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Preferences of Small-Scale Gold Miners Related to Formalization

first steps toward sustainable mining supply chains in Colombia

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Abstract

Artisanal and small-scale gold mining employs millions of poor people, globally, yet also significantly degrades the environment. Support from conscientious buyers, based on the information within certifications, could lower environmental impacts and raise incomes, leading miners to be willing to incur costs to participate in sustainable supply chains. As supply-chain certification may require formalization, we explore miners' motivations for and the barriers to formalization within a choice experiment in two Community Councils in Afro-descendent areas of Colombia's Pacific Region: Yurumangui, in Valle del Cauca and San Juan, in Choco. Community Councils have collective land rights—which might make them more willing to engage in collective action often required for formalization. We find that, while all miners prefer to leave the status quo, views of miners in the two Councils differed with regard to formalization. Yurumangui expressed more interest overall in the options we offered, perhaps due to past formalization experiences in San Juan. Yurumangui miners were also more willing to form or join an association to formalize, very likely due to positive past outcomes from organization. We find no consistent effect of gender regarding preferences, though prior voluntary restoration correlates with individual miners' willingness to restore sites, one requisite of formalization. Our results inform interventions to support formalization in small-scale gold mining communities, as we find miners are willing to try formalization but raise issues related to costs that can hinder adoption and in ways that vary with the past legacies of each Council.

Keywords: sustainability, supply chains, mercury, mining, Afro-descendant communities, formalization, common property resources, motivations, choice experiment, Colombia

JEL Codes: C25, D04, D71, Q31, Q32, Q38

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1. Introduction

Over 40 million people are engaged in artisanal and small-scale mining (ASM) globally, most in the Global South. Artisanal and small-scale gold miners (ASGM) provide close to 20% of the total global supply of gold, while often operating informally with large negative environmental impacts (IISD, 2018). ASM has generated significant local land-use changes as well as local and global environmental pollution through the release of heavy metals such as mercury, arsenic, and lead into the air, water, and soil. This has spurred global efforts to support shifts in ASM practices.

Sustainable mining initiatives, such as Fairmined (FM), Fairtrade, and Swiss Better Gold (SBG), have been established to confront the local and global environmental and social challenges related to ASM. Yet, despite sensible approaches, the adoption of new practices has been slow—while many of the operations certified were already close to compliance with the standards. Low rates of adoption, may be due to technological and market barriers, especially for the smallest producers. In response, less onerous systems are now being promoted in Colombia and globally, such as the Code of Risk-mitigation for ASM engaging in Formal Trade (CRAFT) (ARM & RESOLVE, 2020). However, every certification's code of conduct requires miners to "formalize", i.e., to obtain an official government license to operate. Unlike agriculture, where formal land title is not required, in mining, formalization is a necessary step towards supply-chain certification.

Colombia is a small player in gold, with only ~2% of global annual production (World Population Review, 2022). Yet gold mining supports hundreds of communities, with profound socioeconomic implications, but often in fragile and biodiverse ecosystems of environmental importance. Small-scale mining operations account for ~70% of national production in Colombia (Sarmiento et al., 2013), benefiting more than 180,000 small-scale gold miners (Cremers et al., 2013). Mining is also

an important income source for illicit groups, as most metallic-mineral-production units operate within conflict-ridden areas, without mining permits or titles (UNODC, 2022).

Distributional issues across and within sectors are also relevant in Colombia and more generally. Despite $400 billion in annual trade (OEC, 2023), miners are among the most marginalized workers in the world (World Bank, 2020), while women and children are among the poorest participants within ASM. Although women make up an important part of the labor force occupied in mining (up to 50% in Africa (Forum for Mining, 2017)), they often suffer multiple forms of discrimination. Women are paid less for similar tasks, and have limited access to some activities, as well as credit, asset ownership, and decision power (Buss et al., 2017). In many cases, it is women who work the outskirts of mines to recover gold from low-value ores that male miners have left as residue (Cruz, 2016). Female participation in mining is also constrained by caregiving and involvement in other economic activities such as agriculture (World Bank, 2020). In sum, the benefits of mining are very often highly gendered, with men in charge of the higher-paying activities, such as digging, while the women who grind, pan or wash earn a fraction of what males make (Reichel, 2020). Therefore, despite women's interest in sustainable mining for the wellbeing of their households and communities more broadly, low shares of the gains from participating in mining formalization, and eventually in certification, could well drive female views to differ from those of male miners.

In principle, initiatives which advance more sustainable mining could contribute to alleviating environmental damage, improving livelihoods, reducing violence, and even closing gender gaps in perceived benefits from mining. That could be particularly important along the Pacific coast, where traditional mining has been practiced since pre-Columbian times, but where small-scale

gold mining territories face the threat of encroachment of illegal mining operations controlled by criminal organizations.

Today, 40% of the gold produced in Colombia comes from this Pacific region, which is particularly interesting for this study because communities here hold collective land titles under Community Councils (CC). This institutional juxtaposition may well suggest greater potential for sustainable mining. Collective titling could facilitate formalization and sustainability in the region, as community organizations and other forms of collective action are already present. Further, formalization could help differentiate small-scale mining from illegal mining, with implications for government intervention in these territories.

To understand the motivations and barriers to formalization required for certification, , we studied miners in two of these Community Councils, Yurumangui in Buenaventura (Valle del Cauca department) and San Juan in Tado (Choco department). We explore which, of a number of possible bundles of benefits and commitments, miners indicate they would be willing to accept to be formalized. Factors explored were the price of gold, restoration activities, local associations, and fees. Contrasting CC histories, including formalization, could affect perceived costs and benefits. As participation in mining and its benefits is a gendered activity, we also compared female to male views. Understanding miners' preferences related to formalization can help guide public, civil, and private actors to achieve both environmental and social benefits.

We find that these two Councils differ with regard to miners' views on formalization options. Miners in the CC with prior experience of formalization were *less* attracted to formalization — holding other elements of formalization constant — suggesting the influence of past negative experiences. In contrast, miners in the CC with more experience of prior social organizing were more willing to form associations that could facilitate the formalization process, suggesting

positive past experience matters. Restoration willingness rose in line with an increase in individuals' prior voluntary restoration experience. On average, we find no differences in perceptions and preferences across gender within these communities.

Policy design is frequently done without much input for those impacted. With great intentions, incentives are developed with little attention paid to what costs and benefits communities are willing to bear. Understanding people´s preferences, particularly in the context of collective governance agreements, is key for policy success but also to create institutions that are legitimate and truly respond to specific contexts. Choice experiments are a useful tool to reveal preferences, as people "vote" for bundles of attributes, that make tradeoffs evident as well as the specificities of contexts and pathways.

These results are reflective of the ongoing need for more attractive policy options for formalization, from the perspectives of the miners (as opposed to other important actors in the sector whose objectives may differ). Mining communities may be willing, in principle, to move away from their current situation, yet they will need greater confidence that this would bring gains. Public and civil actors could provide better information on formalization requirements, including the gains from forming groups to comply with markets requirements at lower transactions costs. Also details for formalization options could be adjusted when trying to increase adoption.

The rest of this article is organized as follows: Section 2 reviews the relevant literature. Section 3 describes our field context and Section 4 our methods, presenting the hypotheses behind our models. Section 5 presents the results, and Section 6 discusses the implications for theory and policy.

2. Literature Review

2.1 Mining Formalization

UNEP's handbook defines mining formalization as: "a process that ensures that ASGM actors are licensed and organized in representative entities that represent their needs; policies are implemented, monitored, and enforced; and ASGM actors receive technical, administrative, and financial support that empowers them to adhere to requirements prescribed by national regulations" (UNITAR & UN Environment, 2018, p. 17). Legality and building capacity to meet requirements are linked. Miners with few assets often need support to take steps to become legal, while becoming legal may make miners eligible for government support. However, governments have often focused on legality without providing support, with poor outcomes (Hilson 2020a; Veiga and Fadina 2020). As the Swiss Agency for Development and Cooperation (SDC) argues in a review of multiple efforts: "formalization … must not be limited to the pure legal aspects, but incorporate community development and broad capacity building" (Hruschka, 2011, p. 43). A purely legal focus can paralyze momentum if miners are not organized in ways that would allow them to become formal.

Global rhetoric about formalization tends to be framed around improved environmental and social results, as compliance with environmental and labor laws is expected to render better outcomes (Fritz et al., 2018; Spiegel et al., 2015). However, such efforts have frequently fallen short, as few actors succeed in formalizing while those who do, are often already much better off than average ASGM actors and as a consequence may well be better able to navigate the barriers noted. Further, those who have been formalized have not necessarily performed better socially or environmentally.

In Rubiano et al.'s review (2020), strategies for the formalization of small-scale gold mining face several challenges. There is a need for more flexible state institutions that adjust regulations, bureaucracies and fees depending on miners' situations. Access to permits and mining titles should

not be the only purpose of formalization, which should also advance both labor and environmental regulations and equitable access to land and natural resources. It is important to see not only who owns a mining title but also who controls key capital in the process of formalization.

Challenges leading to low formalization rates include a shortage of official information concerning miners, bias in favor of large-scale mining and high-capacity entrepreneurial lifetime miners over those compelled by poverty to mine part-time, the time required to obtain permits, and one-size-fits-all approaches (Hilson et al., 2021; Hilson, Gillani, & Kutaula, 2018; Hilson, 2020a; Sippl, 2020; Coy et al., 2021). These constraint lead to what Veiga & Fadina (2020) term a formalization "fiasco". To date, less than 1% of artisanal miners in Latin America are formalized (Veiga and Fadina 2020). **¡Error! No se encuentra el origen de la referencia.** depicts common barriers to formalization identified by UNEP.

We emphasize that hurdles to formalization are especially daunting for artisanal miners who work independently, and lack the capacity to meet requirements such as work plans or environmental impact assessments. Those steps require the literacy, technical know-how, and time that many subsistence miners do not have. As a result, those miners who work independently might not be able to access prices or capital which could move them ahead. "Only larger and organized clusters of artisanal miners […] are able to develop beyond subsistence economy, overcome dependencies from local middlemen and even engage with international markets on their own" (Hruschka. 2011, p. 28). Acknowledging such hurdles for the individual artisanal miners, the SDC recommended that ASGM actors form associations or other formal organizations as a formalization pre-requisite. Existing social capital is key here, as formal organizations can be developed more easily when groups have successfully worked together in the past than when they have not.

[Figure 1]

However, formalization is not free of controversy. Some authors link formalization to the lack of progress in outcomes, including exacerbated forest loss (Álvarez-Berríos et al., 2021). Some operators face incentives to extract quickly, secretively, and destructively since they believe access may not last.

A legal focus has gone hand-in-hand with enforcement that can be socially and environmentally damaging, increasing conflicts and pollution. In some cases, titling has allowed outsiders to make claims on indigenous lands. Formalization has failed to reduce mercury use, and the focus on increasing tax revenues rather than capacities, has created more illegality rather than less (Álvarez-Berríos et al., 2021; Spiegel, 2015; Rorato et al., 2020; Veiga and Fadina, 2020).

Further, miners do not necessarily perceive benefits related to formalization, such as better market prices or reduced violence. In cases when formalization has been a centralized top-down decision, it has driven increased militarization and state violence (Geenen, 2012, Kaufmann & Côte, (2021).

Finally, some suggest "formalization fiascos" may be by design. Formalization is state driven, yet some governments do not value the poor rural ASGM sector, over large-scale mining's greater economic and political potential. ASGM may be seen as competition or a nuisance that can ruin states' reputations (Hilson et al., 2020; Hilson, 2019). In Zambia, after the government's mining priorities had shifted, a massive push to formalize gold-panners was transformed into a military operation to shut down illegal mining, which made targets of previously identified beneficiaries (Hilson, 2020b). In Zimbabwe, progress in the 1990s linked to empowerment of local authorities stalled when a re-centralization blocked local governments' ability to issue permits (Spiegel, 2015). In sum, while formalization offers a possible pathway to improve conditions for ASM, it is riddled with challenges, especially when designed without regard for miners' aspirations.

2.2 Mining Certification

ASGM organizations sometimes obtain better gold prices or market access if they meet externally determined standards (e.g., workers' rights or environmental behavior) in certification schemes, such as Fairmined and Fairtrade. Certifications are promoted by NGOs—who often work with development agencies to improve ASGM supply chains, predominantly to Western markets. Formalization is often one prerequisite, linked to compliance with exporters' national laws and sometimes also importing countries' standards. International development agencies, for instance, can be restricted to funding only formalized actors, due to the official nature of their cooperation.

As with formalization, discussions on certification are broadly organized around access, adoption, and impact. Early literature concerning certification in small mining focused mainly on "Fairtrade-Fairmined", a collaboration of the Fair-Trade Organization (FLO) and the Alliance for Responsible Mining (ARM). Distinct certifications, "Fairtrade" and "Fairmined", arose after the organizations split due to disagreements about how to address difficulties faced by the original certification (Sippl, 2020). Studies highlight that certification will not reach the miners most in need of help (Hilson & McQuilken, 2016) and might be rejected by vulnerable miners, given their past negative experiences with interventions and the certifications' lack of answers to the challenges miners face (Childs, 2014). Miners trying to get certified faced requirements including obtaining formal permits (Sippl, 2015; Hilson & McQuilken, 2016; Fisher, 2018). These allegedly pro-poor schemes neither empower nor target the most impoverished miners (Hilson et al., 2018). Fairtrade and Fairmined miners earn almost ten times more than the average uncertified artisanal miner (Sippl, 2020; Sippl, 2019). Certification has reached only a small amount of 'low-hanging fruit' (Hilson et al., 2018) and may inevitably serve only a niche group (Sippl, 2019). Ultimately, as with

formalization, current certification efforts only affect a small and well-organized, high-capacity subset of ASGM actors already very close to compliance.

Monroy et al. (2022) suggest new interest by international organizations in financing initiatives aimed at the most vulnerable miners. ARM, which promotes Fairmined, has responded to the demands of both international agencies and mining groups for a more attainable certification by creating the CRAFT code of conduct. Codes of conduct are less rigorous than certification schemes and tend to favor continuous improvements over strict compliance (Rueda et al., 2017). CRAFT criteria aim to expand access in ASGM by privileging anti-conflict over environmental standards and focusing on "legitimacy"—permission of landholders to mine, including compliance with national laws— rather than "legality" in meeting all formalization requirements. This lowers participation costs for miners, in part via self-reporting, instead of paying for audits (Sippl, 2020). While not promising price premia or access to international buyers, CRAFT connects small producers to more formal buyers who offer prices closer to the spot price—which could be a substantial incentive, given that informal miners frequently receive significantly less than the international price (Coy et al., 2021).

2.3 Mining Formalization & Certification in Colombia

Formalization in Colombia has been found to be onerous, with over 380 steps costing on average $50,000 over 2-3 years (USAID, 2021). Thus, few miners complete the process, despite claims that formalization can be profitable (Coy et al. 2021). Reports about its impact have also been quite mixed. Some say formalization has allowed land grabs and intimidation of land users (Alvarez-Berríos et al.202), while others argue it reduces mercury contamination (USAID 2020). Some contest the latter claims, drawing on visits to formalized small-scale processing plants to argue

that the majority of those formalized plants are misusing mercury, creating pollution similar to that in informal mining and processing (Alvarez-Berríos et al. 2021; Veiga and Marshall 2019).

Colombia has been a pioneer in sustainable gold production. In 1996 it created “Oro verde”, the first project in the Choco Forest that developed and tested an environmental and social standard for artisanal gold production (Sarmiento et al. 2013), which later became the basis for the Fairmined certification. Colombia is also the home country of ARM. Still, the rate of certification in the country remains low. Further, attrition has occurred, with currently only two active Fairmined certified operations, down from a peak of 5 in Colombia and 10 globally in 2018. Certifications can show that best practices are possible, even for relatively few actors (Sippl 2019).

Low levels of adoptions have multiple causes. Informality is widespread. The limited associativity of miners offers an additional challenge, making it harder to create business structures that manage mining titles, collect gold, and include miners in social protection systems. Finally, gold production using artisanal methods is highly variable, thus many small mining communities cannot guarantee to certification partners like Fairmined the production of a minimum stable supply of one kilogram of gold per month.

3. Field Context

Although Colombia is a relatively small player within the global gold market, gold mining is a key source of income for impoverished communities along its Pacific coast, where close to half of the nation’s gold supply is produced. About 40% of this extraction happens in the territories of Afro-Colombian communities (UNODC, 2021). Law 70 of 1993 recognizes the collective rights of these communities under Community Councils (CC), each governed by a Board and a Community Assembly (Vélez, 2011). Currently, over 190 CCs administer almost 6 million hectares of

collective property (ANT, 2022). CCs have rules to manage their territory and resources (Vélez, 2011), perhaps with some impacts. Evidence suggests that without collective titling, deforestation would be higher (Vélez et al., 2020).

While these CCs can design rules to manage gold mining in their territories (Rodríguez et al., 2019; Rodríguez et al., 2021), the subsoil belongs to the State. From the national government's perspective, tools beyond pans are illegal unless a miner or community has a concession. Gold mining is a traditional activity (Leal-León, 2016), though, and the main source of income for an important share of CC families. As the framework for the chapter of Law 70 regulating mining in this territory has not been developed, at the moment this research was conducted, regulations vary depending on local governance. There are tensions with national level regulations. Some CCs effectively prohibit the use of backhoes, as well as the presence of any external miners. Others only allow small motor pumps, mini-dredges, and very basic tools such as pikes, shovels, and *almocafre*. Still others restrict mining areas (e.g., excluding some areas of the river), replant logged forests, or prohibit the use of toxic chemicals which can damage human health, fishing, and agriculture. Enforcement varies with the social capital of the community (Rodríguez et al., 2019; Rodríguez et al., 2021).

[Map 1]

Under current legislation, CCs with small-scale gold operations must use the procedure established by Resolution 266 of 2020 to regulate traditional mining. CCs must define Special Reserve Areas (ANM, resolution 266 of 2020), prepare an Environmental Impact Study (ANM, resolution 546 of 2017, art. 22), have a Work Plan (ANM, resolution 266 of 2020, art. 20), and obtain an environmental license and special-concession title (Decree 1378 of 2020). On average, costs of

complying with formalization requirements for such Special Reserve Areas are around US$50,000 (USAID, 2021). Hardly any CCs can cover such costs without external aid. For artisanal miners using only pans, the only formalization requirement is to register online to receive a tax identification number and then register with the mayor's office. Yet many mining villages lack the required internet connection to complete these steps.

Communities face several barriers to comply with the requirements beyond those already mentioned (Monroy et al., 2022; ARM, 2018). Law 70's mining chapter has never defined roles for CCs in the administrative process or been adapted to traditional models of organization for the Pacific. Instead, the national government employs identical policy tools for substantially different contexts. This makes the informal mining communities vulnerable, including to illegal mining groups (Rubiano et al., 2020; Zabyelina & Uhm, 2020).

We conducted our fieldwork and choice experiments in two CCs that differ in their organization and formalization experiences, San Juan, in Choco and Yurumangui, in Valle (**¡Error! No se encuentra el origen de la referencia.**). They offer empirical contrasts for considering how formalization could be expanded in Colombia's Pacific, with different levels of formalization and social cohesion, as well as differing contact with external actors. The World Wild Fund for Nature (WWF) has worked in San Juan to motivate miners and the CC board to formalize, while this course of action has not been started in Yurumangui's residents. San Juan is highly connected to urban markets of gold and other products. Yurumangui's miners are hours from the closest buyer. Social capital also varies, as will become apparent from the study.

4. Methods

To understand motivationsand barriers to formalization for these Community Councils, we conducted semi-structured stakeholder interviews to understand local contexts, then defined an adequate experiment. Next, we conducted a choice experiment to capture the preferences of participants regarding formalization. This was followed by a survey to capture both individual and household-level information. Each of these instruments was applied to both female and male miners and their responses were analyzed separately and compared to capture possible gender differences. This section provides details about our methods.

4.1 Interviews

For the first stage of our research, we conducted 18 semi-structured interviews with mining leaders from Yurumangui and San Juan. We also held meetings with the CC Boards to understand local production practices, gold markets, community-based governance, and current formalization levels. These meetings also allowed us to discuss our survey and choice-experiment designs and to tailor our questions and choice-experiment attributes and levels to these local contexts. We also interviewed six mining experts from the government and NGOs who work on mining formalization and certification.

4.2 Surveys

We collected demographic information (e.g., age, gender, education level, among others) as well as information regarding local mining practices, governance structures, and relevant gold-market outlets. Surveys and choice experiments were administered to 423 participants in these two communities: 219 in Yurumangui; and 204 in San Juan. Our survey and choice-experiment

participants were all individuals who have derived part or all their income from artisanal and small-scale gold mining.

We hired and trained a local team of enumerators from each community to conduct interviews. Questions were administered mainly via an online platform (KoboTools) using cellphones (one enumerator conducted the survey on paper). Each team spent a month in their CC conducting interviews, supervised by the researchers. We eliminated outliers when the time to complete an interview was infeasibly short.

4.3 Choice Experiment

Since the uptake of formalization has been low, it is important to assess miners' preferences to understand which characteristics miners would accept for formalization options. Choice experiments explore such preferences by presenting potential characteristics of formalization programs. These experiments have been used to study resource use and the design of incentive schemes that could reward shifts toward pro-social/environmental behaviors. They are used to estimate preferences for varied attributes of environmental programs, including willingness to accept payments for environmental services (Lliso et al., 2020; Raes et al., 2017; Beharry-Borg et al., 2013); consider outcomes of collective versus individual payments in Mexico, as well as provision of technical assistance (Costedoat et al., 2016); explore impacts of agri-environment certifications involving specific environmental friendly practices Christensen et al., 2011; Broch & Vedel, 2012; Rodríguez-Entrena et al., 2019); and examine restrictions on third-party access to common-pool resources in Ecuador (Maldonado et al., 2019). Our study contributes to this literature by applying this method to consider formalization programs in ASGM in Colombia.

Our discrete-choice experiment elicits preferences for ASGM-formalization options in theselected CCs. Each participant was presented with a set of six choice tasks. For each choice task, the participant chooses one of three scenarios: two distinct formalization offers and the status quo (i.e., remain not formalized, maintain environmental practices and organization level, and gain no price premium). Formalization offers have attributes linked to the costs and benefits of becoming formalized, that we identified from the interviews with local actors and a review of formalization requirements, which are:

i) participation in an association

ASGM miners operate independently or as a family or as part of larger groups. Even when miners exploit the same area as family and friends, each miner tends to keep the gold they extract. Miners also tend to choose individually when and to whom to sell gold. The formalization process, however, often requires joining associations in order to help to access land titles and gain external support. From the state perspective, such associations may well be easier to support, permit, and regulate. Yet this deviates from how miners operate. It implies less independence, constraining decisions with costly collective action. Thus, joining can be perceived as costly for independent operators but less so in places where local collective action has occurred and succeeded. This is a discrete attribute whose levels are participate in an association, or do not participate.

ii) investment of time in mining-site restoration

Site restoration is required for formalization, which can be costly. Once alluvial operations finish, the common behavior is to depart without restoration, leaving barren pits of mud and stones. This has costs downstream, as pits stripped of vegetation erode, raising the turbidity and sedimentation of waterways. Restoration efforts, such as re-introducing vegetation and/or filling mining pits, can

decrease those costs, and may also have benefits for local communities, such as lower incidence of mosquito-borne diseases. However, restoration efforts can involve days of unpaid work. We therefore represent this attribute in terms of four levels: 0, 1, 2, or 3 days per month. We acknowledge that some miners view certain restoration efforts as beneficial for local communities, yet we suspect most miners view the requirement to restore their exploited sites as costly.

iii) contribution to the community council

Efforts by local authorities may be necessary for formalization to be effective, which may involve some compensation. We include this as a financial contribution to the Community Councils, because CC Boards are the first level of local political organization for managing collective lands. Boards define rules to manage those lands, as well as around access to other resources, and to raise funds for public works via voluntary contributions or external donors. They are the formal authority that mediates interactions with external actors. Boards could support formalization by providing administrative assistance concerning environmental and social compliance. Boards might then expect compensation for their time and for the exploitation of communal resources. We consider fees of 0, 2,000, 4,000, or 6,000 Colombian pesos (COP) per 100,000 COP of income from gold (at that time one dollar (USD) equaled 3,855 COP). These fees mean that miners would contribute 0%, 2%, 4% or 6% of their revenue from selling gold to the Board. Beyond covering the costs of administrative support, however, such contributions could be understood as a way to redistribute the local benefits from mining to various members of the community. Boards are likely to want to channel some of such earnings into local development projects and public goods.

iv) gold price per gram

Formalization is expected to improve access to markets and perhaps differentiate products. Either outcome could raise the price of gold. At the time of our study, miners received on average 130,000 COP/gram when selling to the informal gold buyers closest to their communities. However, formal buyers paid much closer to the international spot price, at least when buying from legal mining operations (at that time 220,000 COP/gram was ~90% of the London Fixed Spot Price, although the prices fluctuated considerably and depended on gold purity). To represent plausible outcomes, we used the amounts of 130,000; 160,000; 190,000; and 220,000 COP/gram for our choice cards. [Table 1]

summarizes the attributes and their values (the "status quo" category is labelled "s.q".). To create the potential incentive bundles for the hypothetical formalization offers, we randomized each attribute. Each card presented two potential offers plus the status quo option {no association, 0 days of restoration, $0 contribution to the CC, and 130,000 COP/gram price}. Considering the complexity of the social context and the multiple alternatives offered to miners to engage in formalization, a design strategy with three options allows us to explore tradeoffs among different combinations of attributes, that would not be available had we just presented a binary alternative. We produced cards with attributes (**¡Error! No se encuentra el origen de la referencia.**). Following Kaczan & Swallow (2013), to reduce hypothetical bias we included an introductory paragraph to explain the value of learning from this choice experiment for those who design actual formalization offers.

We first generated all possible unique formalization offers' attribute-level combinations (128 =2 x 4 x 4 x 4). These could be combined into 16,256 (128 x 127) distinct pairs of two alternatives. We applied the DCREATE algorithm in Stata to reduce this number to 30 pairs to maximize design

D-efficiency, based on the covariance matrix of the conditional logit model (Hole, 2017). For this new design, with a new population, we had no firm priors for attributes' coefficients and used zero in DCREATE. We discarded 5 pairs in which we suspected one alternative would dominate.[1]

[Table 1]

[Figure 2]

Finally, we randomly eliminated one alternative to get 24 choice tasks to be evenly and randomly divided into four packets of six choice tasks each. By presenting each respondent with only 6 choice tasks we avoid burdening participants with too many choices. Each of these four blocks or packets of six-choice-tasks was administered a roughly equal numbers of times in both communities.

We surveyed miners before the experiment to collect information on their mining history and practices; as well as their perceptions of the environmental impacts of mining; gold trade actors; mining governance; community relations; and formalization. After the discrete-choice experiment, we asked additional questions to understand the participants' perceptions of mining associations, formalization processes, restoration work, contributions to community councils, among others (Johnston et al., 2017).

4.4 Analysis Strategy

The empirical analysis of our experiment is based on random-utility theory. We model utility as a function of observed and unobserved characteristics. The former are the attributes and surveyed variables. This strategy assumes utility functions in an ordinal sense, so the magnitudes of utilities

[1] It is common practice to remove illogical combinations (Maldonado et al. 2019; Huber and Zwerina 1996)

for different alternatives are meaningful only when compared to each other (Hensher et al., 2015). The basic model assumes that the utility for the respondent depends on the levels of the attributes:

$$U_{ij} = \beta_0 + \beta_1 Assoc_{ij} + \beta_2 Rest_{ij} + \beta_3 CC_{ij} + \beta_4 GP_{ij} + \epsilon_{ij} \quad (1)$$

where U_{itj} indicates a utility level for individual i from alternative j, while $Assoc_{ij}$, $Rest_{ij}$, CC_{ij}, and GP_{ij} indicate attribute levels in a choice task, and ϵ_{ij} is the random component or unobserved factors in utility. Then β_1, β_2, β_3, and β_4 are the estimated parameters that reflect the marginal utility of each attribute in a Multinomial Logit Model. Finally, β_0 reflects the alternative-specific constant ($ASCSQ$) for the status quo or the utility associated with maintaining the status quo (Adamowicz et al., 1998). Results can be read in terms of the average willingness to accept (WTA) for marginal changes in the level of each attribute, as indicated by the negative marginal rate of substitution[2] between an attribute parameter and a monetary attribute, in this case the gold price, putting attributes' effects in monetary terms. WTA_k, where k is the attributes ($k = 1, 2, 3$) can be estimated as the ratio (β_k / β_4) using parameters that are obtained estimating equation (1).

Equation (1) assumes linear utility as a function of each choice attribute, yet we hypothesize that restoration preferences vary with prior voluntary tree planting efforts. Thus, we interact the attribute of including restoration work within the formalization option with a measure of miners' prior experience in voluntary restoration (measured by voluntarily planting trees, *VPT*), obtained

[2] WTA is the average amount of currency (additional price of gold per gram) CE respondents are willing to accept in exchange for shifting the value of an attribute by one unit. A positive sign indicates that respondents are willing to accept that shift in the attribute if they also obtain an increase in the gold price per gram equivalent to the WTA value (the implications being that this shift in the attribute generates negative utility). In contrast, a negative sign indicates that respondents are willing to accept a reduction of the gold price per gram of a magnitude equivalent to the calculated WTA value, in order to get that increase in the level of the attribute (i.e., this attribute generates positive utility).

from information collected with the survey. Thus, we also use the specification in equation (2) in which the *VPT* is interacted with previous restoration experience:

$$U_{ij} = ASCSQ + \gamma_1 Assoc_{ij} + \gamma_2 Rest_{ij} + \gamma_3 Rest_{ij} * VPT_i + \gamma_4 CC_{ij} + \gamma_5 GP_{ij} + \epsilon_{ij} \quad (2)$$

However, the relationship between accepting a formalization offer and the inclusion of restoration might not be linear with regard to the number of restoration days per month required as part of the bundle. Miners may have preferences for voluntary work up to a certain point, after which they invert their preferences because they perceive that the costs outweigh the benefits. In this context, a linear interaction would not be sufficient. Therefore, we also test whether a non-linear relationship is observable. Equation (3) describes non-linear dummy effects for this variable, which we test below:

$$\begin{aligned} U_{ij} = ASCSQ &+ \theta_1 Assoc_{ij} + \theta_2 Rest_1 day_{ij} + \theta_3 Rest_1 day_{ij} * VPT_i + \theta_4 Rest_2 day_{ij} \\ &+ \theta_5 Rest_2 day_{ij} * VPT_i + \theta_6 Rest_3 day_{ij} + \theta_7 Rest_3 day_{ij} * VPT_i + \theta_8 CC_{ij} \\ &+ \theta_9 GP_{ij} + \epsilon_{ij} (3) \end{aligned}$$

5. Results of Interviews & Surveys

5.1 Qualitative Results: regional context & community differences

5.1.1 Community Council of Alto San Juan (ASOCASAN)

Located in Southeastern Choco Department, between the municipality of Tado and the border with the neighboring Department of Risaralda, this Community Council holds 354,517 hectares that are collectively in the name of the Afro-descendant communities of Alto San Juan. It is locally known

as ASOCASAN (INCORA, Resolution 02727 of 2001). This CC is made up of 21 local councils (or villages), within which 4,637 people reside in 1,460 families (UNDP, 2020).

This ethnic-territorial governance body is led by a Board of five people and a legal representative elected in the Community Assembly every three years (ASOCASAN, 2009). Board decisions rely on a Use-Management-Environmental exploitation plan, an Ethno-Development plan, and internal regulations on land use and natural-resources use, and economic activities (ASOCASAN, 2020).

Inhabitants of Alto San Juan engage in gold mining, platinum mining, and subsistence agriculture (ASOCASAN, 2009). Some community members still use traditional artisanal mining techniques, such as the *zambullidero* and the *mazamorreo*[3]. External pressure to mechanize mining production has grown since the construction of the highway linking Tado to Risaralda (Ayala, 2005). Such pressure increases with the international gold price. Local miners are well connected to markets and sell their output in the main urban areas of Tado, Istimina and Quibdó, the capital of Choco.

All forms of mining coexist in ASOCASAN, including artisanal alluvial mining, predominantly carried out by women; semi-mechanized alluvial mining performed by local crews of mostly men,using mini-dredgers and low-power motor pump; semi-mechanized underground mining, performed by crews; mechanized mining using draglines, backhoes, and hydraulic lifts, which is carried out clandestinely by outsiders but supported in some cases by community members, albeit without authorization from the Board. The risk that mechanized mining is co-opted by illegal armed groups is high, due to the presence of several organized crime and drug trafficking groups in the region, something that exceeds the capabilities of the CC Board to regulate (Ángel et al., 2019; Uhm, 2020).

[3] The *zambullidero* is a wooden box which is used to extract the sand from the riverbed. The term *mazamorreo* refers to the action of panning gold with the use of water and a shallow tray.

Some areas within this CC were declared a Special Mining Zone for Ethnic Communities in 2006. That prevents others from claiming titles (Ministry of Mines, Resolution 181792 of 2006). In 2019, a group of community members managed to have 695 hectares (divided into seven polygons) declared a Special Reserve Area (ARE) (ANM, Resolution 315 of 2017). In 2021, the local Council of Cértegui requested the declaration of an ARE of 3,000 hectares. The request is still under review (ANM, 2022). Currently, the CC is receiving technical advice from WWF-Colombia and ARM to support their application for the environmental license and the mining title.

There is some expectation in the CC and supporting NGOs of eventually connecting gold output to higher value sustainable supply chains certified by Fairmined.[4] One challenge, however, is a cohesive and sustainable model for managing the mining title, including appropriate distribution of benefits, since not all community members have access to mining operations covered by the current and requested ARE. The Board needs to balance the interests of some miners and ARE for market-oriented exploitation and the needs of the community as a whole, including non-miners.

5.1.2 Community Council of the Yurumangui River

Located in southwest Colombia, within the rural area of the municipality of Buenaventura, in the Valle del Cauca Department, this Community Council holds 54,000 hectares that are between the Cajambre River to the north, the Naya River to the south, the Farallones National Natural Park to the east, and the Pacific Ocean to the west. These lands were declared collective territories in the year 2000. The population of this CC is roughly 3,000 people who are distributed across 13 villages along the Yurumangui River. In the upstream villages Juntas and San Antoñito, people are engaged

[4] Since 2008, private companies have filed concession requests for 8,907 hectares within the Community Council (ANM, 2022). These requests are unlikely to pass, though, since they need to undergo a prior-consultation process.

mainly in gold mining. One area has been declared a Special Mining Zone for Ethnic Communities (ANM, resolution 308 of 2017). However, the CC has not initiated formalization processes in their territory. Further, most local miners are not registered at the municipal office as artisanal miners.[5]

Three types of mining occur in Yurumangui: ravine, river, and mountain or hill. The first two are usually carried out by crews of between 10 and 120 miners. The third approach, however, is done individually or using small crews that dig soil from the mountain by hand and wash it in the river. On average, a crew of 20 miners extract between 20 grams and 2 pounds of gold monthly.

Miners who manage to mine a large amount of gold tend to sell it in Buenaventura. Others find it more convenient to sell to *tenderos*, i.e., store owners from the village who supply food to miners and sometimes grant loans for mining expenses. In this CC, *tenderos* face high transportation costs to gold markets, with a 12-hour trip by both river and sea to reach Buenaventura's gold market.

Yuramanguí has been nationally recognized for its effective social organization, including winning a national prize for the successful defense of its territory. Its high levels of collective action, including to avoid the expansion of illicit crops, have been documented (Lobo and Vélez, 2020), as have their practices for managing gold mining (Rodríguez et al., 2019; Rodríguez et al., 2021). The CC's Community Assembly established rules on gold mining—including restrictions on using high-power motorized pumps and mercury. A limited number of mini dredges are allowed, yet no miner is authorized to use big dredges or high-capacity machinery. External miners are not allowed to exploit local gold mines at all—and, at least to date, such outsiders' presence has been avoided.

[5] Since 2017, private companies have filed concessions requests for 5,835 hectares within the Community Council (ANM, 2022). These requests are unlikely to pass, though, since they need to undergo a prior-consultation process.

Yet Yurumangui currently faces a crisis involving the disappearance of well-known mining leaders who had previously led community resistance to residual FARC-EP and ELN armed groups who compete to capture mining rents and to control rivers to facilitate transport of cocaine and weapons. Despite the Colombian Peace Agreement with FARC, there has been an increase in violence, and confinement, and displacement for many Afro-Colombian communities within the Pacific region.

5.2 Survey Results

Our sample is made up of 423 artisanal and small-scale miners from CCs in Choco, San Juan and Valle del Cauca, Yurumangui (see **¡Error! No se encuentra el origen de la referencia.**). The average age of the miners interviewed is 42, while 55% of them are women. Miners from Yurumangui are, on average, 15 years younger than those from San Juan and have 1.3 additional years of education. The average monthly income for miners is substantially higher in Yurumangui, due to higher quantities of gold extracted. In San Juan, a miner extracts on average, 2.73 grams per month, while in Yurumangui, the average extraction per miner is more than double that, at 6.42 grams per month. That difference is due to a large difference in accessibility of gold deposits. High international gold prices produced a gold rush in 2008 and, since San Juan is located on the highway, it was easy for outsiders to use backhoes to extract significant quantities of gold illegally. Surface gold was thus drastically reduced, so that the community must work harder now to extract the remaining gold.

Incomes are higher in Yurumangui, despite a lower reported average gold price than in San Juan. The latter is at least partially explained by the fact that only about a quarter of miners in San Juan sell their gold in their village, while almost 90% Yurumangui sell gold in their villages, where prices are lower than those in the nearest major city. Therefore selling in the city provides higher

returns even accounting for the cost of transporting the gold to the city. Satisfaction with the gold price is consequently almost three times higher in San Juan than in Yurumangui.

[Table 2]

Almost all miners in San Juan have access to the public health-care system, while less than half of the Yurumangui miners have access to the system. Nearly all the miners that were interviewed volunteer within their communities, mainly undertaking church-related activities and cleaning public spaces. Some restoration of the mining sites and replanting of trees also occurs in each of these Community Councils. A third of the miners within San Juan and only 15% in Yurumangui reported participating in reforestation activities. But participation in the CC Assembly is almost three times more common among miners in Yurumangui than those in San Juan — suggesting stronger social cohesion and legitimacy of the local governance structure in the latter. Finally, mining associations are uncommon in these communities, and practically nonexistent in Yurumangui.

Local mining governance is perceived to be stronger in Yurumangui than in San Juan. Most miners in Yurumangui accurately reported that the CC Board establishes rules concerning mining activities, and half of these miners knew that there are penalties for breaking the rules.

Nearly all miners in Yurumangui are willing to contribute to cover the CC's formalization costs, while only about one third in San Juan are willing to do so. Miners in San Juan are more aligned with national mining requirements: 42% are registered with the mayor's office as artisanal miners and 38% have tax identification numbers. In contrast, the focus in Yurumangui seems to be local: only 8% of miners are registered in the mayor's office and only 5% have tax identification numbers.

6. Results of the Choice Experiment

6.1 Constant Marginal Effects (by Community Council)

We analyze data from our choice experiment using a standard multinomial logit model, estimating coefficients for each of the attributes. Given differences in characteristics, we estimated separate models for each Community Council (**¡Error! No se encuentra el origen de la referencia.**). Coefficients are estimates of marginal utilities (holding all other attribute levels constant). Positive signs mean the attributes increase miner utility from the bundle, while negative signs mean that those attributes decrease the utility for the miner.

These CC results reveal substantial variations in preferences, in line with prior observed behaviors. San Juan miners are indifferent to forming associations while Yurumangui miners are in favor of associating, consistent with a positive past experience with organization. Respondents from Yurumangui regarded the requirement of restoration activities as a negative (a cost or a disutility). In contrast, San Juan miners placed a positive value on restoration, consistent with our survey finding that more voluntary restoration efforts were undertaken in San Juan than in Yurumangui.

Miners in both communities indicated that supporting the local Community Council financially is a net cost. It is a literally a financial cost, of course, but respondents' perceptions of what CC's achieve could have made contributing a net positive. Finally, a higher gold price is always a positive, yet the San Juan miners expectations of the price reward for formalizing were lower than those of the Yurumangui miners, which is consistent with Yurumangui having lower gold prices (and, as we found, less price satisfaction).

[Table 3]

The coefficient for the status quo (SQASC) choice is also useful for summarizing any general leanings, independent of these characteristics (the full set of coefficients predicts acceptance for any bundle). **¡Error! No se encuentra el origen de la referencia.** has negative significant SQASC coefficients for each CC. In considering formalization, relative to the status quo, miners from both CCs generally seem to be in favor of formalizing (in line with the fact the Status Quo option was chosen on only 10% of the choice cards). Disutility from maintaining the status quo is judged more extreme by miners in Yurumangui (almost 3 times as high).

The results can be interpreted in terms of the average willingness to accept (WTA) marginal changes for each attribute in a bundle. In Yurumangui, miners would need to observe a higher gold price of 1.14 USD per gram to accept an additional day of work in restoration per month. In San Juan, respondents are willing to accept a lower price (2.77 USD per gram) for that additional day, i.e., on average they value including restoration. Given this striking difference in views, which lines up well with evidence of more prior restoration in San Juan, we will investigate how impacts vary with prior effort and with level of effort.

6.2 Varying Marginal Effects (by Community Council)

6.2.1 Linear Interaction with Prior Effort

Following (2), Table 4 adds linear interactions between restoration and voluntary tree planting. Those who previously chose to plant trees might prefer restoration. The interaction coefficient is positive and significant in both CCs, indicating that individuals who voluntarily plant trees do value restoration. Volunteers in San Juan who record a significant positive valuation for restoration (i.e., the sum of restoration coefficients is significant) drive the positive result depicted in Table 3.

In Yurumangui, the value for restoration is significantly negative for non-volunteers and significantly positive value for volunteers.

[Table 4]

6.2.2 Linear Interaction with Prior Effort & Sample Analyzed by Gender

Table 5 uses the specification in Table 4 above but analyses the sample by gender for each of the CCs. For the Association attribute among the San Juan miners, there is a significant negative for women and a non-significant positive coefficient for men. In contrast, concerning the response to the Association attribute, there is a significant positive coefficient for both men and women miners in Yurumangui, confirming that shown in Table 3.

Table 5 shows that the finding that miners who had previously volunteered to plant trees felt more positive about including restoration in formalization is driven by men. The sums of coefficients here show only men valued restoration. While the Contribution and Gold Price effects are not strikingly different by gender, the preference to move away from the status quo does vary. Yet the direction for this differs across communities. The stronger negative view on keeping the status quo for Yurumangui comes more from women, while in San Juan men are considerably more negative about maintaining the status quo than women.

[Table 5]

6.2.3 Non-linear (stepwise in restoration days) Interaction with Prior Effort

Following (3) above, Table 6 examines a non-linear interaction of prior volunteer tree planting and restoration days. Miners may accept some restoration effort as part of formalization, but not a lot (in Table 6 we test this out using dummy effects but the quadratic results are very consistent).

Further, that kind of non-linear response to marginal changes in effort could well vary with 'type', e.g., miners who have chosen restoration in the past might not tire of it as quickly.

Along those lines, Table 6 shows that, once again, prior behavior matters. Miners in San Juan, with more prior effort in tree planting, do not reduce their valuation of marginal restoration days, unlike miners in Yurumangui, even those who were involved in tree planting. This also confirms that those who planted trees before view restoration more positively.

6.2.4 Robustnes check – heterogeneity analysis with a latent class model

We conducted a robustness check with a latent class model (two classes) which showed that being a woman and being in San Juan reduces the probability of belonging to class 1. Class 1 is linked to a positive valuation of association. This result corroborates our findings that miners from San Juan are less inclined to form an association, including women miners.

7. Discussion

Our results inform interventions to support small-scale gold mining formalization, showing that communities are willing to move away from the status quo and engage in formalization processes. However, the study shows that some requirements, such as to form local associations and engage in restoration practices, are perceived as costly by at least some community members, hindering efforts to formalize miners in these communities.

Our finding show that perceptions of formalization are linked to miners' past experiences. For instance, miners in Yurumangui are more willing to form associations and, express more gains in utility from moving away from the status quo than miners in San Juan. That is consistent with a history of social capital accumulation in Yurumangui. However, even though Yurumangui has a strong and legitimate Board the Yurumangui miners perceive paying fees to a Board as a cost.

Possibly for these miners contributing to the cost of both production and political organization is too costly. San Juan miners have had more experience with external actors and formalization – though not always positive experiences − and are more connected to markets than Yurumangui miners This is reflected in San Juan's higher average gold price. These may explain why formalization is perceived as less beneficial here. Miners in San Juan are more willing, though, to include site restoration as a part of formalization. Past experiences at the individual level matter here as well, in that miner who voluntarily planted trees in the past are found to be significantly more willing to be involved in restoration of sites.

Gender differences are small − yet suggest tensions regarding the costs implied in terms of time. Although women in Yurumangui seem more willing to engage in formalization than men (and to accept lower prices for their efforts), they are not as keen on devoting time to restoration activities. In San Juan, women are not willing to form an association (in contrast to men). While these results are community specific, they may reflect that woman have additional obligations at home. They could also reflect different mining tasks, e.g., the fact that women are mainly artisanal pan miners, which in principle means they need only to register at a municipal office to become formalized. The more striking differences in preference appear to be along community rather than gender lines.

Several barriers prevent ASGM from accessing formalization. The formalization process is cumbersome and expensive; and collective and individual practices need to be adopted in order to formalize. Further requirements in the form of changes in environmental and social practices make the possibility of formalization less accessible. But separating different activities into bundles of preferences can help researchers and policy makers better understand how these barriers play out in specific contexts. They also illustrate what leverage points can be more effective in addressing barriers to both formalization and certification and improving the livelihoods of ASGM.

Choice experiments have traditionally been used as a tool for valuation of environmental goods. In this case, we have extended its use to analyze preferences for alternative institutional

arrangements (besides some monetary valuation of the costs and expected benefits of formalization). Given the collective nature of both property rights and institutional arrangements in the communities under consideration, it is useful to explore not only individual costs and benefits but also the value miners attribute to collective action efforts in facilitating formalization. As anticipated, miners' preferences were affected by their previous experience of collective action and social capital building, revealing the usefulness of this methodology to unveil such interplays.

8. Conclusions

Formalization is a first step towards access to sustainable mining supply chains, including via certification. We explored miners' preferences concerning formalization in two small-scale gold-mining communities in the Pacific Region of Colombia. We analysed elements of the formalization process, as determined by the academic literatures as well as our fieldwork. These were formation of a local mining association; financial contributions to local authorities; days of unpaid work on site restoration efforts; and the gold price.

We found that Councils' distinct histories and contexts strongly influenced what elements of the formalization process miners prefer (i.e., what benefits and associated costs). At the Council level, prior experience with formalization seems to be associated with less interest, yet prior successful local organization increases the perceived value of forming associations to formalize. however, none of the miners were eager to contribute financially to local governance authorities.

We saw differences between men and women miners, though these were not consistent between communities. The only consistent difference was women's willingness to accept lower prices for gold. An individual difference that matters consistently is prior experience with volunteer tree

planting, as those with this experience were far more receptive to accepting restoration within formalization.

These results suggest that public actors and civil society should communicate transparently about what formalization will involve, including restoration requirements, and facilitate the formation of groups in order to address legal processes and administrative burdens at lower transactions cost. Communities that are better informed can assess the benefits but also the limitations of formalization. Policymakers can also advocate for the simplification of requirements and the provision of sufficient incentives for communities to start formalization processes, transparency, and eventually upgrading in the supply chain. Investing in social capital formation is a key first step to overcome the barriers to formalization. A gendered strategy that responds to the needs of overburdened women is also needed to gain their support for these new initiatives. Furthermore, there is an expectation of a price premium that needs to materialize for communities to actively pursue formalization and upgrading. Unfortunately, these improvements cannot address other important obstacles such as illegal armed groups that threaten community-based organizations and miners' livelihoods. Without the permanent presence of the state, formalization will fall short. In fact, as expressed in interviews, miners wonder whether formalization would expose them to a higher risk of being targeted by armed groups in the region who try to capture the rents from mining exploitation. This is a topic that deserves further research.

Methodologically, we contribute new findings to the literature, using choice experiments to understand the contexts for policies concerning the environment and natural resources. Ours is the first study to apply this approach to miners' preferences and we reveal the importance of local context in responses to formalization options. Replication of such surveys in other contexts with gold mining communities could improve the program designs within development interventions.

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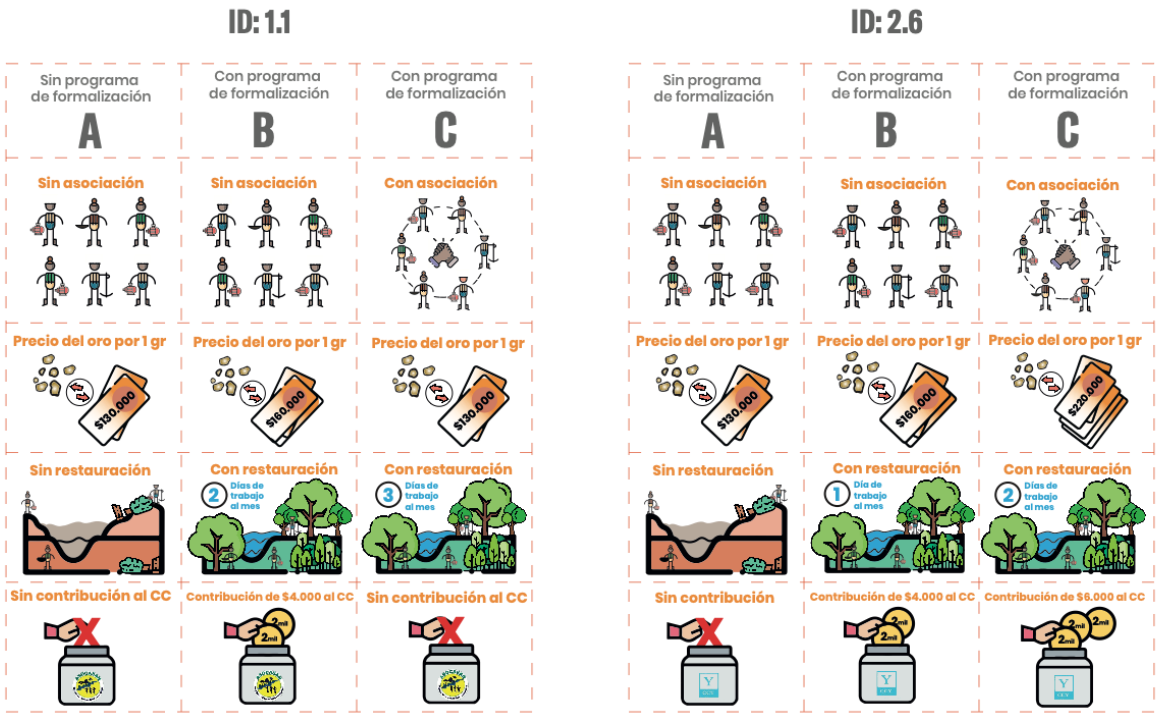
Appendix 1: Figures

Figure 1. Common Formalization Barriers

- Limited access to reliable information on ASGM at the national, regional, and global levels.
- Lack of capacity of local government agencies and inadequate decentralization processes.
- Prioritization of LSM due to lack of appreciation for the ASM sector's development potential.
- Long, costly, and cumbersome formalization processes and lack of incentives to formalize.
- Inadequate understanding of dimensions of formalization and local dynamics of the sector.
- Limited financial, administrative, and technical assistance to ASGM.
- Marginalization of the sector and culture of informality.
- Competing normative frameworks (customary law).
- Prevalence of illicit financial flows investing in sector.
- Resistance from actors who have vested interest in maintaining informality.
- Lack of funding to implement and monitoring of formalization.

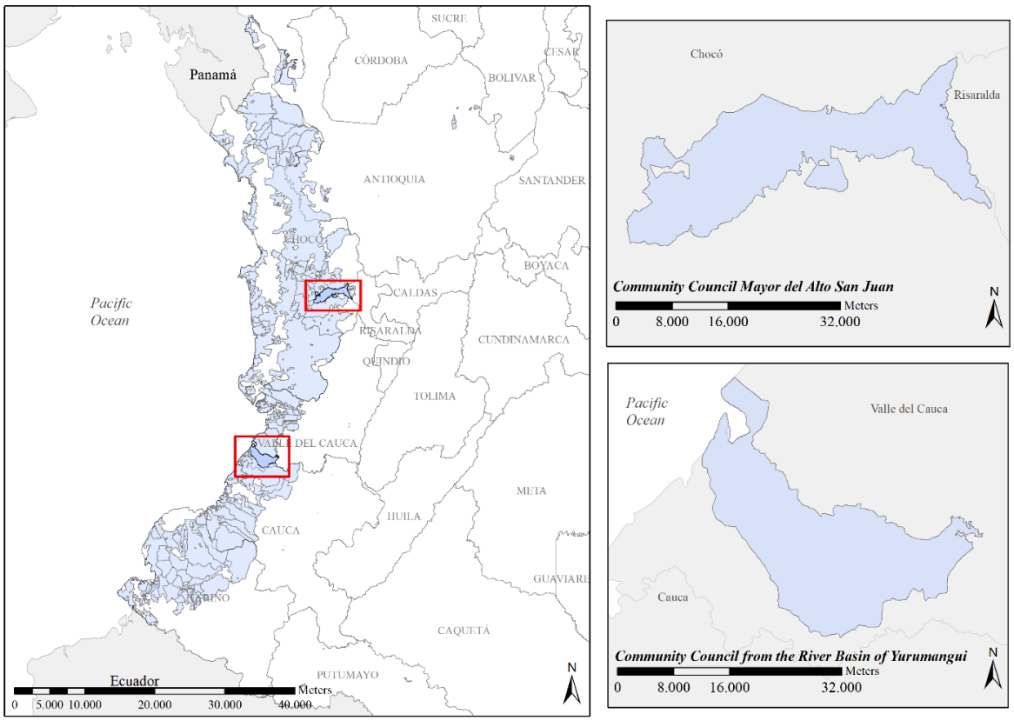
Source: UNITAR &UN Environment (2018).

Figure 2. Example of choice cards presented to respondents in each community council.



Appendix 2: Maps

Map 1. Communities' Locations



Appendix 3: Tables

Table 1. Choice Attributes (with their levels)

Attribute	Description	Specific Levels
Forming Association (*Assoc*)	Requiring the individual mining operator to join an association to access titling in formalization	1. Without association (s.q.) 2. With association
Restoration Effort (*Rest*)	Days per month in implementing restoration plans to fill mining pits after any site is exploited	1. 0 days (s.q.) 2. 1 day 3. 2 days 4. 3 days
CC Board Contribution (*CC*)	Required contribution (per each $100k) to the CC to support formalization / governance processes	1. $ 0,000 COP / 100k (s.q.) 2. $ 2,000 COP / 100k 3. $ 4,000 COP / 100k 4. $ 6,000 COP / 100k
Gold Price (*GP*)	Monetary value to be received per gram of gold	9. $ 130,000 COP/g (s.q.) 10. $ 160,000 COP/g 11. $ 190,000 COP/g 12. $ 220,000 COP/g

Table 2. Descriptive Statistics for both communities (mean values unless otherwise stated)

	San Juan	**Yurumangui**	***difference***	
Socioeconomic Characteristics				
Age	49.50	34.76	14.74	***
Percentage of women	51.96%	57.99%	-6.03%	
Years of education	6.23	7.57	-1.35	***
Average monthly income (USD)	69.88	142.10	-72.22	***
Miners in the subsidized healthcare system (%)	96.08%	48.86%	47.22%	***
Social Capital				
Miners who do volunteer work in communities (%)	88.73%	100.00%	-11.27%	***
Miners doing reforestation (%)	34.31%	15.07%	19.25%	***
Miners who participate in the CC-assembly (%)	32.84%	91.78%	-58.94%	***
Miners belonging to an association of miners (%)	4.41%	0.46%	3.96%	**
Mining Governance				
Miners think CC Board sets rules on mining (%)	14.22%	82.19%	-67.98%	***
Miners think authorization for operations required (%)	31.37%	52.05%	-20.68%	***
Miners believe in penalties if break CC rules (%)	5.39%	51.14%	-45.75%	***
Miners think mining prohibited for outsiders (%)	0.98%	34.70%	-33.72%	***
Miners say CC allows mining by some outsiders (%)	29.90%	48.40%	-18.50%	***
Miners think owner can allow outsider mining (%)	85.78%	60.73%	25.05%	***
Percentage of miners with tax identification (%)	38.24%	5.02%	33.21%	***
Percentage of miners registered in mayor's office (%)	41.67%	7.76%	33.90%	***
Miners willing to contribute to the CC for costs (%)	35.78%	96.80%	-61.02%	***
Local Gold Market				
Monthly gold extraction (grams) per miner	2.73	6.42	-3.69	***
Percentage of gold sold in the village (%)	27.45%	88.58%	-61.13%	***
Share of gold sold in the nearest major city (%)	2.45%	50.68%	-48.23%	***
Average gold price per gram (USD)	41.22	26.12	15.09	***
Miners satisfied with the gold price (%)	63. 73%	23.29%	40.44%	***
Percentage of miners who know buyer is legal (%)	35.78%	30.59%	5.19%	
Percentage with agreement to sell to same person (%)	22.55%	28.77%	-6.22%	
Mining Operations				
Percentage of people involved in alluvial mining (%)	30.39%	40.64%	-10.25%	*
#obs	204	219	423	
** p<0.05, ** p<0.01, *** p<0.001*				

Table 3. Multinomial Logit Model Results by Community

Marginal Utilities	San Juan			Yurumangui		
	Coeff.		*Std. Error.*	*Coeff.*		*Std. Error.*
Association	-0.081		0.068	0.220	***	0.069
Restoration work	0.088	**	0.037	-0.102	***	0.040
CC Contribution	-0.081	***	0.019	-0.105	***	0.021
Gold Price	0.008	***	0.001	0.023	***	0.001
SQ ASC	-0.616	***	0.129	-1.741	***	0.191
Log-likelihood	-1,229			-881		
Willingness To Accept (compare to effect of price)						
Association (USD/gram to balance association)	*2.55*		*2.05*	*-2.47*	***	*0.82*
Restoration (USD/gram to balance day of restoration)	*-2.77*	**	*1.28*	*1.14*	***	*0.44*
Contribution (USD/gram to balance contributing 1%)	*2.53*	***	*0.61*	*1.17*	***	*0.02*
OBSERVATIONS	204 x 6 choice sets = 1,224			219 x 6 choice sets = 1,314		

*** 99% significant; ** 95% significant; * 90% significant

Table 4. Multinomial Logit Results, adding a linear interaction of restoration with prior tree planting.

	San Juan		Yurumangui	
Association	-0.081		0.223	***
	(0.069)		(0.069)	
Restoration	-0.044		-0.145	***
	(0.042)		(0.042)	
Restoration * Prior Planting	0.404	***	0.297	***
	(0.063)		(0.102)	
[Restoration coefficient sum]	*[0.359]*	***	*[0.153]*	
	(0.057)		*(0.096)*	
CC Contribution	-0.081	***	-0.105	***
	(0.020)		(0.021)	
Gold Price	0.008	***	0.023	***
	(0.001)		(0.001)	
SQ ASC	-0.623	***	-1.743	***
	(0.130)		(0.191)	
Log-likelihood	-1,208		-876	
Observations	204 x 6 choices = 1,224		219 x 6 choices = 1,314	

Notes: *** 99% significant; ** 95% significant; * 90% significant; estimated parameters corresponding to the sum of restoration coefficients are given in square brackets; standard errors are given in parentheses.

Table 5. Multinomial Logit Results, with linear interaction as in T4 but splitting by gender (for each CC).

	San Juan				Yurumangui			
	Female		**Male**		**Female**		**Male**	
	Coeff.		*Coeff.*		*Coeff.*		*Coeff.*	
Association	-0.203	**	0.040		0.215	**	0.254	**
	(0.099)		(0.096)		(0.089)		(0.113)	
Restoration	-0.015		-0.067		-0.107	**	-0.215	***
	(0.056)		(0.068)		(0.053)		(0.070)	
Restoration * Prior Planting	0.117		0.514	***	0.152		0.496	***
	(0.094)		(0.094)		(0.142)		(0.151)	
[Restoration coefficient sum]	*[0.102]*		*[0.447]*	***	*[0.045]*		*[0.282]*	**
	(0.091)		*(0.076)*		*(0.136)*		*(0.139)*	
CC Contribution	-0.108	***	-0.054	*	-0.098	***	-0.122	***
	(0.028)		(0.028)		(0.027)		(0.034)	
Gold Price	0.009	***	0.008	***	0.021	***	0.027	***
	(0.002)		(0.002)		(0.002)		(0.002)	
SQ ASC	-0.331	*	-1.314	***	-1.977	***	-1.438	***
	(0.171)		(0.221)		(0.259)		(0.288)	
Log-likelihood	-674		-495		-516		-356	
Observations	106 x 6 choice sets = 636		98 x 6 choice sets = 588		127 x 6 choice sets = 762		92 x 6 choice sets = 552	

Notes: *** 99% significant; ** 95% significant; * 90% significant; estimated parameters corresponding to the sum of restoration coefficients are given in square brackets; standard errors are given in parentheses.

Table 6. Multinomial Logit Results with Stepwise Interaction of Restoration Days with Prior Tree Planting

	San Juan		Yurumangui	
Association	-0.066		0.254	***
	(0.069)		(0.071)	
Restoration = 1 day	0.090		0.049	
	(0.130)		(0.123)	
Restoration = 1 day * Prior Planting	0.863	***	1.160	***
	(0.192)		(0.303)	
[coefficient sum for 1 day]	*[0.953]*	***	*[1.209]*	***
	(0.171)		*(0.286)*	
Restoration = 2 days	-0.046		-0.177	
	(0.134)		(0.128)	
Restoration = 2 days * Prior Planting	1.072	***	1.137	***
	(0.199)		(0.324)	
[coefficient sum for 2 day]	*[1.027]*	***	*[0.960]*	***
	(0.179)		*(0.306)*	
Restoration = 3 days	-0.024		-0.370	***
	(0.137)		(0.136)	
Restoration = 3 days * Prior Planting	1.196	***	0.961	***
	(0.206)		(0.340)	
[coefficient sum for 3 day]	*[1.172]*	***	*[0.591]*	*
	(0.189)		*(0.324)*	
CC Contribution	-0.078	***	-0.096	***
	(0.020)		(0.022)	
Gold Price	0.008	***	0.023	***
	(0.001)		(0.001)	
SQ ASC	-0.491	***	-1.567	***
	(0.144)		(0.203)	
Log-likelihood	1,202		-867	
Observations	204 x 6 choices = 1,224		219 x 6 choices = 1,314	

Notes: *** 99% significant; ** 95% significant; * 90% significant; estimated parameters corresponding to the sum of restoration coefficients are given in square brackets; standard errors are given in parentheses.

Table 7. Heterogeneity Analysis using a Latent Class Model

	Class 1			Class 2		
Average class probability	0.790			0.210		
Attribute	Coeff.		Std. Error.	Coeff.		Std. Error.
Association	0.4388	***	0.0617	-2.1669	***	0.2209
Restoration work	0.0190		0.0334	-0.0996		0.0793
Contribution to community council	-0.0001	***	0.0000	-0.0001	***	0.0000
Gold Price	0.0190	***	0.0011	0.0089	***	0.0028
SQ ASC	-1.8809	***	0.1809	-0.5171	**	0.2271
Class probability model						
Constant	5.0391	***	0.9437			
Age	-0.0087		0.0113			
Female	-0.7417	**	0.3743			
Zone (San Juan = 1 / Yurumanguí = 0)	-3.8874	***	0.8356			
Log-likelihood	-1,930.58					
Observations	(423 participants, 6 choice sets) = 2,538					

*** 99% significant; ** 95% significant; * 90% significant