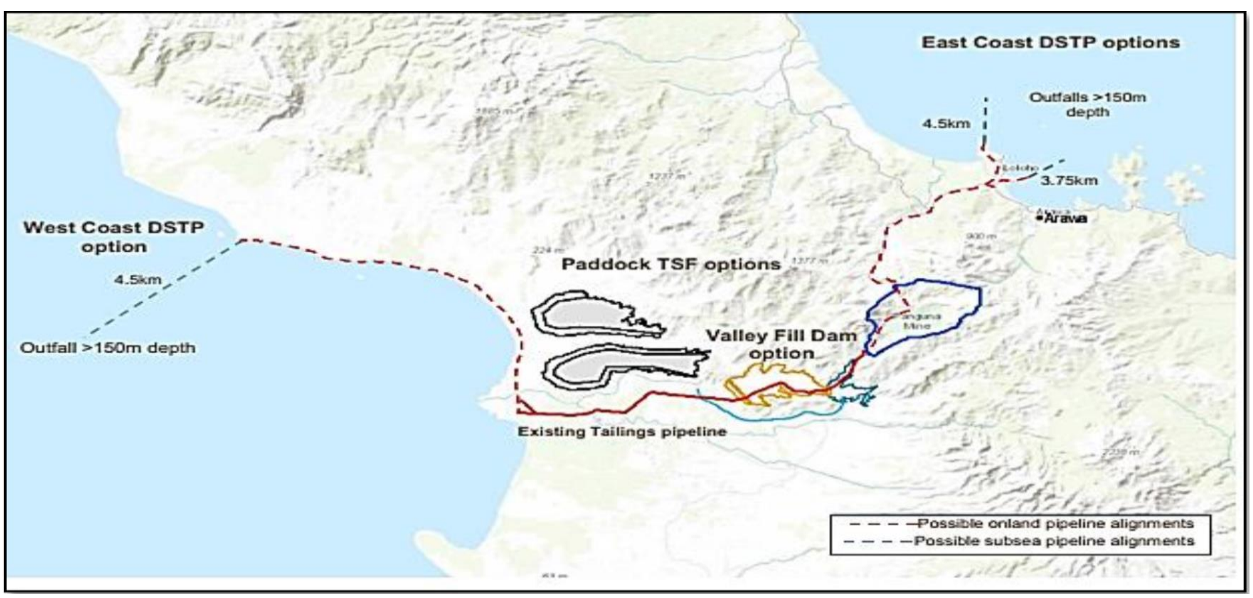


Figure 16: Panguna mine’s tailing containment options. Source: www.bcl.com.pg/wp-content/

In *Figure 16*, BCL's scoping study in 2016 considered some options for tailing dam construction for offshore placement of mine waste and options for deep-sea tailing placement practices (DSTP). DSTP practice began with the former Misima gold mine in PNG (Vare et al., 2018), which was later adopted by mines located near the coast, namely, Ramu Nickel, Lihir, and Simberi gold mines. The main issues associated with the DSTP are chemical pollution and related impacts (Spitz & Trudinger, 2019). AMD forms when oxygen and rainwater react with sulfides to generate bio-conditions suitable for oxidation. Sulphide oxidation induces kinetic iron transfer that in, turn, dissolve trace metals into solution and flow into waterways and aquatic habitats. The kinetic iron transfers are more rapid in a riverine environment due to rainwater and atmospheric oxygen exposure than in deep-sea environments (Kwong et al., 2019). The process of transferring iron can be slow in conditions where atmospheric oxygen and rainwater are absent, especially in a deep-sea environment. Thus, formation of AMD could be more rapid in a riverine waste disposal than the DSTP practice.

From a policy perspective, tailing disposal practices should be determined on a case-by-case basis. Policies reserved for practical solution depend largely on geographical location, geological instability, seismic activity and environmental risk and social sensitivity. Having a fair knowledge of these factors could provide practical options to devise risk-based options such as constructing tailing storage facilities versus terrestrial disposal options (Tuomela, 2022). As often argued, the marine tailing practice could free up land for community’s use and avoid the risk of tailing dam failures. Such incidents are well known for polluting agricultural lands of communities living downstream (Rotta et al., 2020). Furthermore, applying a waste disposal strategy should be determined based on scientific evidence, instead of qualitative and perceptive judgements that are discrete from material facts of anticipated impacts in real time. Further, waste management policy may require classification codes for risk characterisation, such as innovative waste management strategies are contingent on geochemistry, geographical location and social and environmental sensitivity of host regions. That said, flexible environmental regulations and policies should be adopted to encourage technological innovation to take place that in, turn, could provide long-term solution to societal and environmental impacts of mine waste placement (Dickin et al., 2014).

8 Conclusion

In light of the sensitivity surrounding Bougainville’s past history in which economic and social foundations were shattered by the civil crisis, the CBA study was cautious in investigating the importance of developing mineral resources to raise revenue to resuscitate the economy. The CBA study attempted to recount the benefits of recommissioning the Panguna mine that could exceed the net benefits of the former mine. The historical and conceptual efficiency ratios being higher than *1* depicted that monetary benefits could exceed the production and opportunity costs of mining. The CBA study found that regardless of ABG’s political visions, recommissioning the Panguna mine to revive agriculture, fisheries and tourism sectors and reconstruct the physical infrastructure should be the primary objectives. Thus, the CBA highlighted the importance of strengthening mineral sector policy, including capacity of tax authorities and efficient revenue and mine waste management policies. These were recognized as policy recommendations that highlighted the need for capacity building in areas of regulations, taxation and local content policies (see *Section 9*).

Essentially, Bougainville's mining law was tailored towards reviving the economy through inclusive decision-making by enhancing greater participation of the community and to avoid a repeat of past socio-political and environmental legacies. Past policy gaps denied Bougainvilleans, mainly landowners who expressed their voices for inclusive decision-making to be an integral part of development process. A major finding of the CBA study was that, despite the recognition of landowners as owners of minerals, the inclusive mining law may not alter the interdisciplinary collaboration that forges commercial and financial partnerships of a viable mining venture. The local stakeholders may not explore and develop a standalone mine due to capacity constraints, especially their credibility to secure financial capital. Hence, having assessed some options, we identified that an equitable JV partnership arrangement with an investor or a contract mining option could create sufficient value for ABG and the community. From a broader perspective, Bougainville's mining policy has strived to adhere to international best practices as pillars to deliberate on modern legal and policy frameworks for optimizing financial, social, and economic benefits and adopt suitable strategies for environmental management.

Since minerals are finite and complex, numerous challenges are expected to emerge, especially in the legislation and policy domains. These challenges require progressive reforms to suit the needs of participating stakeholders and establish viable partnerships with investors to ensure risk and rent sharing. To enhance these, ABG would periodically review and rectify its policy stance to create synergies for community engagements on a win-win basis to share the risks and benefits of resource developments. The dynamic nature of mineral sector would necessitate continuous adaptation and reforms to ensure their relevance and effectiveness are facilitated in future mining ventures. The commercial dialogues and negotiations can be filtered through understanding project risks and value chain distribution. Moreover, some enabling factors could maintain industry competitiveness and promote foreign direct investment (FDI) in exploration and mining. Inflow of FDI are important to intensify exploration activities based on past geological mappings, which could assist discover other porphyry and epithermal systems similar to Panguna deposit (e.g., *Figures 1 and 2*). Thus, investors would be well assured that community ownership of minerals may not restrict competitive bidding for lease rights and land access and deviate from commercial norms of mining business on par with international practices.

The CBA study has emphasised the importance of mining sector's ability to generate revenue to support an emerging economy. The former Panguna mine supported economic and political independence of PNG as a sovereign nation, even for a much larger country such as PNG, in which mine-derived benefits were considerable. The positive legacies of former Panguna mine benefited PNG more than other mines developed later in the post-Panguna era. That said, ABG has had an overarching vision to devise targeted policies to create social cohesion to enhance fast-tracking the recommissioning of Panguna's remnant deposit of 1.8 billion tonnes of copper-gold resource. Moreover, the CBA study inspired an optimism not only about redeveloping the brownfield deposit. It also could represent a landmark attainment of Bougainvilleans' decades-long aspiration for freedom and independence through inclusive decision-making in all aspects of economic and social developments. Despite the enterprising experiences of blessings and curses a mining industry could bring, Panguna's story has strongly influenced the adoption of the inclusive mining law, which could entail the fall and rise of Bougainville to manage its own destiny. This article could attract wider research audience on determining the flight of Bougainville people.

9 Recommendations

9-A: Mineral taxation

Taxes are important instruments for collecting revenue from mining activities. Direct and indirect tax instruments could collect over 70% of resource revenue (Ail et al., 2024). However, the magnitude of revenue depends on the financial performance of a mining project. Thus, it is important to design an efficient mineral taxation regime. The mineral taxation regime should focus not only on internal revenue raising. It should also establish a sound and balanced fiscal structure to attract investment and maintain the long-term competitiveness and sustainability of the sector. A mining taxation regime could be integrated into Bougainville's Mining Act (2015). The justification for this recommendation was the revenue gap could be closed if ABG builds capacity to collect revenue. However, finding a suitable structure to capture equitable share of profits is challenging.

9-B: Direct equity participation

The CBA study revealed that mining law provides a guideline for local ownership structure to reduce social risks and increase inclusive decision-making and win-win outcomes. This would ensure that mining projects operate profitably and may generate dividends from collateral equity participation. Despite the legislative impetus for direct ownership of minerals, local stakeholders may need more capacity for exploration and wholly develop mining projects. Some options could be considered under mining leases:

- The free-carried interest ownership arrangement was identified to be a financially viable option that may suit the capacity of ABG and landowners, although there could be other options available for equitable retention of resource benefits. This financial arrangement (i) reduces the risks of seeking market-based financial capital and (ii) allows a project to self-finance the equity interest on behalf of the landowners.

- The 50/50% interest or 51/49% bracket amongst could be a viable option for equitable benefits redistribution.

- A high royalty rate can replace direct equity participation, especially for low-value and high-cost mines. The CBA study showed that direct equity participation may not be viable for high-cost and low-value mineral deposits and medium-scale mines. Equity stake ownership can be determined on a *case-by-case* basis, especially for mining leases (MLs) that are long-lived and highly profitable mines compared to high-cost and short-life mines.

- The option of contract mining could resolve the capacity constraint face by local stakeholders.

9-C: Local content policy

Microeconomic growth could rely more on non-tax benefits than direct tax revenue. Indirect benefits may include contract and employment opportunities, spin-off business activities, and income repatriation policies such as those for FIFO operations. The incentives for indirect benefits needed to be improved when commissioning the former Panguna mine. An efficient local content policy could be pivotal in recognising skill levels and contract opportunities consistent with Bougainville's production capacity, including opportunities for downstream processing and technical innovation. A suitable local content policy could capture more of the quasi-rents compared with receiving dividends from equity participation. Bougainville could capture indirect benefits through employment, local goods and services procurement, and agricultural, construction, and manufacturing inputs.

To strengthen Bougainville's local content capacity, ABG may focus on local and international supply chains and develop a skilled workforce through holistic technical education and financial inclusion through the SME sector (linked to financial institutions) to increase local productive capacity. To enforce this, ABG may holistically develop a localization program through budgetary support to sponsor young people to enroll at technical colleges in PNG and abroad.

9-D: Artisanal and small-scale mining

As reflected in *Section 3*, the geological setting of Bougainville Island poses significant potential for small-scale mining (*Fig. 1* and *2*). Access to alluvial mining and licensing procedures are suitably covered under *Bougainville's Mining Act* 2015 (Boege, 2023). Thus, the following could be considered:

(i) The ASM sector may require capacity building to impart skills in the following areas: (i) apply suitable mining and recovery techniques; (ii) mitigate environmental impacts; and (iii) economic and financial management to encourage reinvestment in the SME and other sustainable sectors instead of direct consumption; (iv) regulatory capacity building.

(ii) Devise control mechanisms to regulate the local market for gold sales and monitor smuggling gold out of Bougainville. Another means of control could be to impose a levy on gold disposal agencies. It would be important to monitor gold being smuggled out of Bougainville and reduce the unexpected conflicts between external investors and landowners.

(iii) Evaluate and map out alluvial deposits and artisanal works in Bougainville to establish an inventory of artisanal and alluvial gold reserves by sampling rivers and artisanal sites. The information would be helpful in upskilling miners to use suitable mining and recovery technology depending on gold size distribution and regional geomorphological processes.

(iv) Devise mechanisms to discourage foreign involvement in the ASM sector and encourage landowners to have 100% stake ownership.

9-E: Indirect cost of mining

Given the past legacy issues surrounding the former Panguna mine, ABG needs a firm policy for mine waste management. Legislation and policy on mine waste placement should be grounded in scientific knowledge and evidence-based decisions to avoid repeating past mistakes. That said, future environmental legislations should be flexible to leave options open to determine waste management strategies such as the tailing dam and the DSTP practices. These decisions should be supported by scientific evidence and designs that meet safety specifications and international practices. Legal restrictions on mine waste management options could inhibit innovation, increase treatment and restoration costs, and disincentive to investment. Riverine tailing disposal practice may not be implemented in environmentally and socially sensitive regions in Bougainville.

ABG may develop a suitable environmental code of practice that complements the Mining Act (2015) and allow Conservation and Environment Promotion Authority (CEPA) to provide technical assistance to progressively develop and enforce environmental regulations on mine waste management policies for Bougainville. Further, the regulator may devise post-mine land use policy (i.e., mine closure) that could include waste impoundment policies to allow extraction of residual gold from tailing using environmentally safe leaching and other green technologies. This may provide a long-term tailing storage facility solution by converting mine waste into sustainable assets that reduce post-mine management costs, generate income, and create employment.

9-F: Revenue management

As explained in *Figure 14*, Bougainville may establish a revenue management system, notably the SWF, using a suitable structure, which could establish a strong foundation for prudent management of resource revenues. ABG could replicate Botswana's revenue management structure in which budget surpluses would be retained in an RSF (*Fig. 14*). The reserve funds in an RSF would be used for debt service, and excess funds can be diversified into a SWF (interest-bearing investments abroad). ABG may establish a constitutional framework that enables the SWF to grow over time. Replicating Botswana's revenue management structure could ensure transparent procedures for drawing funds from the MSF and SWF sources for development purposes. The SWF could serve the objective of saving surplus revenue for two purposes: (1) diversify rents from extractive activities; and (2) support social expenditure shortfalls during economic shock (downturn) due to low commodity prices.

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APPENDIX A

Summary of Historical Financial flows and Benefit Redistributions of former Panguna mine

Table 1-A: Mineral production and financial data of Panguna Copper mine

Year	Copper (t)'000'	Gold (Oz)	Silver (Oz)	Free Cash Flow (FCF)	Pre-tax CF	Post-tax CF
1971				**-536**	**-536**	**-536**
1972	124	371,960	944,206	95.9	27.7	27.7
1973	182.9	638,892	1,395,050	252.4	158.7	158.4
1974	184.1	637,724	1,440,858	292.6	181.1	114.6
1975	172.5	565,336	1,316,028	183.1	58.6	46.2
1976	176.5	629,200	1,412,453	208.9	61.6	41.3
1977	182.3	694,969	1,474,177	205.3	42.2	28.5
1978	198.6	727,127	1,634,500	225.1	70	48
1979	170.8	612,807	1,387,452	343.1	161.8	83.9
1980	146.8	436,520	1,146,062	338.7	122.7	71.5
1981	165.4	523,440	1,317,564	296.4	43.4	22.8
1982	170	545,462	1,342,247	282.2	28.5	11.2
1983	183.2	560,555	1,473,685	392.9	101.5	54.6
1984	164.4	487,414	1,381,287	310.9	26.1	11.6
1985	175	446,921	1,434,853	317.6	47.1	28.1
1986	178.6	508,987	1,567,096	342.7	74	45.3
1987	178.7	469,793	1,573,262	415.4	144,2	93.6
1988	166	430,897	1,505,563	493.4	201.8	108.6
1989	68.7	209,552	644,023	231.6	5.1	-20.6
Total	**2,989**	**9,497,557**	**24,390,365**	**5,228**	**1,412**	**975**

Source: BCL Annual Report (2014), https://www.bcl.com.pg/annual-report-2014-released/

Table 2-A: Indirect and non-tax benefits of former Panguna mine.

	Total (30-years)	Annual est.	PV@5%
Quasi-rents (local procurements)			
Labour	956	50	52
Utilities	2105	31	54
Fixed Overheads	1542	45	65
Local contract value	1302	34	46
Materials & Supplies	1844	44	57
Other external services	61	2	2
Total procurements (*B*)	**6508**	**172**	**231**
Social expenditures[1]			
Compensation (environment)	164	5.5	38
Mining lease and occupation fees	50	1.5	11.5
Tax credit scheme (TCS) (5% of CIT)	305	10.2	70.6
Special support grant (SSG) (0.25% *GR*)	147	4.9	34
In-house and external training			
Apprentice training	45	1.5	10.4
Tertiary scholarships	35	1.2	9.1
Education donations (materials, books)	9	0.3	2.1
(*C*) Total	**755**	**25.2**	**176.7**
(*D*) Total indirect benefits (*B* +*C*)	**7,263**	**242.1**	**1,680.5**
Net benefits (*A* + *D*)	**39,758**	**1,325.3**	**9,199**

[1] The social expenditures were estimated based on PNG's community incentive rates

Table 3: Summary of costs and benefits.

Table 3-A: Summary of costs and benefits of former Panguna Copper mine

ABG's net value	11,821
LOs net value	5,960
Direct tax revenue	12,633
Indirect tax revenue	2,081
Infrastructure expenditure	666
In-house and external training	89
Quasi-rents (local procurements)	6,508
Total benefits	**39,758**
Summary of all costs	
Capital costs	6,806
Operation costs	31,632
Costs of biophysical impact & management	323
Total (Net) Costs	**31,955**

Appendix B:

Dynamic Cash Flow Model of Recommissioning the Panguna mine

Table 1-B: Results for 100% local ownership structure

Input variables	Values	Input variables	Values
Capital Cost ($B)	5.8	Copper Production/Yr (t)	176667
Unit Operating Cost ($/t)	10.9	Gold Production/Yr (Oz)	643333
Reserve (Mt)	1838	Revenue from Copper ($M/Yr)	1060
Mine Life (Years)	30	Revenue from Gold ($M/Yr)	933
Annual Throughput (Mt)	61	Total Revenue ($M cu + $M Au)	1784
Mill Recovery Rate	75%	Operating Cost ($M/Yr)	512
Refinery Recovery Rate	85%	Royalty Rate	5%
Copper Grade	0.30%	Corporate Income Tax	35%
Gold Grade (g/t)	0.34	Discount rate	8%
Copper Content (Mt Cu)	5.3	Real discount rate	4.9%
Gold Content (Moz Au)	19.3	Inflation rate	3%
Copper Price ($/t) (stochastic table used)	6000	Working capital (1% of capex) (US$M)	58
Gold Price ($/Oz)	1450	Salvage value ((2% of capex) (US$M)	116
Copper Production/Yr (t)	176667		
Gold Production/Yr (Oz)	643333		
Revenue from Copper ($M/Yr)	1060		
Revenue from Gold ($M/Yr)	933		
Total Revenue ($M cu + $M Au)	1,993		
Operating Cost ($M/Yr)	668		
Fiscal Data			
Royalty Rate	5%		
Corporate Income Tax	35%		
Discount Rate	8%		
Real discount rate	4.9%		
Inflation Rate	3%		

Table 2-B: Results for 100% local ownership structure

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Gross Revenue	1,993	2,053	2,114	2,178	2,243	2,310	2,380	2,451	2,524	2,600	2,678	2,759	2,841	2,927	3,014	3,105	3,198	3,294	3,393	3,494	3,599	3,707	3,818	3,933	4,051	4,173	4,298	4,427	4,559	4,696	4,837
Royalty (5%)		-103	-106	-109	-112	-116	-119	-123	-126	-130	-134	-138	-142	-146	-151	-155	-160	-165	-170	-175	-180	-185	-191	-197	-203	-209	-215	-221	-228	-235	-242
Operating Cost	-668	-688	-708	-730	-752	-774	-797	-821	-846	-871	-897	-924	-952	-981	-1010	-1040	-1072	-1104	-1137	-1171	-1206	-1242	-1280	-1318	-1358	-1398	-1440	-1483	-1528	-1574	-1621
Depreciation (Straight Line)	-5800	- 193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193	-193
Net Income Before Tax	**-5800**	**1,069**	**1,107**	**1,146**	**1,186**	**1,227**	**1,270**	**1,314**	**1,359**	**1,406**	**1,453**	**1,503**	**1,554**	**1,606**	**1,660**	**1,716**	**1,773**	**1,832**	**1,893**	**1,955**	**2,020**	**2,086**	**2,155**	**2,225**	**2,298**	**2,372**	**2,449**	**2,529**	**2,610**	**2,694**	**2,781**
Apt revenue																															
APT Calculation																															
Pre-tax IRR		**-82%**	**-46%**	**-23%**	**-9%**	**0%**	**6%**	**10%**	**12%**	**15%**	**16%**	**17%**	**18%**	**19%**	**19%**	**20%**	**20%**	**21%**	**21%**	**21%**	**21%**	**21%**	**21%**	**21%**	**22%**	**22%**	**22%**	**22%**	**22%**	**22%**	**22%**
IRR TRIGER (15% Threshold Rate)		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1453**	**1503**	**1554**	**1606**	**1660**	**1716**	**1773**	**1832**	**1893**	**1955**	**2020**	**2086**	**2155**	**2225**	**2298**	**2372**	**2449**	**2529**	**2610**	**2694**	**2781**
Apt revenue @20% * NIBT If IRR>15%		-	-	-	-	-	-	-	-	-	**- 291**	**- 301**	**- 311**	**- 321**	**- 332**	**- 343**	**- 355**	**- 366**	**- 379**	**- 391**	**- 404**	**- 417**	**- 431**	**- 445**	**- 460**	**- 474**	**- 490**	**- 506**	**- 522**	**- 539**	**- 556**
Taxable Income After APT		**1,069**	**1,107**	**1,146**	**1,186**	**1,227**	**1,270**	**1,314**	**1,359**	**1,406**	**1,163**	**1,202**	**1,243**	**1,285**	**1,328**	**1,373**	**1,418**	**1,466**	**1,514**	**1,564**	**1,616**	**1,669**	**1,724**	**1,780**	**1,838**	**1,898**	**1,959**	**2,023**	**2,088**	**2,155**	**2,225**
Tax (35%)		-374	-387	-401	-415	-430	-444	-460	-476	-492	-407	-421	-435	-450	-465	-480	-496	-513	-530	-548	-566	-584	-603	-623	-643	-664	-686	-708	-731	-754	-779
Net after tax	-5800	**695**	**719**	**745**	**771**	**798**	**825**	**854**	**883**	**914**	**756**	**782**	**808**	**835**	**863**	**892**	**922**	**953**	**984**	**1,017**	**1,050**	**1,085**	**1,120**	**1,157**	**1,195**	**1,234**	**1,274**	**1,315**	**1,357**	**1,401**	**1,446**
POST-TAX APT CALCULATION																															
Add back																															
Depreciation		193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193
Capital Cost	-5800																														
Working Capital		-58																													141
Salvage Value																															116
Net Cash Flow	-5800	830	913	938	964	991	1,019	1,047	1,077	1,107	949	975	1,001	1,029	1,057	1,086	1,115	1,146	1,178	1,210	1,244	1,278	1,314	1,350	1,388	1,427	1,467	1,508	1,551	1,594	1,896
Discount Factor		0.93	0.86	0.79	0.74	0.68	0.63	0.58	0.54	0.50	0.46	0.43	0.40	0.37	0.34	0.32	0.29	0.27	0.25	0.23	0.21	0.20	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10
Present Value (PV)	-5800	769	782	745	709	674	642	611	582	554	440	418	398	378	360	342	326	310	295	280	267	254	242	230	219	208	198	189	180	171	188
Cummulative PV		-5031	-4249	-3504	-2796	-2121	-1479	-868	-286	267	707	1125	1523	1901	2261	2603	2928	3238	3533	3813	4080	4334	4576	4806	5024	5233	5431	5620	5800	5971	6159
Net Present Value (NPV)	**6159**																														
Excel NPV Calculation	**6159**																														
Internal Rate of Return (IRR)	**17%**																														
Discounted Pay back period (DPBP)	**8.52**	Years																													
Capital Efficiency	**1.06**																														

Table 3-B: Results for 100% local ownership structure

SCENARIO A: 100% LOCAL OWNERSHIP		
A. SUMMARY FOR 100% LOCAL OWNERSHIP	nom	AMOUNT
Copper metal recovered	tonnes	5,147,704
Gold metal recovered	Oz	23,290,752
Project Expenditure	US$m	6806
Exploration	US$m	500
Mining Project CapEx	US$m	6,806
Mining Project OpEx	US$m	31,632
Total Gross Revenue	US$m	74,423
Export Revenue	US$m	74,423
Foreign Partner Share	US$m	-
State Partner Share	US$m	-
Domestic Revenue (Undiscoutned Economic Profit)	US$m	21,445
Foreign Partner Share	US$m	-
State Partner Share	US$m	-
Other Income / By-Product Revenue	US$m	-
Economic Profit (100% State-owned)	US$m	21,445
Net Present Value NPV)	US$m	5,402
Internal Rate of Return	%	13%
Discounted Payback Period*	Years	9
Total Fiscal Revenue	US$m	32,495
Total Direct Tax Revenue	US$m	12,633
Indirect Tax Revenue (Employment, Excise/Duties)	US$m	2,081
Non-Tax Revenue	US$m	7,263
Royalty	US$m	1,732
Production Levy	US$m	x
Development Levy	US$m	x
Mining Levy	US$m	194
Corporate Income Tax	US$m	6,264
Additional Profits Tax	US$m	2,500
Dividend Withholding Tax	US$m	1,943
Excise and duties	US$m	287
Employee Payee tax	US$m	287
Foreign Contractor Withholding Tax	US$m	1,141
Local Contractor Tax	US$m	189
Indirect benefits (Local procurements)	US$m	6,508
Net Benefits From Panguna Mine	**US$m**	**39758**

Table 4-B: Results for 50% local ownership structure

SCENARIO B: JV PARTNERSHIP WITH 50% FOREIGN INTEREST		
B. SUMMARY FOR FOREGN PARTNER CASH FLOW (50%)	nom	AMOUNT
Copper metal recovered	tonnes	2,573,852
Gold metal recovered	Oz	11,645,376
Project Expenditure	US$m	12947
Exploration	US$m	385
Mining Project CapEx	US$m	2901
Mining Project OpEx	US$m	9661
Total Revenue	US$m	37211
Export Revenue	US$m	37211
Foreign Partner Share		50%
State Partner Share		50%
Foreign Economic Profit	US$m	14,075
Net Present Value (NPV)	US$m	2,819
Internal Rate of Return (IRR)		11%
Payback Period (Years	Years	8
Royalty	US$m	1,402
Production Levy	US$m	x
Development Levy	US$m	x
Mining Levy	US$m	97
Corporate Income Tax	US$m	4,242
Additional Profits Tax	US$m	1,250
Dividend Withholding Tax	US$m	972
Excise and duties	US$m	144
Employee Payee tax	US$m	144
Foreign Contractor Withholding Tax	US$m	1,141
Local Contractor Tax	US$m	-
Indirect benefits (Local procurements)	US$m	3,254
Net Benefits From Panguna Mine	**US$m**	**12,644**

Table 5-B: A 30% local JV ownership structure

SCENARIO C: JV PARTNERSHIP WITH 30% STATE (ABG) INTEREST		
C. SUMMARY FOR ABG's CASH FLOW (30%)	nom	AMOUNT
Copper metal recovered	tonnes	1,544,311
Gold metal recovered	Oz	3,421,031
Project Expenditure	US$m	7771
Exploration	US$m	234
Mining Project CapEx	US$m	1740
Mining Project OpEx	US$m	5797
Total Revenue	US$m	22327
Export Revenue	US$m	22327
Foreign Partner Share		50%
State Partner Share		30%
State's Economic Profit	US$m	12,050
Net Present Value (NPV)	US$m	3,217
Internal Rate of Return (IRR)		15%
Payback Period (Years	Years	10
Royalty	US$m	841
Production Levy	US$m	x
Development Levy	US$m	x
Mining Levy	US$m	58
Corporate Income Tax	US$m	1,273
Additional Profits Tax	US$m	750
Dividend Withholding Tax	US$m	583
Excise and duties	US$m	86
Employee Payee tax	US$m	86
Foreign Contractor Withholding Tax	US$m	-
Local Contractor Tax	US$m	189
Indirect benefits (Local procurements)	US$m	1,952
Net Benefits From Panguna Mine	**US$m**	**5,818**

Table 6-B: Results for 20% landowner's equity interest benefits

SCENARIO D: JV PARTNERSHIP WITH 20% LANDOWNER INTEREST		
D. SUMMARY FOR LANDOWNER's CASH FLOW (20%)	nom	AMOUNT
Copper metal recovered	tonnes	1,029,541
Gold metal recovered	Oz	2,339,075
Project Expenditure	US$m	5072
Exploration	US$m	46.8
Mining Project CapEx	US$m	1160
Mining Project OpEx	US$m	3865
Total Revenue	US$m	14885
Export Revenue	US$m	14885
State Partner Share		30%
LO Partner Share		20%
Landowner's Economic Profit	US$m	5,960
Net Present Value (NPV)	US$m	1,424
Internal Rate of Return (IRR)		13%
Payback Period (Years	Years	13
Royalty	US$m	561
Production Levy	US$m	x
Development Levy	US$m	x
Mining Levy	US$m	39
Corporate Income Tax	US$m	848
Additional Profits Tax	US$m	500
Dividend Withholding Tax	US$m	389
Excise and duties	US$m	57
Employee Payee tax	US$m	57
Foreign Contractor Withholding Tax	US$m	-
Local Contractor Tax	US$m	189
Indirect benefits (Local procurements)	US$m	1,302
Net Benefits From Panguna Mine	**US$m**	**3,942**