

Employing Strategic Planning to Achieve Sustainable Livelihoods in a Post-Mine Period: A Case Study of The Porgera Gold Mine in Papua New Guinea

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Abstract:- Attaining broad-based economic and social developments associated with mining activities are complex to achieve since mining companies take ownership of social responsibility while all layers of government become complacent and social inclusion entices direct involvement of landowners in decision-making. To reduce community boycott and social crisis, mining companies and the Government of Papua New Guinea (GoPNG) adopted a preferential mode of social inclusion to redistribute the benefit streams associated with a mining operation. However, the preferential treatment of landowner communities inhibits achieving the social sustainability goals. There is no clear framework within which the social preferential mode of benefit redistribution could work in mobilizing the cultural and land-based endowments. In recognising the issue, employing a bottom-up approach to planning of physical infrastructure and social institutions and integrating them into government's existing service delivery mechanisms could achieve broad-based sustainable livelihoods in the post-mine era. The qualitative data were collected from interviews of selected stakeholders from the Tipini and Porgera special mining lease (SML) communities to predict the scenarios that could emerge in the post-mine period. The strategies discussed could guide the stakeholders to achieve social sustainability to occur during the remaining life of the Porgera mine.

Keywords:- Social Sustainability, Social Inclusion, Preferential Mode of Benefit Redistribution, Strategic Planning, Asset Repurposing, Post-Mine Period.

I. INTRODUCTION

This case study identifies some underlying constraints that may have inhibited the strategies for improving Porgera mine's quest for sustainable development. The social inclusion paradigm may have partly failed to achieve its goals. The marginalized communities in remote locations deliberately request for recognition that leads to demand for constructing unsustainable infrastructures, like the Paiam Mining Town (PMT) and largely misuse the benefit streams received from the mine. Further, the cultural pride of demanding short-term handouts causes ferocious rivalries amongst the factious landholder groups. These are common

trends in the extractive resource sector. This study identifies two impediments. First, company's lack of understanding the social structures and economic implications tend to derail setting clear goals and directions for a coordinated transition from a contemporary subsistence living to a modern lifestyle. Secondly, the lack of untangling and linking each stakeholder's interests could crowd-out establishing effective government functions, social institutions and physical infrastructure in rural settings of PNG.

Creating a sustainable pathway for regional communities to transition to a much-improved traditional way of living in a post-mine period is not given much consideration in social inclusion programs associated with mining activities. The social inclusion paradigm involves mobilizing the productive capacities and cultural endowments that suit the underlying management capabilities and governance conditions to localize social development (Blackwell et al., 2017). A well-executed social inclusion program could enhance a long-term presence of social and economic institutions that are created using benefit streams from a mining operation. However, the underlying weak governance and local community's poor decision-making processes could be responsible for inefficient redistribution frameworks. The rivalry amongst factious community groups may complicate achieving the social sustainability goals. Likewise, the diverging objectives of government and investors tend to divert the attention away from their aims of achieving integrated social developments that are cost-effective and manageable, adaptable, and outcomes that are strategically verifiable. Since mining is a finite activity, the diminishing nature of mine-based income streams could place fiscal burdens on sublevel governments for maintaining infrastructure and socioeconomic institutions (NAtHAlIA, KrISHAN, et al., 2017).

The article is organised in the following order. Section 2 gives a brief outline of how the research was conducted. Section 3 provides a brief background on how the social inclusion paradigm has shifted the policy landscape in PNG. Section 4 examines the decisions and the failures of stakeholder engagements and strategies for optimizing the physical infrastructure and social institutions. Section 5 examines some options available for restructuring the

administrative capacities of EPG and Porgera Local Level Government (LLG). Section 6 discusses some options for repurposing the mine assets for income generation and employment in the post-mine period. Section 7 examines Porgera region's potential for agriculture and other non-mineral sectors for revenue generation in the post-mine period and Section 8 is a brief conclusion.

II. MATERIAL AND METHODS

This research uses a bottom-up method of qualitative data collection through face-to-face interviews based on a set of questionnaires. The questionnaires relate to predicting the sustainability of economic and social conditions and outcomes beyond the Porgera mine life. The four survey questions used were:

- What are the influences of social inclusion and preferential mode of benefit distribution that may contribute to create excess physical and social infrastructure?
- What are the administrative capacities of the EPG and the Porgera LLG to administer the Porgera region after the Porgera mine closes?
- Are there viable options for repurposing the production assets and the mine infrastructure for income generation and employment after the Porgera mine closes?
- Is there a potential for agricultural development to generate revenue and employment in the Porgera region after the mine closes?

III. BACKGROUND

Sustainability of physical infrastructure, economic and social development initiatives associated with mining activities have been extensively investigated. However, there are not many studies conducted on the continuity of economic and social services in a post-mine era after a mine closure. The literature loosely applies the term 'social sustainability', which could infer the benefits received during the extraction phase only and may not visualize the post-mine period. It ignores the significance of time preferences in determining the longevity of infrastructure and social institutions created during a mine's life. The assurances gained from merely reporting the benefits in form of monetary values and social indicators (e.g., Johnson, 2012) may divert the attention away from devising strategies for sustainable socioeconomic growths beyond a mine's life. The present social indicators may be deceptive since negative impacts could exceed the positive growths in future. This may lead to communities being worse off than the conditions before commissioning a mine. This lack of visualization may give a false perception that present social changes from traditional livelihoods to modern versions are indicative of attaining social sustainability (Basu et al., 2013).

In the 1970s, mines were developed by engaging the society on a '*trust me*' basis. It assumed the community would prosper as long as the industry made a profit. For example, when commissioning the former Panguna copper

mine in 1972, the community did not bargain for benefit packages because there were few policies recognizing their financial and social needs. The gradual increase in transparency exposed the failures of executing the top-down social planning on *trust-me* basis of engagement. The communities perceived that they did not benefit from the then Panguna copper-gold mine and distrusted the GoPNG and the investor on their abilities to create sustainable social capitals. This led to a civil war, which eventually closed the mine in 1988. The tragic event transformed the mining policy landscape in PNG. It enticed the industry and the government to recognize the social needs of host communities (Regan, 1998). In the early 1990s, the '*include me*' basis of engagement emerged strongly with other mines that were developed in the post-Bougainville era. The past events enticed the GoPNG to shift policies towards creating fiscal incentives by involving host communities in decision-making processes (Macdonald, 2017).

The government allows impacted communities to decide on what benefits they would expect to receive from extracting mineral resources located on their traditional lands (Filer, 2008). The preferential mode of social inclusion entices traditional landholders to engage them in decision-making and benefit redistribution. The Mining Forum and Memorandum of Agreement (MoA) serve as avenues for communities and Provincial Governments to collectively bargain for benefit packages from the developer and the central government (Jackson, 2015). The MoA reserves contracts and employment opportunities for communities located within the profoundly impacted areas compared to those that are geographically outside of a mining region. Further, the traditional methods of production and redistribution include redistribution of surpluses to neighbour clans and distant relatives through a barter exchange system. By contrast, the preferential mode of redistribution associated with the mining industry recognizes the social structures of clans within a tribe, which communally owns the land. It ring-fences the benefit redistribution to traditional landholders within a mining lease area and affected communities.

In the 1990s, preferential treatment of host communities motivated them to have an exclusive slogan: '*the Misima mine for Misimans only, the Porgera mine for Porgerans only and the Lihir mine for Lihirians only*'. The slogan impeded the mobility of skilled labour from one mine to another and regionalized the multiplier effects featured by unequal redistribution and encourage them to misuse royalty and compensation incomes. For instance, the preferential mode of benefit redistribution adopted in the initial design of the Porgera MoA encouraged poor decision-making. It encouraged the landholders to focus on short-term handouts in form of monetary benefits that translate into extravagant lifestyles and a high level of polygamy, to build cultural prestige and dominance (Mek et al., 2018). Their indecisiveness complicates achieving the goals of social inclusion paradigm, especially their failure to visualize the value-chain distribution.

The situation is exacerbated by sub-level governments lacking the knowledge required to guide the community in terms of initial decision-making, planning, and implementation of development programs. Yet, in cases where the state being a shareholder, the government would use agnostic tactics (i.e., use of armed forces) to suppress community's concerns about the parties not complying with social agreements. The suppression could enforce a decentralized and unconventional regulation for investors to comply with a community's social responsibility goals (Sing, 2015). In response, a mine operator would intervene to make voluntary contributions to meet their fiscal expectations and, thus, prevent community protests. The mining companies have learnt the lessons to integrate the social and political risks into a mine's operational activities as they attempt to reduce the socio-political risks as much as possible (Jackson & Green, 2016).

The GoPNG has shifted the social responsibility roles to mining companies as they have location advantages, skilled workforce, and technical capacities to execute the development programs more efficiently than all layers of governments. However, mine operators taking over government's service delivery roles over a prolonged period could weaken the public service delivery mechanisms (Hurst et al., 2019). This could entangle the private and public interests that in, turn, may entice mine operators to focus on mitigating the socio-political risks (social license to operate) and neglect to focus on the long-term socioeconomic goals (Banks et al., 2013).

The visions required for planning and designing socioeconomic programs were not clear since mobilizing the cultural and land-based endowments occurred slowly and sporadically. The accelerated impacts associated with a mine development give little time for the host community to make strategic decisions and socio-cultural adjustments. Likewise, conflicting interests amongst the local stakeholders and a mine operator could tarnish their long-term relationships. The Panguna civil crisis and the premature closure of the Porgera mine was due to poor relationships amongst the stakeholders. A high level of transparency between the mine operator and the National Government could solicit community tolerance that, in, turn could increase the chances of achieving social sustainable outcomes. This article presents a case study of the Porgera gold mine to analyse the predicaments of the social inclusion and the effects of weak governance crowd-out achieving the social sustainability goals.

IV. STREAMLINE THE TRANSPORT AND SOCIAL INFRASTRUCTURE

➤ Demand for Social Infrastructure

The EPG, the landowners, and the Porgera LLG Officers were interviewed. The stakeholders expressed their views based on certain criteria such as risk (issues), and management options that focus on the post-mine

sustainability (*Table 1*). It shows the matrix of concerns and options of resolving the socioeconomic issues. It also provides the options to close the gaps by streamlining the facilities established. Three important factors were identified to influence the decision-making processes. First, the EPG and the National Government signed the Porgera MoA without comprehending how they would fulfill the social obligations. Second, the PJV, notably the former owner, Placer Dome did not become a party to the initial MoA (avoided signing the MoA). The PJV intentionally isolated itself from fulfilling the corporate social obligations, which was conservatively the '*trust me*' mode of social engagement. The PJV argued that investors are entirely responsible for resolving the biophysical impacts, while all layers of governments are responsible for executing social development programs (Peck & Sinding, 2009).

Third, driven by the '*include me*' mode of engagement, the Porgera SML landholders and community leaders (most of them are deceased now) were excited to sign the initial MoA without understanding its contents and were deceptively given handouts and received short-term benefits. The '*trust me*' mode of engagement of social contract failed to fulfill the MoA obligations. In realising this, the young generation advocated the '*show me*' mode of engagement, which, resonates a review of the initial MoA signed in 1988. They affirmed their unfriendly defiance against all layers of governments and PJV as retaliation for marginalizing them and failing to provide social services before commissioning the Porgera gold mine in 1990. A lengthy delay in reviewing the MoA, which is still not reviewed now, partly escalated into a temporary shutdown of the Porgera gold mine in 2019. When that happened, the benefit streams dissipated quickly, which led to a permanent social dislodgement and environmental degradation. The Porgera scenario is a dilemma contributed by each stakeholder's inability to rationalise the decision-making processes.

The lack of visualizing the long-term effects when making decisions complicates one's ability to strategize the use of benefit streams derived from a mining activity. All layers of governments have shifted the social responsibility to mining companies. The companies apply the tax credit scheme (TCS) to provide economic and social infrastructures within the Paiam Mining Town (PMT) and the surrounding regions. The TCS ensures a portion of corporate income tax is retained to meet the development needs of host mining regions. It also relieves the investors from financial obligations, especially in regions where basic social services are absent, mostly in remote communities. While providing the social services, mine operators positively responding to community demands to reduce the social risks. This could divert the attention away from creating sustainable facilities. The demanded the establishment of the PMT (*Fig. 1*), which was intended to discourage the fly-in, fly-out (FIFO) mode of mine operation.

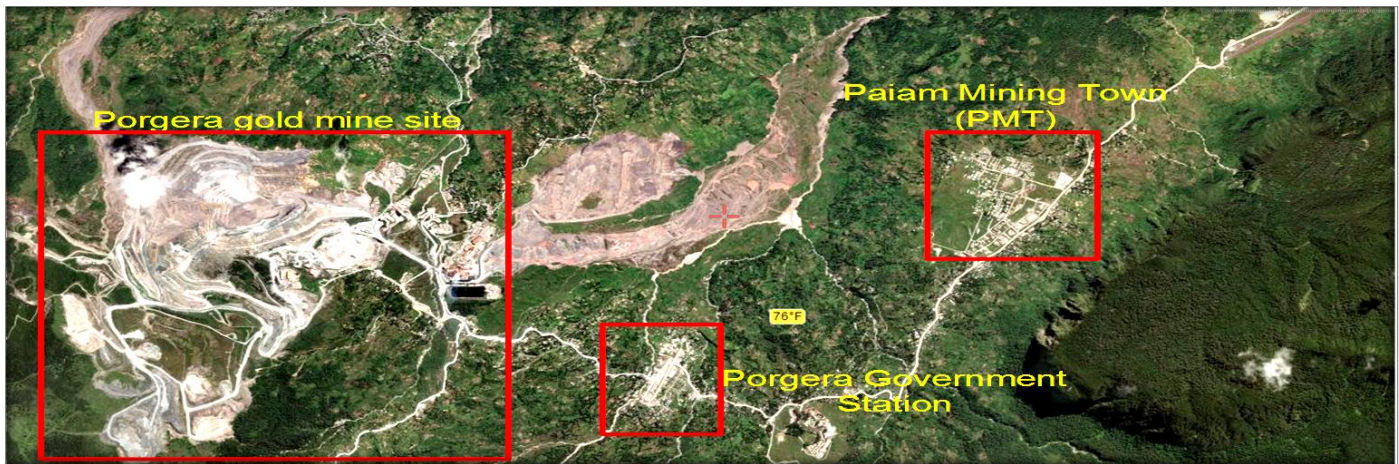


Fig 1 Location of Paiaam Mining Town (PMT) and Porgera Government station

The community petitioned the government to ban the FIFO mode of mine operation (McKenzie et al., 2014). Mining companies use the FIFO mode of mine operation to attain labour productivity by outsourcing employment and retaining skilled labour. McKenzie et al. (2014) noted, "The use of non-residential workforce involving block shifts and long-distance commuting (LDC) is now common in the resources sector and associated industries across Australia." The FIFO arrangement provides opportunities for employees to reunite with their families from the points of employment. However, Porgerans argued that employees should work and live amongst the host community to prevent wealth leakages and boost multiplier effects in the region. The FIFO is a common concern amongst mining regions globally (Perry & Rowe, 2015). As a result, the Porgerans were not prepared to make correct decisions at the time of constructing the Porgera mine. It complicated aligning the sustainability goals, including EPG's lack of understanding the benefits of constructing the PMT (Table 1).

Table 1 Matrix of issues and strategic options for infrastructure and social institutions

Social/Economic	Issues	Management options	Sustainability issues
FIFO accommodation facilities	-unused houses future use not viable & costs	<ul style="list-style-type: none"> Lease or sell to private use post-mine town development 	-financial liability, post-mine use not viable for Porgera LLG and EPG
Paiaam market	-not used by locals, maintenance costs & low local production	<ul style="list-style-type: none"> support local production improve transportation & market access 	-Porgera LLG manage the market in the post mine period
Paiaam & Porgera Station hospitals	-long-term funding issues, shortage of staff	<ul style="list-style-type: none"> options for EPG and Porgera LLG to finance and operate the two hospitals: one at Paiaam and the other at the Porgera station 	-place management under a church-public partnership, mainstream churches can operate the hospitals efficiently
Porgera Secondary School & Other facilities	-long-term funding and management of education facilities are critical	<ul style="list-style-type: none"> strategies for the EPG and Porgera LLG to finance and operate the schools at Paiaam Mining Town 	-Paiaam Secondary School can exist as it is and convert the International School into a multi technical school
Social infrastructures of outlying regions	-accessibility and cost of maintenance of roads, primary education and health facilities	<ul style="list-style-type: none"> strategies for EPG and Porgera LLG to finance and operate the primary schools and aid posts in the Porgera and Paiala regions 	-build access roads into the outlying regions and connect with the Porgera-Wabag road corridor
Transport infrastructure	-financial constraints for long-term maintenance of roads, bridges and airstrips	<ul style="list-style-type: none"> strategise the access roads and bridges by focusing on demographic regions that link with the main road system 	-EPG and Porgera LLG to streamline the physical infrastructures to suit their financial capacities in the post-mine period
Porgera District vs Laigam District Administration Centers	-duplicated public offices & functions, resource & wastage and mismanagement of goods and services delivery in the post-mine period	<ul style="list-style-type: none"> devise transition plans for merging or separating the District Administration functions to reduce cost, improve governance & improve efficiency of delivery of goods and services 	-EPG and Porgera LLG to streamline the public offices and functions into a single administration district or create a separate Mulitaka-Porgera District, requiring political intervention

As shown in *Table 1*, the facilities at the PMT were constructed in 1998 after executing the FIFO agreement between the Porgera landholders and the EPG (Fig. 1). The FIFO agreement was intended to encourage mine employees to spend their incomes to support the economic and the multiplier effects in the Porgera region. The Paiam Accommodation Development Company (PADC) was established to construct the residential houses using financial contributions from EPG, Porgera Development Authority (PDA), and the SML landowners (Bonnell, 1989). This arrangement detached the PJV from inheriting financial liability of constructing and operating the mining township and the future liability of decommissioning it. Notably, most of the infrastructure facilities within the PMT were established for boosting economic and social activities. However, the Paiam market, banking facilities, the Ipli Porgera Investment (IPI) grocery store, and recreational facilities are not fully utilized. The PADC has sold or leased the residential houses to private interests. The Porgera mine still insists on applying the FIFO mode of employment partly due to law-and-order scenes not are favourable to a residential living in the Porgera region.

The PJV has employed over 65 percent of the workforce from the Porgera region and the Enga Province. By comparison, a 35 percent of the total workforce comprised of expatriates and skilled personnel from other parts of PNG. Despite the high rate of local employment, there has been low cash circulating in the Porgera region. This is because local employees and foreign contractors spend their disposable incomes in other towns and overseas as there is no restriction on regional labor mobility. Also, local Porgerans who reside in other towns in PNG and those from overseas spend their disposable incomes on leisure and entertainment. The PMT has not attracted both local and expatriate workforce to reside and work in the Porgera region. The Porgera case stands in contrast to Aboriginal employees who live in a remote mining region of Western Australia to support the socioeconomic growth of their region (McKenzie & Hoath, 2016). The sustainability of Porgera's PMT and Ok Tedi mine's Tabubil mining town could become deserted post-mine towns following the eventual closure of the mining operations (Jenkins, 2015).

Many mining towns have become deserted (Knierzinger & Sopelle, 2019), mostly in locations where a community never lived there prior to establishment of a mining activity. PNG's case is entirely a different scenario where the host communities have lived there for generations. They would continue to live on their traditional lands after the mine closes. Furthermore, the mines developed within the vicinity of an established infrastructure could discourage the need for FIFO mode of mine operation. With the experience of sustainable growth of mining towns such as Kalgoorlie-Boulder region of Western Australia (Maxwell, 2015), new mines emerging within existing infrastructure could support the expansion of existing towns. The FIFO arrangement can be determined on a case-by-case basis. For instance, a mine located within the proximity of an existing city like Lae in the Morobe Province of PNG can encourage residential employees.

➤ *Strategizing the Sustainability of Social Services*

The Porgera case reflects that there is excess social infrastructure being created within the region because the community initially demanded for health (aid posts), education (secondary and primary schools) and other social services within the PMT (*Table 1*). The Paiam Hospital has been operating on incomes collected from outpatient fees and annual subsidies through a cost-sharing agreement amongst the EPG, the PDA and the PJV. The 'non-landowner' communities perceive the Paiam Hospital serves and benefits the SML landowners only, as they have the money to pay the high outpatient fees. Such perceptions could partly arise from an unskilled population that is deprived of employment and business opportunities. Further, the lack of coordination and poor management led to persistent funding problems that eventually forced the hospital to close for almost three years (2017 and 2019). In 2020, the National Planning Department approved a submission to integrate the staff positions into the Public Service system. Presently, it operates as a public hospital following the restructure, which allows Porgerans' to have access to improved health services at affordable costs.

Porgera operates two hospitals: one at Paiam mining town and the Health Centre at the Porgera station (see Fig. 1). These also include other rural health centers in Paiala, Politika, and the Lower Porgera regions. Using data from the Lihir, Hidden Valley and Misima (now closed) mines, Kuir-Ayius (2016) found that sublevel governments do not give serious consideration to providing health services, both before and after a mining operation closes. In anticipation of such neglects, outsourcing the management liabilities to mainstream faith-based organizations such as Seventh-day Adventist, Lutheran and Catholic churches could help in sustaining the continuation of social institutions in the post-mine period. The faith-based organizations are known for providing health care and education services efficiently throughout PNG. In the long run, the financial constraints, inefficient transport systems and declining regional population patterns alluding to emigration could create excess capacity. In this context, a small population may not fully utilize the hospital (Kuir-Ayius, 2016).

The delivery of education services in the Porgera District has been ineffective due to some underlying problems. These include shortage of skilled teachers, overcrowded classrooms, insufficient materials for curriculum development and a lack of district in-service training (Loh Epri, 2016). The delivery of quality primary education is affected by engagement of low-quality teachers (mostly at the elementary level) and bypassing the merit-based selection procedures for appointment of headmasters and principals (Abady, 2015). Also, abandoning the school in-service programs cause skills to become obsolete over time. Furthermore, the absence of community support caused the collapse of primary and secondary education in Porgera and Enga Province. These issues are characterized by poor enrollment of students in technical institutions and universities throughout PNG. Thus, the education system needs a holistic reform to attain cost effectiveness and staff quality at all levels of the education system. The reform

would resolve political and culture-induced and gender-bias in selection of principals and teachers to improve the standard of education (Rena, 2011).

The EPG has streamlined the education services by upgrading the Paiam High School into a Secondary level school (Grades 11-12). The school serves the Lagaip-Porgera District; other parts of Enga and the Hela Province. With the view of planning for suitable infrastructure, the Porgera International School (PIS) may cease to serve the community (*Table 1*). The EPG may seek to convert the PIS into a top-up primary School (grades 3-8) as a feeder school for the existing Paiam Secondary School. Further, the PJV has voluntarily assisted the education sector to build the capacity of teachers as a top priority for empowering the community. It also assisted in training the elementary school teachers who are high school dropouts and have no prior teaching qualifications. These efforts include imparting the skills for teaching early primary learning (Brownlee et al., 2012). To sustain the education and health facilities, it may require geographical and demographic planning to make sure these facilities are suitable for use and maintain in the post-mine era.

➤ *Strategizing Road Network within Porgera*

Centralizing the social infrastructure along the main road corridor is crucial to ensure the outlying communities have access to quality education and health services (Wiegand et al., 2017). It requires proper demographic planning to predict the population patterns in distant locations such as Paiala and Politika regions. The demographic plan would place health and educational institutions in central and populated regions that are strategically linked to feeder-roads with the main Porgera-Wabag road network. Centralizing the social services along the main road corridor and linking them to feeder-roads connecting the outlying regions could enhance the mobility of goods and services to the surrounding communities. The outlying communities would have access to rural Health Centers, Elementary Schools and Top-up Primary Schools, and relieve the sub-level governments from the burden of maintaining social institutions in the post-mine period.

Having access to multiple road networks, electricity and telecommunication are prerequisites for increasing productivity, labour mobility and boost commercial activities in mining regions. The community strongly believes that Porgera should not be the end of the Okuk Highway. Wiegand et al. (2017) find that maintaining quality roads tend to boost economic activities (both formal and informal sectors), create access to markets and reduce relying on subsistence farming. Porgerans anticipate that a road linking the region to Hela Province could allow them to have access to government, markets and banking services. Presently, the sealed Wabag to Porgera section of the Okuk Highway increases business activities. However, because Porgera is an isolated district, the excess infrastructure could become obsolete in the presence of weak governance. This could be a large financial capital to maintain the infrastructure and social facilities in the post-mine era.

V. **RESTRUCTURING THE ADMINISTRATIVE CAPACITIES OF SUB-LEVEL GOVERNMENTS**

Restructuring the Porgera District Administration to a manageable level that suits EPG's administrative capacity is important to achieve long-term social sustainability. Previously, the Porgera region existed within the Lagaip-Porgera District of the Enga Province. A legal interpretation was sought to affirm whether the Porgera District Administration could operate as a defacto district to co-exist with the Laiagam District Administration. This led to an amendment to the OLPGLLG to formalize the establishment of PDA in 2014. The PDA represented the presence of the EPG and the National Government in the Porgera District. As such, the PDA executes infrastructure developments using special support grant (SSG) and TCS funds in the absence of government services in the remote mining region. Since Porgera is a separate District, the PDA and sub-level governments could duplicate the functional roles that may cause a waste of resources and fail to achieve the desired outcomes (Duncan & Banga, 2018).

In the past, there was a dilemma of having two District Administrators; with one based in Laiagam and the other at Porgera station. The OLPGLLG does not give a clear direction regarding the recognition of a district within a district such as the case of Porgera and Tabubil mining towns. Fortunately, the National Electoral Boundaries Commission created the Porgera-Paiela District whose first political leader was elected in the 2022 National Election. The political transition enables the decentralization of executive powers to a single district administration (Duncan & Banga, 2018). It could enable the Porgera region to exist with fully functional district services and eliminate the duplicated functions and enhance effective governance. However, the sub-level government faces two challenges of regaining control of the public service machinery.

First, the concentration of power occurs when local politicians take control of District Budget Priorities Committee. It causes the LLG Priorities Committee to become ineffective in deciding social development plans, allocate funds, and measure the indicators (Reilly, 2019). The District Support Improvement Program (DSIP) fund is highly politicized and it has failed to eradicate rural poverty in PNG. This is partly attributed to OLPGLLG's model of decentralized governance and power sharing structure, which gives exclusive powers to politicians to make decisions on allocation of the DSIP funds (Barcson, 2015). Thus, a political representation in the Porgera region may not detach and neutralize the concentration of administration and political powers from the EPG, where latter's governance bottlenecks may affect the service delivery. Further, politicians and public officers' often desire to live in towns (Duncan & Banga, 2018). It would require efficient transport and institutional infrastructures that must be maintained and provide alternative income sources to attract public servants (including school teachers, nurses and doctors) to live and work in Porgera in the post-mine era.

Second, the sublevel governments relying on the technical expertise of mine developers, foreign NGOs and consultants makes the existing public sector machinery to be complacent and ineffective. For instance, PJV and the police Mobile Squad 14 have been the governments in Porgera and Laigam region for maintaining law and order. The shifting of social responsibility to mining firms raises a critical question as to how all layers of governments could regain control of the public sector machinery for service delivery in the post-mine period. Despite their good intentions, the top-down planning tend to weaken the initial functions of sub-level governments in terms of service delivery. This is partly due to private entities coordinate the planning and execution of the development programs without transferring the technical skills to sub-level governments over a prolonged period of time.

The mining companies concentrate on attaining corporate social responsibility through executing top-down approach to plan and implement mine-sponsored programs. However, the top-down approach causes social disengagement and thus future sustainability is not secure. These issues could distract the integration of development programs into the existing public service delivery mechanism (Banks et al., 2013). It would be convenient to engage the local expertise who understands the cultural content to achieve high success rates, especially when designing and executing the social development programs. Further, there is a loss of interest amongst the stakeholders in prioritizing social welfare and fail to measure the indicators (Bainton, 2017). For instance, the district politicians lost control of the social service delivery to an extent where it is difficult to realistically predict the outcomes of mine-driven social growths in host mining regions in PNG.

Given the underlying political and administrative power struggles that inhibit the delivery of social services in districts and provinces, sustaining the growth of host mining regions is a real challenge. A mining company often initiates the mine closure plans where its core focus is on biophysical sustainability. However, it also sponsors the socio-economic aspects of the mine closure plan. As such, all layers of governments must take ownership of the economic and the social developments initiated under a mine closure plan. The mine closure plan must align the closure plans with a predictable demographic baseline that is interfaced with the capacity of the sub-level governments to maintain these facilities in a post-mine period.

The continuation of social services in the host mining region depends on sustainable income sources that must be developed by diversifying the revenue streams received from the present mining operation. The OLPGLLG model of governance allows each province to raise internal revenue to support the economic and the social development programs (Reilly et al., 2014). This provision permits host sub-level governments to benefit from income streams such as the TCS, SSG, royalties and derivative grants. In this instance,

EPG's primary sources of income are derived from central government's budgetary appropriations and the Porgera mine. Also, a significant portion of income are raised from goods and services taxes (GST) and other income sources. However, the EPG has a low capacity to raise internal revenue from the non-minerals sector. When the Porgera mine closes, the mine-derived income streams (e.g., royalty, TCS and SSG) will cease and eventually government's social budget would decline. Thus, diversifying and substituting the mine-derived benefit streams into revenue generating enterprises is, crucial to ensure all levels of governments to cooperate to maintain the social services in the post-mine era.

VI. OPTIONS FOR REPURPOSING MINING FACILITIES

This section focuses on assessing the options for repurposing mine production facilities to generate incomes and provide employment for the host community to fall back after the mine closes. The Tiene and Pulumaini Ambo clans are the dominant SML communities. They were consulted for their views on the options for reusing the mine facilities. The Tiene clan revealed the risks of overcrowding, shortage of land for animal domestication, firewood and gardening, loss of food crop seeds and unsafe drinking water sources. These are the major factors that support the subsistence existence in Porgera and rural PNG as a whole (Yamarak & Parton, 2019). The mine's prolonged occupation of land for over four decades caused a permanent detachment to their traditional livelihoods. The social dislodgement could constitute a permanent loss of their identity as a tribe or a clan. Thus, selectively retaining few of the mining assets could compensate community's exposure to adverse impacts such as permanent loss of traditional gardening and hunting grounds.

Repurposing the mining asset can sustain the economic and social growths and offset the long-term effects of social dislodgements, loss of culture and the environment (Lottermoser, 2011). The strategy of repurposing could also create direct employment and generate income for host community. Kivinen (2017) noted that "Sustainable reuse of post-mining areas requires an efficient evaluation of land use potentials and limitations and the overall suitability of the sites for local land use needs." Some specific criteria such as social risks, safety regulations, and environmental codes of practice would determine the options available for disposing production assets such as plant and equipment and post-mine land use. Various options should be strategically planned to avoid interfering with decommissioning and rehabilitation programs required by the Mine Safety Act (1957). These regulations enforce the rehabilitation of mining areas and control the formation of acid mine drainage in tailing and waste rock dump sites that could endanger community's livelihoods in the post-mine period (Kivinen, 2017). These include the options for reuse of the lands occupied by the SML and the LMPs (Fig. 2).



Fig 2 Kogai competent waste rock dump and low-grade stockpile
(Source: PJV)

The Kogai waste rock dump covers gardening lands and drinking water sources are increasingly becoming unsafe (Fig. 2). The Tieni and Pulumaini Ambo clans have vigorously sought permanent relocation because they are displaced and may never return to their traditional land. The Pulumaini Ambo clan faces similar challenges to that of the Tieni clan as they live on the fringes of the Kogai waste rock dump (Fig. 2). Also, the Ambo clan owns the land on which the Anawe administration building, the Alipis and Yoko camps, and warehouses and workshops are located (Fig. 3). These facilities would be demolished and rehabilitated to restore the land to a useable condition for the community to resettle after the mine closure.



Fig 3 Mill and administration facilities within the SML
(Source: PJV)

As shown in Figure 3, the Anawe Administration building has the potential for having some forms of social returns after the mine closes. It could be converted into a multi-purpose public library for storing historical archives and display Ipili, Enga, Paiala, and Tari arts and crafts for geo-tourism purposes (Nita & Myga-Piątek, 2014). Further, deconstructing the Alipis and Yoko accommodation camps could free up the land for traditional use, or individual landholders may decide otherwise. The Suyan camp can be used as a guest house, education, or a sports training facility after the mine closes. Moreover, the asset repurposing can reduce the liabilities associated with decommissioning the facilities as required under a mine closure policy. A Post-mine Liability Transfer Agreement (PLTA) could be devised to protect PJV against the post-mine closure liabilities (risks) if the landholders decide to repurpose the mining facilities, including residual mining.

The Porgera SML landowners have indicated their interests to continue residual mining in the open pit, the low-grade stockpile, and the competent waste dump areas (Fig. 2). The option of residual mining within an SML area after a mine closure could sustain the social growths through income generation and employment. Rupprecht and Pieters (2016) point out that "re-opening of abandoned mines offers the opportunity to employ now defunct historical mining communities". However, there could be few options available for accessing the open pit, the underground openings, and the waste rock dumps. These are designated as high-risk areas that are often targeted for intensive risk mitigation planning (Table 2). For instance, some safety design requires flooding the mine pits to allow lake formation to prevent acid mine drainage from occurring.

Table 2 Matrix of options for repurposing mine operational facilities

Mine aspect	Issues	Management options	Reuse options
Open pit	<i>-public safety metal leaching</i>	<i>• pit lake water quality management</i>	<i>- small scale mining</i>
Underground mine	<i>-public safety metal leaching & instability</i>	<i>• detoxify contaminants, remove installations and seal-off openings</i>	<i>-leave some sections open for geo-tourism activities</i>
Low grade stock piles (LGSP)	<i>-public safety, & acid mine drainage</i>	<i>• rehabilitate by soil covering & maintain water quality</i>	<i>-process the LGSP under organised small-scale mining</i>
PJV Admin building	<i>-public end use, maintenance, water supply & electricity</i>	<i>• demolish and rehabilitate the area and backfill the cyanide pond</i>	<i>-art gallery and public library for eco and geo-tourism</i>
Yoko 1 and Suyan Camps	<i>-customary land use and public safety</i>	<i>• requires economic viability study • demolish and salvage the facility</i>	<i>-establish LO firm to operate the plant -rehabilitate & manage runoff chemical residues</i>
Pangalita limestone quarry	<i>-commercial operation options & public safety</i>	<i>requires economic viability study • demolish and salvage the facility</i>	<i>-establish LO firm to operate the plant and -rehabilitate & manage runoff chemical residues</i>
Wailie creek dam	<i>-demolish & rehab as it is unsafe for community</i>	<i>• rehabilitate to meet closure criteria • locals can decide use for water supply and fish farming purposes</i>	<i>-public safety and cost-benefit analysis for reuse</i>
Hides-power plant & transmission lines	<i>-vandalism vs long-term use</i>	<i>• rehabilitate to meet closure criteria • EPG and Porgera LLG reuse options</i>	<i>Local stakeholders may assess its costs and benefits in the post-mine period</i>

As given in *Table 2*, the matrix of options proposed for retaining and diversifying the mine operational facilities depend on exceptional levels of economic and social returns for their reuse in the post-mine period (Nathalia, Kumar, et al., 2017). The authors make similar suggestions (as given *Table 2*) for securing social sustainability after the mining activities ceased in Aravalli Hills of Faridabad District in Haryana. Furthermore, Zvarivadza (2018) assert that repurposing the mine operational assets that have net social returns is "to leave a lasting positive legacy for the communities so that they can sustain life well beyond mine closure." However, PJV has the legal obligation to weigh the risks against the repurposing options that are consistent with PNG's Mine Closure Policy. The mining company would seek to reduce environmental footprints, especially the requirements for lowering biophysical risks to comply with the Mining Safety Act. On the other hand, the EPG may carefully assess these options to minimize its exposure to financial liabilities (maintenance and operating costs) that may arise in the post-mine era.

The PJV could seek to fulfill the regulatory requirements for safely relinquishing the land occupied by the SML and the LMP back to the traditional landowners. The absence of post-mine legislation and weak governance amongst the remote communities may entice illegal mining activities to occur. To resolve these issues, the Mineral Resources Authority (MRA) may establish a post-mine land authority (PMLA) to monitor an orderly transition towards freeing up the land for traditional use. The PMLA can effectively manage the post-mine land after rehabilitating the SML and the LMP and would relinquish these back to the traditional landowners (Kivinen, 2017). The PMLA and the Porgera LLG may collaborate with the community to follow MRA's regulatory procedures for a mining lease application to ensure the post-mine small mining activities are sustainable (Zvarivadza, 2018). However, as far as biophysical sustainability is concerned, the instruments of liability transfer under the MPLA to the PMLA must be cautiously determined on technical qualifications and administrative competency of the local stakeholders.

The Porgera LLG and SML landowners expressed their interests in retaining the Pangalita limestone quarry. The Porgera region's abundance of high-quality limestone deposits could be extracted for use as a chemical reagent in mineral floatation in process plants, and calcium carbonate for agricultural application. The production of these products can be a good source of income-generating activity and employment in the post-mine period (Rupprecht & Pieters, 2018). The option of retaining and repurposing the Pangalita limestone quarry requires a technical study of market availability could indicate its repurposing. However, the limited market availability, the lack of product development for industrial application and long-distance to industrial cities like Lae may make the limestone production economically impractical as it is a bulky industrial mineral.

Another option is to retain the limestone quarry and lease it to Mt Kare gold deposit if it progresses to a development stage in the future. Otherwise, PJV could seek

to meet its mine closure and regulatory requirements by decommissioning and salvage the Pangalita limestone plant and rehabilitate the quarry area. Moreover, PJV plans to dismantle the Walie Creek dam, which supplies water to the Porgera mine and the surrounding communities (*Table 2*). The dam can be converted into a high-altitude fish farm to generate income and to support local food security goals (Shava & Gunhidzirai, 2017). However, maintaining the pumping system is expensive and the dam could fail because it was constructed using gabion baskets. Likewise, the Walie Creek dam may not be suitable for reuse as a water supply or hydro electricity production.

A sustainable energy source is an essential prerequisite for the post-mining economy (Fraser, 2018). The 76 km power transmission line from the Hides gas field in Hela Province supplies electricity to the Porgera gold mine. Since natural gas-powered electricity is eco-friendly compared to diesel and coal-fired energy sources (Viswanathan et al., 2019), retaining the Hides power line could support the Porgera region's energy needs in the long-term. Presently, the entire Porgera valley receives free electricity, which is paid for by the PJV. The PJV reserves the option for EPG and PNG Power to take ownership of the gas-powered electricity transmission line and extend the existing grid to Laiagam and Wabag.

However, rival Huli tribes (landholder groups) would vandalize the power pylons as they dispute amongst themselves over land rental payments. These are the main obstacles to consider when deciding the options of retaining and reuse the Hides gas power transmission line. To reduce these risks, the PJV may deconstruct and salvage the electrical hardware and dispose the materials when the mining operation ceases. The EPG has proposed to develop a separate 2.5 MW hydropower plant using the Pongema River. The local stakeholders can mobilize resources towards constructing the proposed hydroelectricity to sustain the long-term electricity supply in the Porgera valley. Such projects could attract the support of donor agencies that advocate rural electrification programs to reduce poverty (Kaur & Segal, 2017). A shift to a user-pay system could make sure the existing electricity grid is economically viable through sharing the maintenance costs in the post-mine period.

VII. STRATEGIES FOR A FALLBACK PLAN ON AGRIBUSINESS AND SUBSISTENCE AGRICULTURE

The lack of productive capacities and the effects of labour shift towards mining-related employment has led to a decline in subsistence agriculture, which, in turn, can cause acute food insecurity problems and outmigration in the post-mine era. The shift of local labour towards the booming mining sector (Avalos et al., 2015), often causes a general decline in subsistence farming and household productivity amongst host mining communities (*Table 3*). The Porgera mine has created modern techniques of household production, consumption and social engagements that have severely dislodged the traditional dimension of subsistence

livelihoods. The prolonged mining activities have disrupted systems that support food production and conventional ways of seed preservation and cultivation.

Essentially, developing food security programs and alternative income sources such as commercial tilapia (fish) and strawberry farming can prepare the communities for an orderly closure of the mining operation (de Paiva Duarte & Imbun, 2016). The transition from subsistence agriculture to dependence on processed foods sold in grocery stores and the introduction of a cash economy has had a profound effect on traditional agriculture. The communities around the PMT, Porgera Station and the SML areas have raised concerns about the loss of traditional food crops as they neglected subsistence cultivation and depend mostly on cash incomes associated with direct and indirect forms of employment. Having visualized these impacts, the host communities may have few interests to return to their lands occupied by the SML and the LMPs.

The practice of passing farming skills and seasonal recycling of crop seeds is at a high risk of extinction. Porgerans born within the four decades of the mining operation (1990-2040) would have gradually abandoned their traditional ways of seed preservation and distorted their seasonal cultivation patterns. The trend could replace traditional farming techniques with costly inorganic agriculture, such as the procurement and use of introduced seedlings, fertilizers and pesticides and herbicides to control crop diseases and pests. These constraints may induce a decline in income per capita on agricultural outputs and household consumption would decline when the mine-driven multiplier effects cease (de Paiva Duarte & Imbun, 2016). The cessation of direct and indirect employment is likely to cause emigration amongst the young generation that does not possess traditional farming skills. This is highly likely because unattractive socioeconomic conditions are the common push factors that cause emigration as people search for attractive opportunities in larger towns and cities (Mancini & Sala, 2018).

The matrix of risks and options for developing some fallback strategies when mining related benefit streams cease are presented in *Table 3*. It reflects that subsistence farmers in Porgera and rest of Enga Province face a market accessibility problem as they struggle to sell their food crops. The market accessibility requires efficient road networks and transportation, and fresh-produce storage facilities to facilitate household production for income generation (Wiegand et al., 2017). The community does not fully use the Paiam market for commercial activities. The vendors often sell food crops and merchandise along the Tipinini-Paiam road corridor and the Porgera Station market where there are informal commercial activities occurring. As a result, the prices of garden-foods are often high, which is a clear sign of food insecurity emerging in the region (Omot, 2012). The food crops transported to markets at the PMT and Porgera Station markets are supplied mostly from Laiagam, Tipini, Lower Porgera, Paiala or other parts of Enga and Mt. Hagen. Hence, there is limited capacity to cultivate food crops using traditional farming skills as there is scarce arable land available for commercial agriculture in the Porgera region.

In the past, sustainability programs earmarked for developing commercial agriculture have been unsuccessful because the Porgera region lacks arable lands. As a result, extension services conducted on coffee cultivation trials in the lower Porgera and Paiala regions have been largely unsuccessful (*Table 3*). The plans for experimenting the coffee production have failed due to a collapse of the agricultural extension services in Enga Province and PNG as a whole (Sengere, 2016). As for the Porgera region, coffee is the most reliable crop, which could be easily cultivated as an alternative source of income. The market accessibility makes it more convenient for local to cultivate coffee (Jacka, 2020). However, negligence of extension services caused a drastic decline in planting and harvesting coffee in the Porgera region. This means the local stakeholders may grasp the opportunity to diversify the benefits into non-mining enterprises instead of relying on mine-driven income streams. The EPG and Porgera LLG may devise the fallback strategies that encourage develop the existing productive endowments of the Porgera region.

Table 3 Matrix of options for sustainable agriculture development

Socio-economic	Issues Identified	Development options	EPG & Porgera LLG options
Socio-economic Impacts	<i>-inequal benefit distributions & poor sustainability planning</i>	<i>• identify sustainable projects and community involve in implementing the programs</i>	<i>-device framework for integrating development into goods and services delivery mechanism</i>
Agriculture	<i>-lack of land & decline of extension services</i>	<i>• identify innovative options for farming high altitude crops that are whether resistant</i>	<i>-put more effort into agriculture extension services and skill training</i>
Subsistence Agriculture	<i>-traditional crops disappearing, introduce crops expensive & no skill replication</i>	<i>• restore traditional food production to improve food security through integrated, innovative and sustainable gardening techniques</i>	<i>-use benefit streams such as the TCS to build capacities of CBOs and impart skill to young generation</i>
Commercial Agriculture	<i>-Porgera region is not suitable for commercial agriculture</i>	<i>• coffee extension services have failed despite some potentials are there. Need to explore other income generating options</i>	<i>-EPG & Porgera LLG to revive the extension services on some trial projects that may grow well the Porgera, Paiala and Laiagam</i>
Market Accessibility	<i>-lack of market accessibility, & poor road infrastructure reaching markets</i>	<i>• link feeder roads to main Porgera-Wabag road corridor increase access to markets within the region as well in other regions</i>	<i>-EPG, PJV and Porgera LLG to design transport infrastructure linking Politika, Lower Porgera and Paiala and link up with the main road corridor</i>
Skills training and community involvement	<i>-loss of traditional skills and depend on mine incomes</i>	<i>• develop integrated training centre for multi-skill training using the benefit streams such as the TCS and SSG</i>	<i>-EPG, Porgera LLG and PJV to design build technical schools</i>
Sustainable subsistence agriculture	<i>-lack of options for alternative income generating projects</i>	<i>• identify and devise ICARD projects using supports from SME programs consistent with government's goals</i>	<i>-EPG, Porgera LLG and PJV to allocate some portions of the TCS funds towards supporting SMEs and entrepreneurship skills development</i>

The limited commercial agriculture potential necessitates the introduction of skills-based integrated conservation and development (ICAD) concept (Addison & Roe, 2018). The ICAD concept is widely promoted and supported by donor organizations like the United Nations Development Program (UNDP). The integrated approach to initiating micro-enterprises involves devising the means of transferring technical skills through informal training by the way of community participation. The flexibility to replicate skills is one of the cultural strengths that could encourage self-reliance through capacity building in areas of technical and entrepreneurial skill development. These strategies could empower the community to become self-reliant by participating in small and medium enterprises (SMEs) identified under the ICAD strategy.

The SME activities include agro-forestry, husbandry, livestock, inland fish farming, literacy training and occupational health, energy, and eco-tourism. These should

go a long way in eradicating poverty, which is not happening in PNG's extractive industry (Datt & Walker, 2019). Using GoPNG's push for SME-driven rural growth and poverty reduction, building the productive capacities of rural communities could be an important objective of the social inclusion paradigm for the mining industry. That said, directly engaging the community in micro-enterprise activities is a practical demonstration of implementing the social inclusion paradigm. The experiences of donor agencies that support community-based organizations (CBOs) could be an ideal means to replicate the multiplier effects when the mine-related benefit streams cease to exist in the post-mine period. Instead of developing stand-alone infrastructures demanded by the community, a bottom-up approach to sustainability planning and skill development could create synergies that can provide multiple solutions to secure a sustainable future.

The PJV assisted young people from the Porgera region to attain technical skills under the Job Ready Program (JRP). The JRP assisted the development of skills-based micro-enterprises to boost the commercial agriculture and food crop production for sustaining the socio-economic growth. A recent study by Wiegand et al. (2017) found that buildings and other physical infrastructure had deteriorated when the former Misima gold mine closed in 2004. By contrast, the technical skills acquired from the then Misima mine continue to assist the host communities to be self-reliant through the development of micro socioeconomic activities. The self-reliance attained through skill training relates to a famous phrase by Tzu (1992: 31): "Give a man a fish, and you feed him for a day; teach him how to fish, and you feed him for a lifetime". This paradigm could give a valuable direction for empowering the host communities to acquire skills in appropriate technology to become self-reliant (Tzu, 1992) in subsistence living in the post-mine period.

VIII. CONCLUSION

This article has examined the opportunities and the underlying constraints and provided some guidelines for employing some strategic approaches to design and implement economic and social development programs associated with the Porgera gold mine. This study finds the preferential mode of engaging the local community in decision-making and implementation phases of development programs inhibits achieving the social sustainability goals in the PNG context. This is partly because the marginalised communities demand the construction of excess social infrastructure (including those established under the FIFO agreement) that may not be sustainable in the long-run. The lessons learnt suggest that a guided approach to strategic planning could achieve the expected outcomes by integrating the services into government's existing social service delivery mechanisms.

Finally, Porgera's main strength is implicit in the need for developing technical skills. The skill-driven growth could support the sustainability of socio-economic growth beyond the mine life. This is because human skills do not deteriorate over time unlike buildings and physical infrastructure that require costly maintenance. Moreover, emigration of rich Porgerans and the young generation (those born during the mining period) to other urban centers is, highly predictable if law and order scenes and socioeconomic conditions stagnate over time. The majority of Porgerans who decide to transition back into the traditional subsistence living could be contingent on some degree of modern lifestyle augmented by skill-based agribusinesses recognized under the ICAD programs. That said, it is important to construct infrastructures that are financially manageable for sub-level governments. The sub-level governments and mining companies should act in concert to induce efficient utilization of the existing benefit streams to develop suitable micro-enterprises to leave behind a sustainable legacy of the Porgera region and the mining industry as a whole. As yet, there is more research required to devise a workable framework for the preferential

mode of benefit redistribution to align with the social inclusion goals to achieve the sustainable livelihoods in a post-mine period.

➤ *Conflict of interest*

None declared

➤ *Ethical statement*

The authors declare that the research was conducted in accordance with ethical standards, which includes plagiarism check with Turnitin™ that have a pass-through ID number of 883632571.

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