

Gold to Green: Financing Sustainable Mining in Peru



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Acknowledgments

This work was supported by Yale Center for Business and the Environment.

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The authors were advised by Stuart DeCew, Program Director at Yale Center for Business and the Environment. The report was edited by Kat Friedrich, News Editor at Yale Center for Business and the Environment. The graphic design was created by Henk van Assen, Senior Critic at Yale University School of Art, together with Igor Korenfeld and Meghan Lynch, Designers at HvADESIGN. The authors thank these individuals for their valuable insights, support, and assistance.

Jeremy Menkhaus, Yale MF/MBA 2018, and Martín Cillóniz Milberg, Yale MEM/MBA 2019 significantly contributed to the research and development of this report.

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January 2019

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PART 1

A New Financing Model for Gold Mining

A PERSISTENT PROBLEM

For subsistence farmers and unemployed workers in Peru, illegal artisanal gold mining is an attractive avenue to relative wealth—48 hours of work can bring in more than the national monthly minimum wage (Fraser, 2009).

However, commonly-used techniques and materials tie this work to severe environmental degradation and negative health impacts.

Artisanal miners clear-cut the rainforest to reach alluvial gold. To process the ore, they jump waist-deep into barrels where they use their legs to mix gold slurry with toxic mercury, resulting in prolonged skin contact with the dangerous substance.

Because the mining activity itself is illegal, miners are not concerned with violating environmental regulations. Combined with a dearth of knowledge about the significant dangers associated with mercury, this leads to liberal use and cavalier disposal of the element.

Around 40 tons of mercury enter Peruvian waterways every year from mining, harming the environment. This further affects human health when residents along the river catch and consume contaminated fish (Ming, 2016).

Peru is one of the largest gold producers in the world. An estimated 40% of the country's gold is mined illegally.

The Madre de Dios region of the Peruvian Amazon is one of the most biodiverse areas on the planet. It has up to 300 tree species per hectare. It also has a high density of charismatic megafauna such as jaguars and primates (Asner, 2013).

While Madre de Dios is home to all this biodiversity, it is also home to over 30,000 people involved in the small-scale gold mining industry. 95% of miners in the region operate illegally (Ming, 2016).

The government conducts raids to shut down these illegal operations and destroys mining equipment it finds, but the miners return and replace their equipment, undeterred from their conviction that mining offers the best opportunity for them to provide for their families (CGTN America, 2016).

The economy in which this small-scale mining occurs is informal: it imposes no health or environmental regulations. It provides little access to global markets. Forced to skirt legitimate supply chains, miners must sell to intermediaries who wield tremendous power.

As in other areas of the black market, profiteering is rampant. Miners' share of the value of their labors is dramatically reduced. In addition to hurting the miners, this black-market activity causes the government to lose out on tax revenue it would collect if these transactions occurred within the boundaries of the formal economy.

A POSSIBLE SOLUTION

This situation presents a complex tangle of social, environmental, and economic issues. The government has attempted to enforce the legal prohibition on mining in Madre de Dios, but environmental degradation continues, driven by miners' limited alternative economic opportunities.

A potential way to address this problem would be to formalize this economy and foster the use of improved technology. While environmental impacts would not disappear, formally connecting small-scale miners to global markets could incentivize more responsible practices and allow improved government monitoring and enforcement. Improved technology could allow the mining to continue with fewer environmental and health impacts.

According to Jorge Ayala Mina, CEO of Mining Technology Center in Peru, mobile processing units (MPUs) process ore without the use of mercury, dramatically reducing the environmental and health effects of gold-mining operations while boosting yield by 50%. MPUs are not currently in use due to their high cost—around \$150,000 USD. They are also not being used because of a lack of understanding about the harms of mercury.

Furthermore, miners currently prospect for gold through the act of mining itself. Improved geological surveys providing a clearer understanding of gold deposits could eliminate the need for miners to do this, reducing mining's footprint. Ayala Mina said the surveys would also facilitate miners' transition from mining at a depth of 10 meters to mining at up to 45 meters, increasing site-based efficiency and reducing mining expansion rates.

Access to such improved technology as well as the international market for gold requires capital. Given these conditions, a novel financing structure could provide access to MPUs and the global marketplace, thus reducing harmful mercury use and improving livelihoods for miners.

This proposed financial vehicle provides low-interest-rate loans to small-scale miners for the purchase of MPUs, which in turn reduce mercury impacts to soil, air, water, ecosystems, and health while significantly increasing gold recovery. The 50% increase in gold recovery would support a miner's ability to simultaneously service debt and increase income.

The fund would additionally provide short-term financing to enable artisanal miners to access the Swiss market for gold without having to endure a transaction-prohibitive time lag before receiving payment.

Without the short-term note, the amount of time separating a miner's relinquishment of gold and receipt of payment would deter the miner from selling on the international market; it would be like having to wait months after working to receive a paycheck.

Miners could instead be attracted to the option of immediate payment from a local intermediary.

With the short-term note, however, the miner receives payment immediately even though the buyer pays months later.

A third-party contractor would securely transport ore from Madre de Dios to Lima, refine it for manufacturing, and bring it to Switzerland.

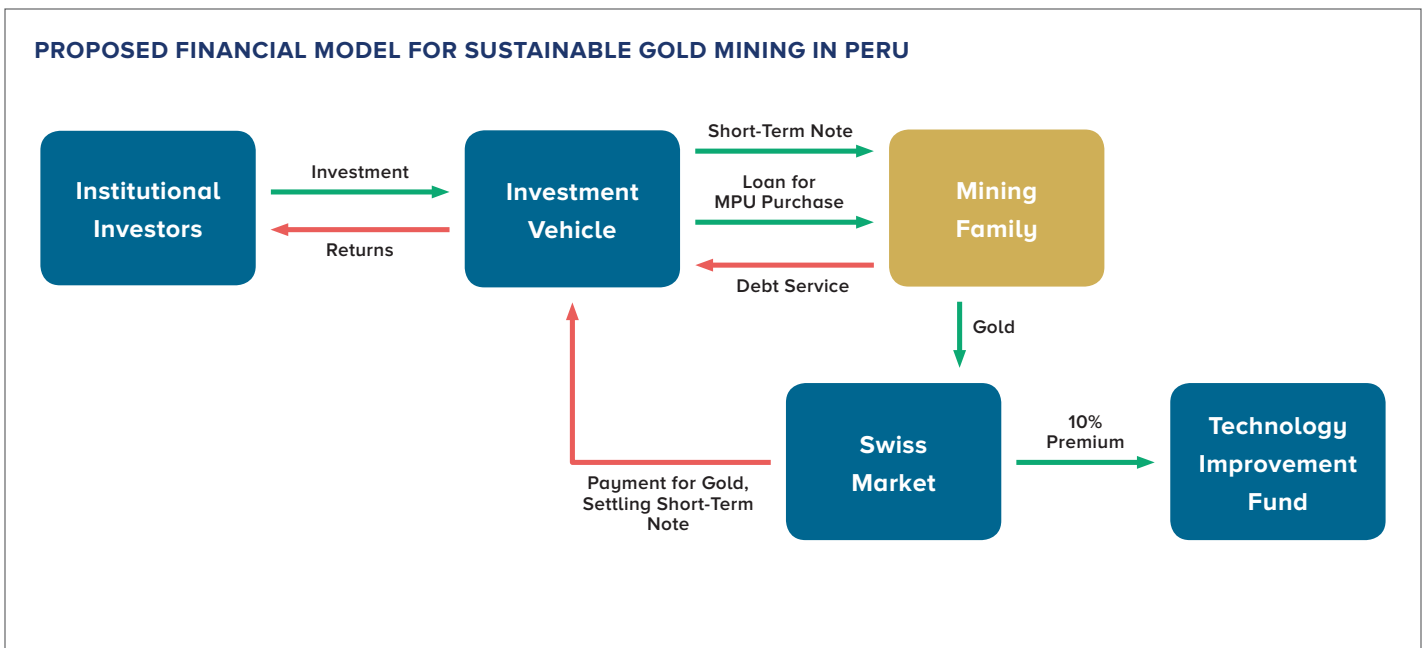
The short-term note would be advanced to the miner upon delivery of ore to the third party—allowing the miner to meet personal needs and service debt—and would be settled by the buyer's payment for gold several months later. This and the market formalization below would obviate the need for miners to sell ore to profiteering intermediaries.

A contract made with the buyer at the time the miner provides the gold would protect investors from market exposure, while a 10% spread between the short-term note and the contracted sale price would fuel the fund's returns.

Ayala Mina said that separate from the 10% spread is an additional 10% premium garnered from the Swiss market for improved sourcing—a result of the market's increasing preference for responsible mining.

The 10% premium paid by the buyer will be put toward a technology-improvement fund that enhances geological surveys, enabling targeted mining and slower expansion.

To access this fund, miners would need to acquire legitimate mining and processing concessions in addition to all other government-required permits. This would enable tax collection and foster market formalization.



THE IMPLEMENTATION BARRIERS

The goal of this proposed financing structure is to use the private market and a financial vehicle to address a multifaceted problem. It suggests there could be a way for private investors to earn a competitive return while having a positive social and environmental impact.

However, while the idea offers some useful strategies and levers to consider, it is far from investible at this time. Major concerns include MPU theft, solution scalability, government opposition, and environmental degradation. There are also concerns about the proposed idea relying on a massive shift in behavior.

There is a possibility that MPUs could be stolen. Also, miners could abscond with their own MPUs without repaying their loans.

While this is possible, however, the risk is mitigated by the value to the miner of a relationship with the lender: this relationship enables connection to the global market and therefore supports higher revenues.

If the borrower steals the MPU, they will lose access to the supply chain that supports higher income.

However, miners could take their MPUs and continue selling ore to the same intermediaries, benefitting from higher yield even if they do not increase their prices.

The potential loss rate of MPUs is a significant unknown before program implementation.

Regarding scalability, there is reason to believe that if this program was successful, it would be feasible to scale. There are an estimated 100,000 artisanal miners in Peru. This would allow the model, if successful, to replicate beyond Madre de Dios to areas such as Puno and Huánuco (Fraser, 2009).

Globally, up to 30% of global gold mining is artisanal (Swenson et al., 2011). This financial vehicle could be adapted to other countries with alluvial gold deposits such as Ecuador, India, and South Africa.

However, applying the model in different regions and countries is far from simple—it would require nuanced understandings of local conditions, norms, and behaviors. Government stances would be different, as would behavior-change trajectories.

This idea relies heavily on the assumption that the government would support it. However, the government has not indicated in any way that it has an interest in formalizing the artisanal mining sector or giving its blessing to currently illegal mining operations.

Perhaps the government's concern is rooted in the question of what behavior this idea incentivizes. Success means improved incomes for small-scale miners. Higher incomes will attract even more people.

It is certainly within the realm of possibility that, if this idea works, it would pull more people into mining in Madre de Dios, resulting in greater environmental degradation.

While pursuing artisanal miners and destroying their equipment has not been an effective way to stem the tide of environmental harm, supporting the miners and rewarding their efforts may accelerate the problem.

However, given the severity of the current situation from an environmental and health perspective, assisting the miners may be better than ignoring or suppressing them.

THE PATH FORWARD

The issue of small-scale miners prospecting illegally in the Peruvian Amazon is a sticky one. There is potential for a financial vehicle funded by private investors to provide bridge financing and enable technology adoption that could help move mining in Madre de Dios toward less destructive practices. However, there are many challenges to this model, some of which are outlined above.

Perhaps the largest single hurdle is that successful implementation of this plan demands major changes in behavior by the small-scale miners. They would need to trust a government they currently avoid, engage with bureaucratic licensing and registration processes they currently circumvent, use new and unfamiliar forms of technology, work with new gold buyers, and follow procedures for formalized debt repayment.

PART 2

The Obstacle of Behavior Change

Changing a person's behavior is not a simple task. The question of which method of behavior change is best is hotly contested in research psychology. Each theory relies on a different baseline understanding of how human beings are motivated to act. Major theories of behavior change debate whether humans are driven by internal or external factors. They also debate whether behavior is a result of intentions.

This case study investigates the obstacles to convincing small-scale Peruvian gold miners to taking the following actions:

1. Become owners and users of Mobile Processing Units (MPUs)
2. Work with a government that currently tries to shut down their operations and destroy their equipment
3. Engage in a new supply chain

These changes would allow the miners to process their own gold and sell directly to the international market, drastically reconfiguring the existing supply chain and cutting out the processors and middlemen who currently play a central role in small-scale mining.

No single theory captures the entire range of forces at play for a small-scale Peruvian miner. Instead, the concerns and motivations of the miner can be examined through the lens of key elements that exist across a few major theories.

ELEMENTS OF BEHAVIOR CHANGE

The World Bank's Governance Program has worked extensively on behavior change. It has identified key variables that are common among behavior-change models.

Thematically, these elements break down into three main areas:

1. Impact on Self
2. Achievability
3. External Motivations

In the following three paragraphs, italicized words highlight the crucial elements that must be targeted in successful behavior-change programs.

Impact on Self

Behavior change requires action (and often effort) from the change-maker. So the person must believe they will benefit from these actions. Net improvement can come from risk avoidance or or wellbeing gains.

The elements connected with risk avoidance are *threat*—the motivating factor that one's current behavior is dangerous or harmful—and *fear*—the concern that this particular threat could cause harm.

In the case of Peruvian mining, one threat is the vast amount of mercury released into river from informal gold processing. The fear is that mercury pollutes the river and could make a miner or their family sick from ingestion.

The benefit due to adopting the new behavior is primarily financial gain.

Achievability

An individual's perception of their capacity to achieve a desired outcome is colored by three primary elements.

The first is *self-efficacy*—the individual's belief that they can complete the task at hand.

For a Peruvian miner to achieve this, they would need to be confident they have the necessary skills and support to negotiate government licensing and registration requirements, operate a new piece of machinery, manage shipments of a final product, and be properly compensated for the product.

This self-efficacy is impacted by *attitude*, which reflects a miner's belief that, if they complete all of the required steps, the promised outcome will be achieved.

Finally, the miner must consider potential *barriers*—such as difficulties with securing the proper permits for the operations.

External Motivations

The miner's decisions and actions do not exist in a vacuum. The impetus to make the jump to a new behavior can be sparked by *cues to action*.

For miners, this may be the opportunity to operate an existing MPU before purchasing—or the observation that a neighbor has purchased an MPU.

These cues are intertwined with *subjective norms*—what others in their community think they should do. These factors help explain how adoption of a new technology such as social media can grow exponentially after hitting a critical mass.

In summary, the eight key elements to behavior change explored above are threat, fear, benefit, self-efficacy, attitude, barriers, cues, and norms.

STRATEGIES TO IMPROVE THE INVESTMENT THESIS

Any investment thesis that requires significant behavior change is bolstered by a strategy that carefully considers the activation of these key elements.

The following five strategies were identified as ways to strengthen the original Peruvian mining investment thesis with behavior change in mind.

Identify Influencers

Any miner making a major decision about their method of gold processing will consult a number of opinions in weighing the decision.

These could range from a specific politician to an acquaintance to their spouse or child.

Identifying who impacts the thinking of the decision-maker allows the investing body to target the message.

If families are the primary influencers, the investor should publicize the health benefits of new mining practices to their networks.

If civic leaders are the primary influencers, these individuals should be informed of how their towns can become more stable and increase tax revenue with a new gold supply chain.

Elements targeted: Benefits, Attitudes, Norms, Cues

Give away MPUs

MPUs represent an entirely new method for processing gold. Miners would be rightfully wary to question the efficacy of any new model they have not seen in practice.

By giving away MPUs, organizations could mitigate the financial risk to the miners. Users could experiment with the technology at their own pace. This would help create trust between the investors and the communities and would make the benefits of the product more tangible to the miners.

Elements targeted: Benefits, Efficacy, Attitudes, Intentions

Define a Point of Contact

Regional organizations are responsible for the development and production of MPUs in Peru. While these organizations may not be local to the Madre de Dios region specifically, they will be better equipped to connect personally with Peruvian miners than a foreign financing organization.

A single organization such as Peru's Mining Technology Center could act as the primary point of contact. This arrangement would deemphasize the financial vehicle as much as possible and foster personal connections that can help establish trust and decrease concerns about barriers.

The role of the financier would still need to be transparent, since an absence of transparency could degrade trust if miners felt misinformed about the financing mechanism.

Elements targeted: Barriers, Norms, Reactance

Create a “Freemium” Network

Peruvian miners today have few opportunities to share knowledge with one another. A financial instrument could strengthen its investment by supporting a platform for knowledge-sharing through which miners could easily ask questions or seek out information about challenges with their work.

For example, this could be a hotline that miners could text to receive weather updates or gold prices.

It is important that such a network be designed using culturally competent choices of technology and outreach. This includes providing face-to-face assistance if that is appropriate.

The “freemium” network would provide basic connectivity and information access to any Peruvian miner, with greater support for those who own MPUs.

MPU owners could access additional information on best practices for owning and operating their processing units—as well as opportunities to connect with other MPU owners.

Elements targeted: Norms, Intentions, Cues, Attitudes

Build a Government Pilot Program

Small-scale Peruvian miners often work without a permit and thus are concerned about interfacing with the government.

By getting support from the government with a pilot program, miners would be assured that they can safely make this investment without risking being shut down by the government or having their property confiscated.

Elements targeted: Threat, Barrier

CHALLENGES OF BEHAVIOR CHANGE

The specific challenges of gold mining are not generalizable to other conservation-finance or behavior-change challenges, but the complexities of decision-making are.

For instance, identifying the influencers who can drive behavior change will be different in any context. There is no “cookie-cutter” plan of identifying key members of civil society because the level of trust between local government and its citizens changes from locale to locale. Working with national governments could be viewed as a positive opportunity by some communities and as a corruption hazard by others.

Even giving away free MPUs could be met with greater skepticism by some miners.

This understanding of behavior change widens the conception of the due diligence that an outside investor needs to conduct.

A country or region that seems extremely profitable based on its labor source, geographic location, and raw resources may be an inadvisable target for investment if barriers to adoption in the local context are insurmountable.

When a financial prospectus relies on changes in behavior by its target user group, its financial return and long-run viability are dependent on the users’ willingness and motivations to change their behavior.

In this case, the target user group of Peruvian miners would be asked to give up their current mercury technology for a more complex option.

It is important to recognize the target user group has concerns other than economic self-interest. They are also considering the likelihood they can successfully operate a mobile processing unit and the impact on themselves and their families of doing so.

They are additionally looking for external indications from influencers among their friends, families, and communities that this change of behavior is the right choice.

In the context of small-scale Peruvian miners, behavior change presents a significant challenge. The success of the financial vehicle depends on miners changing their routines, their processes, and their relationships. They need to put trust in parties they have not trusted before. They need to use equipment they have not used before.

For this to be feasible, investors would need to rely heavily on several strategies that foster effective and sustainable behavior change. Identifying influencers will be crucial in spreading interest and trust in this program among a scattered group of illegal miners.

Giving away MPUs would likely be effective in generating buy-in and interest among a skeptical population. Working with the government is necessary if investors want to foster a sustainable program that miners will willingly buy into.

It is impossible to say for certain whether these strategies would adequately address the hurdle of behavior change. However, while this particular conservation-finance strategy faces many challenges, it seems the challenge of behavior change may be surmountable.

Given thoughtful implementation of at least some of the strategies outlined above, as well as ongoing recognition and mitigation of new challenges that arise over the course of project implementation, behavior change appears feasible enough that this concern alone should not forestall the investment.

When building this sort of economic model, each node of the model and economic vehicle must be considered not only for its impact on internal rate of return, but also for its impact on behavior change.

For instance, the model in Peru includes selling to the Swiss market. Would Peruvians know Switzerland is a premier gold buyer and thus trust this model more, or would they be skeptical about the feasibility of shipping their gold as far as Europe?

Each node on a financial model must be viewed from a human angle and investors must consider what they are asking the miners to do.

This requires an understanding of their background, experiences, and needs. It also requires seeking information about their trust of the stakeholders involved.

The success of any environmental-finance project can be decided by these very human elements.

References

- Asner, G., et al. (2013). "Elevated rates of gold mining in the Amazon revealed through high-resolution monitoring." *Proceedings of the National Academy of Sciences*. 110(46): 18454–18459. <http://doi.org/10.1073/pnas.1318271110>
- CGTN America. (2016). *Time is dust: Illegal gold mining in Peru*. Retrieved from <https://www.youtube.com/watch?v=ADQyPEWGox8>
- Fraser, B. (2009). "Peruvian gold rush threatens health and the environment." *Environmental Science & Technology*. 43(19), 7162–7164. <http://doi.org/10.1021/es902347z>
- Swenson, J., et al. (2011). "Gold mining in the Peruvian Amazon: global prices, deforestation, and mercury imports." *PLoS ONE*. 6(4), e18875. <https://doi.org/10.1371/journal.pone.0018875>
- Ming, K. (2016). The fate of the Amazon. *Wake Forest Magazine*. Retrieved from <http://magazine.wfu.edu/2016/09/30/the-fate-of-the-amazon/>